Edible Trees and Climate

A Focus on Arizona

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LEAF
Linking Edible Arizona Forests

Arizona Community Tree Council, Inc.

Linking Edible Arizona Forests

Edible Trees and Climate: A Focus on Arizona

Contributors and Reviewers

The Linking Edible Arizona Forests (LEAF) Network has the mission of linking people with the benefits of edible trees and supporting edible trees with peoples' stewardship. This publication, *Edible Trees and Climate: A Focus on Arizona*, was written by Melanie Lenart in consultation with other members of the LEAF Network Steering Committee. LEAF Network Steering Committee members include: Ann Audrey, Chair, Wendy Burroughs, Rafael De Grenade, Barbara Eiswerth, Katie Gannon, Brad Lancaster, Melanie Lenart, Barbara Rose, Beverly Babb, Alix Rogstad, and Chris Erickson. Emilie Conway did the layout design. Photos are by Melanie Lenart unless otherwise indicated.

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PLEASE NOTE: Information provided in *Edible Trees and Climate: A Focus on Arizona*, along with supplemental information at the LEAF Network Website, is intended as general guidance. Consult experts in local government, Cooperative Extension and plant nurseries to discuss which tree species, planting locations and strategies will work best for your Arizona location. Research and comply with all regulatory requirements and restrictions that might apply to planting trees, especially in regard to planting trees in the vicinity of overhead power lines and buried utilities.

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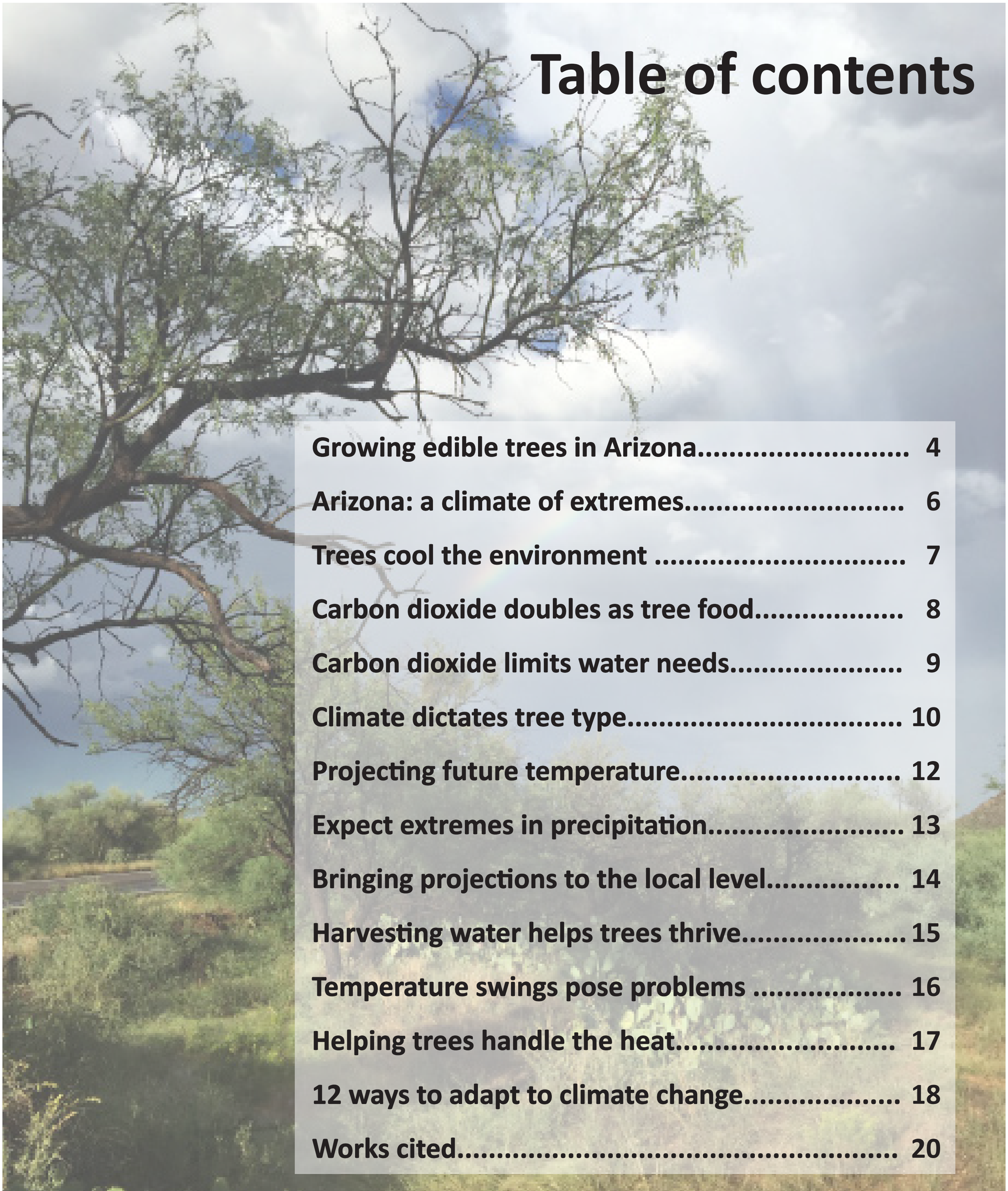

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Growing edible trees in Arizona

When you're talking climate in Arizona, you're talking extremes--extreme heat, drastic drops in temperature from day to night, and intense dryness followed by rains that pour when they do come. These extremes in precipitation and temperature are likely to get even more erratic and out-of-the-box as climate continues to change in decades to come.

Photo by Ashley Hodes

Arizona's many days of sunshine can make it challenging to grow edible trees, such as these olive trees, without supplemental water.

Rising temperatures pose challenges for trees, especially given the extra drying of soil that comes with higher temperatures. Yet the news is not all bad. Trees have been around far longer than human civilization, so on the whole they've faced both cooler and hotter climates. Thus trees have their own defense mechanisms for coping with climate change.

For instance, trees tend to grow better when there's extra carbon dioxide in the air, which there generally is during warmer climates—today and in the past. *(See page 8.)* That's an important adaptation skill that might help trees cope with the higher evaporation rates that come with higher temperatures.

Basically, trees use water stored in the soil along with carbon dioxide floating in the air to make the carbohydrates that form their leaves, wood, flowers and fruit. They use the energy in sunlight—solar energy—to power this transformation. This basic linking of carbon and water into carbohydrates launches the circle of life on Earth.

As it happens, trees actually can use less water when carbon dioxide levels are higher than when levels are lower. This so-called increase in water-use efficiency might help keep forests viable in a warming world.

Cultivated food forests have an even better chance of surviving climate change because the other crucial ingredient for plant growth—water—often can be provided by people. While the competition over water supplies will likely increase, Arizona does not restrict landowners' ability to harvest rainwater from the landscape and rooftops. Even household water from showers and washing machines can help support trees.

Rainfall is not expected to decrease nearly as much as soil moisture, and individual storms have the potential to become more intense. It's the higher evaporation rates that come with higher temperatures—something far more predictable than future rainfall—that typically lead to projections for increased aridity in the this region. That's why harvesting water before it has a chance to evaporate will likely remain an excellent strategy for supporting trees.

Trees provide excellent returns on this investment of water, time and sometimes money. They pull carbon dioxide out of the air in order to make leaves, wood and fruit, thus helping to diminish levels of one of the main greenhouse gases behind global climate change. Edible trees also help to offset the need for clearing additional land for agriculture, and for using gasoline to transport food.

Harvesting water before it has a chance to evaporate will likely remain an excellent strategy for supporting trees.

In short, there are many good reasons for growing edible trees, whether in back yards, public right of ways or urban forests.

Trees can live for many decades or even centuries, so long-term climate change can affect them in their lifetimes. Yet with appropriate tree selection and proper care, as described in detail in a related publication—the *Edible Tree Guidebook for Arizona*—the trees you plant now should thrive even in the face of the changes to come.

Fig tree seedlings thrive at San Xavier Cooperative Farm in Tucson, Arizona. As they grow, they pull carbon dioxide out of the air to create new leaves, wood and fruit.

Arizona: a climate of extremes

Native edible trees, such as these mesquite, are adapted to the climate extremes typical of Arizona.

There's no getting around it: Arizona trees have to endure some hot, dry spells. Even trees ensconced on a relatively cool mountainside have to withstand drought–and sometimes the wildfires that can come with an overly dry warm season. Meanwhile, the dry heat means weeks, even months, of 100-degree-plus days for desert cities such as Tucson, Yuma and Phoenix.

Climate change is likely to make it even more challenging, with these likely effects:

- Higher temperatures will dry out soil more quickly.
- Rainfall will become more extreme and erratic, with hotter droughts between rain spells.
- Competition for conventional water supplies is likely to worsen as evaporation rates and population growth take their toll.
- Asphalt and buildings will build up additional heat in urban areas, or even where they occur locally in neighborhoods outside of cities.
- Temperature changes won't follow a straight line, so trees face a long-term reduction in total "chill hours," but no short-term decline in risk from frost events.

The Southwest registered its hottest decade in the 110-year instrumental record from 2001 through 2010. Temperatures were roughly 2 degrees Fahrenheit warmer than average for the period. Then 2015 set a new record for global annual temperatures by an unusually wide margin. Despite that, the year 2016 broke yet another temperature record.[1]

In fact, the 17 hottest years on record for the planet have all occurred since 1998, while it's been more than a century (since 1911) that a year has shattered any global records for cold.[1]

> ***Temperature changes won't follow a straight line.***

Based on detailed computer modeling, there's more heat ahead. Projections call for another rise beyond 2 degrees by the middle of the century, with a continued trend toward more "frost-free" days and more severe heat waves.[2]

In Arizona, much of this heat comes in the "dry heat" variety. This is more than coincidence. When moisture remains on the ground after a rain, some of the sun's energy is expended evaporating that moisture.

When the soil is bone dry, on the other hand, much more of incoming sunlight goes to heating up the ground and surrounding air. That's why regions that receive more rainfall, such as the moist tropics, rarely hit 100 degrees Fahrenheit unless they're in a drought.

In short, the water that helps keep trees alive also cools the environment—as does the presence of trees themselves.

Trees cool the environment

Trees are no cure-all for climate change, but global forests do moderate the warming of the planet by capturing some of the carbon dioxide contributing to the warming. Locally, their cooling power is even more impressive.

Everyone recognizes the cooling effect of shade. On a hot summer day, pavement under trees can be up to 40 degrees cooler than pavement in the direct sun. This affects the heat collecting in the air, and puts less stress on people. To desert-dwellers dealing with Arizona summers, 98 degrees in the shade sounds pretty good.

Less obvious is the cooling effect trees create by their daily habit of pulling water from the ground into the air as they grow. This makes them natural evaporative coolers. Their ability to "mist" the air with water creates a cooling of the local environment, typically by 5 to 9 degrees Fahrenheit.

This effect applies to other plants too. For instance, a California study found that the air temperature around irrigated crops was typically about 9 degrees Fahrenheit cooler during peak daytime temperatures than nearby non-irrigated areas.[3]

Both moisture in the air and trees also have the effect of cooling during the heat of the day and warming, overall, during the cool of the night. Tree branches serve to keep closer to the ground some of the heat that would otherwise escape to the sky.

This palo verde trees and its neighbors cast shadows on sidewalks and asphalt, keeping them cooler. Cars and pedestrians also benefit from the cooling power of shade.

While this influence is unwelcome during hot summer nights, most hospital visits from heat illness occur during the high heat of the day.[4]

Also, during cold winter nights, trees can reduce the risk of freezing temperatures below their branches. As a detailed year-long study in New Mexico found, trees have the greatest warming effect on the coldest nights, and the greatest cooling effect during the hottest days.[5]

Even while they cool the environment locally, trees work to store carbon dioxide—one of the main greenhouse gases behind the ongoing warming of the planet. Forests around the globe currently take up about two thirds of the carbon dioxide entering the air from the world's cars, electricity production and industry.[6]

Much of this returns to the atmosphere thanks to deforestation, wildfires and other forest-killing factors, especially in the tropics. Still, the world's forests and oceans together still manage to pull down on average about half of the human input of carbon dioxide from burning coal, oil and gas.

Basically, once you squeeze out the water, trees are composed of half carbon—all of it derived from carbon dioxide in the air. So even as they chill the local environment with their shade and evaporative cooling, trees remove some of the gases warming the planet. What's more, even as increasing carbon dioxide levels warms the planet, it nourishes trees.

Carbon dioxide doubles as tree food

There's a funny thing about the ongoing atmospheric changes that could be the saving grace of trees: The same carbon dioxide that boosts global temperatures also serves as plant food.

In what must have been an evolutionary twist to keep them viable during hothouses of the past—when there was so much carbon dioxide warming the air that ice caps melted—plants growing under higher levels of carbon dioxide also use less water.

These little-known scientific facts are well documented. Hundreds of experiments with plants consistently showed that plants growing in air with carbon dioxide boosted to futuristic levels grew much faster than their counterparts in normal air.[7]

Sour oranges trees grow faster under futuristic carbon dioxide levels, a study in Maricopa County found.

Perhaps these findings shouldn't be such a surprise. After all, as we learn in grade school, plants build their tissues from carbon dioxide and water. They use energy from sunshine to fuel this feat, but it's the carbon dioxide from the air and the water from the ground that provide the primary materials for plant growth.

Most of the field experiments described involved crops such as wheat and potatoes, but some experiments did involve trees. One set of experiments even involved edible sour orange trees growing in Arizona's Maricopa County.

After about 13 years of study, the Maricopa researchers found that fruit production and tree mass increased by an average of 80 percent for the young sour orange trees exposed to higher carbon dioxide levels compared to those grown in regular air in these well-fertilized plots.[8]

The findings from this study were more dramatic than the typical 25 percent to 30 percent increase in productivity that scientists found in trees. Other researchers found productivity increases in apple and pear trees.[9]

The so-called sour orange tree *(Citrus aurantium L.)* yields fruit that flavors many dishes from the Middle East. Perhaps more importantly, it serves as the base of many different types of citrus trees. Lemons, sweet oranges, grapefruit and other cultivated citrus varieties are grafted onto the sour orange trunk, known as the rootstock, to take advantage of its drought tolerance.

Thus, the results of this study might apply to many citrus trees—at least from the seedling stage through the early years of growth.

Carbon dioxide limits water needs

Trees and other plants use water more efficiently under higher carbon dioxide levels, as numerous studies have found.

In fact, some of the extra growth and production found in the Maricopa study described on the previous page appeared directly related to the trees' ability to use water more efficiently when carbon dioxide levels run high.

There's a good reason for this. Plants collect carbon dioxide from openings underneath leaves called stomata. *(See photo at right.)* Water escapes from these same stomata when they're open. So, if there's more carbon dioxide in the air, plants don't have to hold their stomata open as long to get what they need for growth.

This close-up of the underside of a leaf shows stomata (seen here as white dots), which let carbon dioxide into the plant.
https://www.flickr.com/photos/avlxyz/18226713748/in/photostream/

That means that when carbon dioxide levels are higher, water has less opportunity to escape the plants' clutches. Scientists figured out this mechanism after years of lab and field experiments alike.

The ability of trees to get more out of existing water may help explain the results of another study at Duke University. Researchers there found that loblolly pines grown under higher carbon dioxide levels grew better than their counterparts grown in normal air, especially when water was in short supply—in effect, during dry years.[10]

Duke researchers surmised that the difference related partly to the fact that the trees needed less nitrogen during dry years, because all the trees grew less overall than they did during wet years. In other words, the lack of nitrogen slowed growth during wet years when there was abundant water to spur growth; when water was more scarce and growth was slow, there was enough nitrogen to go around.

This fits in with other studies indicating that lack of nitrogen can limit the extra growth that otherwise might occur under the higher carbon dioxide levels of the future.

Still, the evidence suggests that trees that receive adequate fertilizer, including in the form of compost, could benefit from the extra carbon dioxide levels in the air.

Trees use water more efficiently under higher carbon dioxide levels.

Many Arizona native edible trees, such as mesquite, palo verde and ironwood, have relationships with root microorganisms to help supply nitrogen. This makes them less susceptible to nitrogen shortages. Plants growing around them also benefit as these nutritious leaves decay into a form of fertilizer.

These findings highlight the complexity of predicting how edible trees will fare in the ongoing climate change. Although higher temperatures lead to higher evaporation rates, the effect carbon dioxide has on plants suggest transpiration rates—in effect, evaporation of water from plants—will not rise as predictably as evaporation rates from soil. It should be noted that these experiments were conducted outdoors, and thus subject to the recent temperature regime rather than the future's higher temperatures.

Still it's encouraging to know that trees have their own set of skills in adapting to a changing atmosphere and climate.

Climate dictates tree type

Together, temperature and precipitation patterns can generally predict what types of trees can grow in a specific area. The connection is so strong that scientists can use evidence of the types of plants growing in the distant past—such as by analyzing the pollen trapped in ancient sediments—as a thermometer of sorts.

Arizona trees generally are more vulnerable to problems from too little rain rather than too much. That's because flood conditions rarely leave standing water in place long enough to kill tree roots, while dry spells and droughts can leave trees short of an essential ingredient for their growth and fruit production. Irrigation can alleviate this, but only if water is available for this use.

The U.S. Department of Agriculture provides a Plant Hardiness Zone Map for U.S. residents, and it basically ignores water availability. The agency provides its planting recommendations based exclusively on the plants' frost tolerance.

Warming temperatures influence on which tree species and varieties can thrive in a particular location. In fact, the USDA adjusted its growing zone map in 2012 in response to a trend toward warming temperatures. Keep in mind that within their growing zone, Arizona residents often may have the option of growing a range of species—but some may require different planting locations and more care during temperature extremes.

Because different types of trees and forests evolved in response to different combinations of temperature and precipitation regimes, a tree's climate of origin can provide clues for tree growers on the kind of care they might need. Some general rules that apply are described below.

The USDA provides an interactive map to help U.S. residents gauge their planting zone by zip code at http://planthardiness.ars.usda.gov/PHZMWeb/.

Tropical trees

On the globe, the tropics stretches from about 23½ degrees North to 23½ degrees South, including the equators and areas on both sides of it that receive spot-on sunlight at some point in the year. With all that energy striking the planet, and all the tropical ocean area providing water to the atmosphere, many parts of the tropics have abundant rainfall.

This is the haven for tropical rainforests and a variety of trees featuring exotic fruit as well as some breakfast standards, such as bananas and citrus.

Trees that evolved in the lowland tropics are accustomed to a frost-free existence. That's why tropical trees, which include date palms, oranges, lemons and other citrus varieties, generally do not tolerate freezing temperatures.

Tropical trees growing in Arizona can suffer from the cold blasts that sometimes strike even in the warmest parts of Arizona, so they may need occasional protection from frost. They also generally need abundant water.

Citrus trees, such as the sour orange tree depicted at right, are tropical in origin and thus subject to damage from cold temperatures. Leaves of tropical species tend to be smooth on the edges, sometimes with a "drip tip" in the middle to drain off abundant rainfall.

Temperate trees

Temperate trees evolved in the regions closer to the poles, where winter temperatures typically drop low enough for precipitation to fall as snow. Temperate species tend to drop their leaves once the descent into freezing temperatures begins. Edible varieties include apple, peach, pear, apricot, pistachio, and mulberry.

These trees use the cold to help gauge the passage of time so they'll know when to start leafing out again. They detect the arrival of spring by clocking "chill hours"—the number of hours when temperatures range between 32 and 45 degrees Fahrenheit or so. As a result, temperate trees typically require a certain amount of winter chill hours to thrive and yield fruit.

As temperature increases in Arizona in coming decades, these trees may falter in their production. With this in mind, people living in areas that support temperate trees should choose their varieties carefully so they can thrive throughout their long-lived existence as the number of chill hours potentially declines by perhaps a fifth to a third by mid-century. Placement of trees where they will receive shade during winter can help keep them productive in decades to come.

Trees that originated in cooler climates, such as the mulberry depicted at left, often have leaves with ragged edges rather than smooth edges.

Subtropical trees

Being subtropical—somewhere between tropical and temperate conditions—Arizona can support some varieties of both tropical and temperate trees, as well as the native trees adapted to the local extremes typical of the subtropics.

However, the locations most suitable for apples will not be ideal for oranges, and visa versa. That said, appropriate varieties of both may coexist on some sites, given attention to planting location and proper care.

While the tropics are defined by year-round warm temperatures and the temperate zone by seasonal freezing, the subtropics tend to host the world's deserts with their daily and seasonal extremes in temperature and precipitation. In Arizona, climate variations tend to relate to elevation, with mountaintops generally cooler and wetter than lowlands.

Leaves of desert trees tend to be small, and roots adept at finding water. Mesquite, palo verde and carob are among the edible tree varieties from subtropical deserts.

Subtropical trees, such as the native mesquite depicted at right, tend to have small leaves that help them tolerate the hot, dry months typical of Arizona's lowland regions.

Projecting future temperature

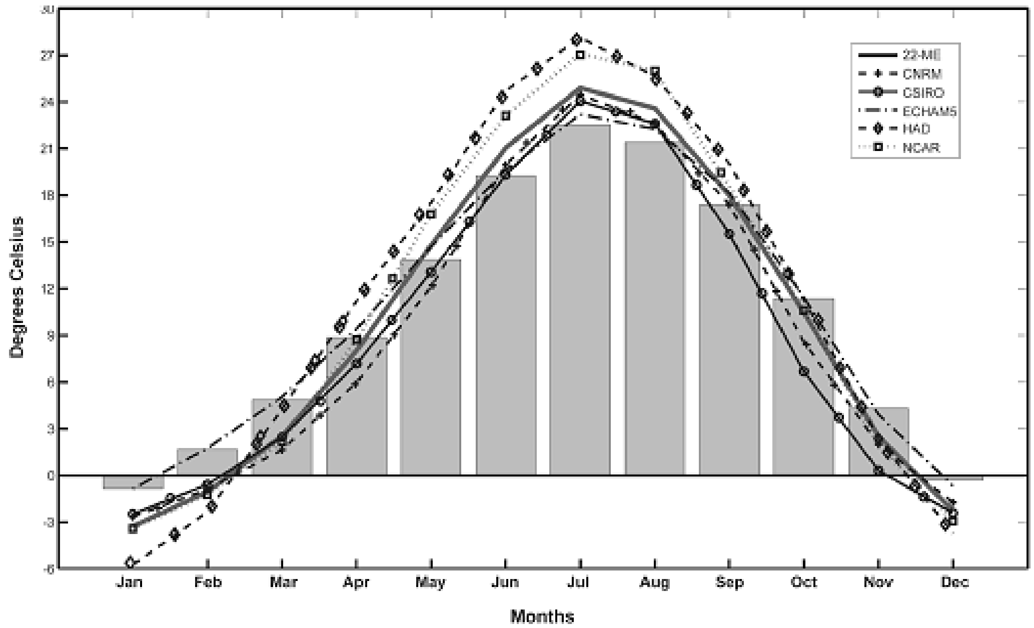


Figure 1. The gray bars represent actual average monthly temperature for 1950 through 1999 for the Four Corners area of the Colorado Plateau, which includes northern Arizona. The lines represent projections by Global Climate Models for the same time frame (1950-1999). Please see the box below for more details.

Temperature has been rising around the world in recent decades. Scientists have connected the ongoing temperature rise to an increase in greenhouse gases, most notably carbon dioxide.

The levels of carbon dioxide and other heat-trapping gases in the planet's atmosphere continue to grow, so temperatures are expected to continue rising through this century and beyond. *(For more details, see the Southwest Climate Change Assessment Report at this link: http://www.swcarr.arizona.edu.)*

Because trees can live decades or even hundreds of years, the upcoming changes could well affect them in their lifetimes.

Global Climate Models generally do well at reproducing temperature patterns in the near past *(Figure 1).* With correlations on the order of 95 percent, this skill would earn the models an A.[11]

That's why scientists tend to have strong confidence in temperature projections for the future, in the context of fitting them into expectations for what society will do to curb future emissions of greenhouse gases. Temperaure projections are worth keeping in mind when considering what type of tree to plant.

Regional annual average temperatures could increase by between 2.5 and 5.5 degrees Fahrenheit by mid-century.[2]

These values could roughly double by the end of the century, with an increase in average annual temperature of about 9 degrees Fahrenheit. Actions to curb projected increases could reduce the high end of temperature increases to about 5 degrees Fahrenheit or so by century's end.

High-density urban areas often face greater extremes than rural areas, with pavement and buildings adding extra heat load to local temperatures.

Heat waves are likely to increase in both duration and intensity. As with people, extended heat causes more problems for trees than shorter bursts.

Dry spells and droughts are likely to be hotter in general. Because evaporation rates increase with temperature, the landscape could become drier just because of the extra heat, even if precipitation doesn't change.

Temperature plays an important role in Arizona climate because of its effect on evaporation rates. Long, hot days dry out the landscape far faster than short, cool days. In Pima County, for instance, evaporation rates in spring and summer are roughly triple wintertime rates.

Evaporation rates have a strong effect on soil moisture. Trees can only access the water in the ground, within reach of their roots. So it's really soil moisture that counts to trees, rather than the amount of rain or snow that actually falls to the ground. That's one reason heat matters.

The gray bars represent actual average monthly temperature (or precipitation, on page 13) in the Colorado Plateau for the time frame (1950-1999). The thick black line shows the average monthly values for this same historic time frame (1950-1999) as projected by 22 Global Climate Models, when averaged together. The other lines show monthly averages projected by individual GCMs. The five individual models shown were selected because they performed best on precipitation for the western U.S. For more details on this approach, see the publication by Garfin, Eischeid, Lenart and colleagues (2010).[12]

Expect extremes in precipitation

Projections for rainfall in the Southwest sometimes look like loose spaghetti, in that the lines tend to be all over the place. In truth, the factors governing precipitation are far more complex and variable than those governing temperature.

Global Climate Models have a difficult time even reproducing current patterns in rainfall for the West as a whole. Winter precipitation is highly overestimated in general compared to real values in recent history *(see image at right).*

Meanwhile, summer rainfall estimates do not always follow the pattern observed on the ground of extensive rainfall during the summer monsoon, when much of Arizona receives roughly half of its annual rainfall.

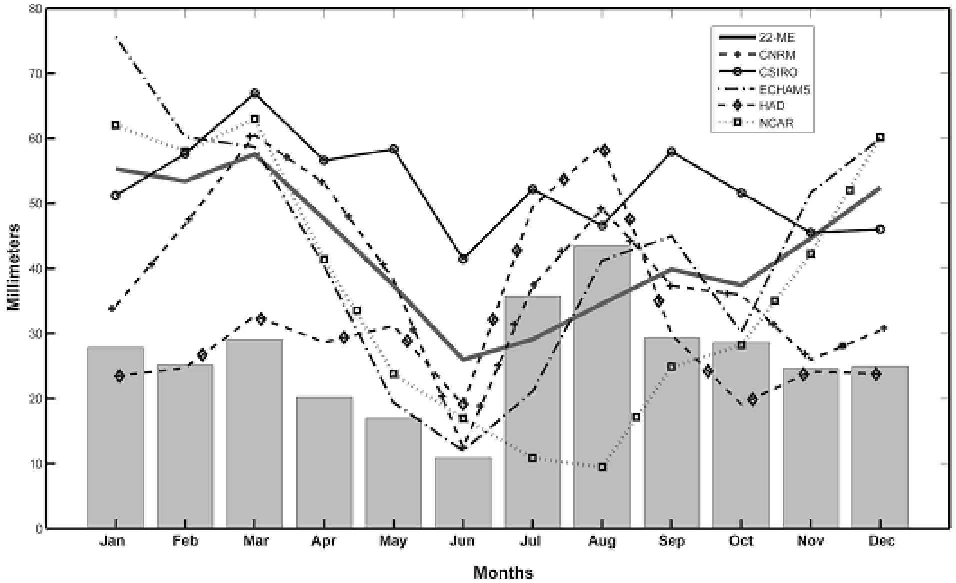


Figure 2. The gray bars represent actual average monthly precipitation during the time frame (1950-1999) for the Four Corners area of the Colorado Plateau, which includes northern Arizona. The lines represent projections by Global Climate Models for the same time frame, including the five individual models that performed best on precipitation for the West as a whole. Please see the box on page 12 for other details.

If you average out the mish-mash of results from 22 Global Climate Models, the results suggest a possible decline in precipitation of maybe 5 or 10 percent for the Southwest by about mid-century.

Even so, the individual model that did the best job of estimating past precipitation for the western U.S. actually projects a sizable increase in precipitation for the Colorado Plateau area, which includes northern Arizona.[12]

In a detailed global analysis comparing actual monthly precipitation to projections of monthly precipitation made by climate models for that same time frame of the past, the correlation was between 50 and 60 percent.[11] If this were a homework assignment, even a 60 percent might not be a passing grade.

Models have improved slightly since that 2003 analysis, but precipitation remains far more challenging to simulate than temperature. A similar analysis of temperature yielded correlations of about 95 percent or above *(see page 12)*.

That's partly why projections for temperature are considered far more reliable than those for precipitation.

Still, there are predictable processes at work that can inform projections for future rainfall.

Here's an underlying reality at work: Warmer air holds more moisture. Thus, hotter dry weather means the sun's evaporative pull will desiccate drylands even more drastically. That's why it's so important to prepare for dry times.

Keep in mind, though, that the evaporative pull that comes with warmer temperatures also will pluck more water from the 70 percent of the planet that is covered by water. What goes up, must come down. (Well, most of it, at least. When this evaporated water comes back down to earth, the results can be storms that are more extreme.)

That's why Arizona also has to prepare for more intense rains and floods. Rainfall rates can exceed previous upper limits for an hour or a day. In winter, snowfall can draw on the extra moisture stored in warmer air to come down thicker and deeper.

In the Southwest, heavier rains are most likely to occur during the summer monsoon, as well as during the autumn when remnant hurricanes sometimes reach the region. Both types of precipitation involve tropical storms that gain strength from warm oceans.[13]

An increase in heavy rainfall events helps explain why harvesting water from rooftops, pavement and the surrounding landscape will remain a viable way of supporting trees in the Southwest even as climate continues to change. This is especially true if some of that water is captured and stored in tanks.

Bringing projections to the local level

Some government agencies and non-governmental organizations provide interactive Web sites that allow you to create your own climate graphs for your county. This can be useful when planting edible trees in a changing climate.

Still, it's worthwhile to keep some caveats in mind, especially when it comes to projections. Namely, Global Climate Models make projections for the globe as a whole. So there's a limit to how local these projections can be made and remain robust.

Researchers at the University of Arizona and elsewhere have found that GCM results work best at the scale of a continent, and when averaged across three decades.[14] Climate modelers understand this, and to them "mid-century" typically refers to a 30-year time frame, such as between 2040 and 2070.

The problem is akin to zooming in too much on a digital image. A spot on the image might look purple when viewed at the proper resolution, but if you keep enlarging it, the purple starts to reveal pixels of red and blue. This is similar to the kind of distortion that might result from turning a 30-year projection for the continent into a one-year or even one-month projection for a county.

So, understand that county projections at the monthly scale are bound to include plenty of distortion of the original global results.

When reviewing them, also know that GCM results tend to be far more reliable when you average many model results together rather than when you examine the results of one particular model. Yet this very act of averaging them out eliminates the spikes of highs and lows in rainfall that characterize Southwest climate.

County-level projections

The U.S. Geological Survey provides an interactive option at its National Climate Change Viewer Web site so users can see various GCM projections for their county (keeping the above caveats in mind). The options include viewing average results from 30 different climate models. The site also offers the option of considering models of future soil moisture in the form of a water balance model, with additional caveats provided.

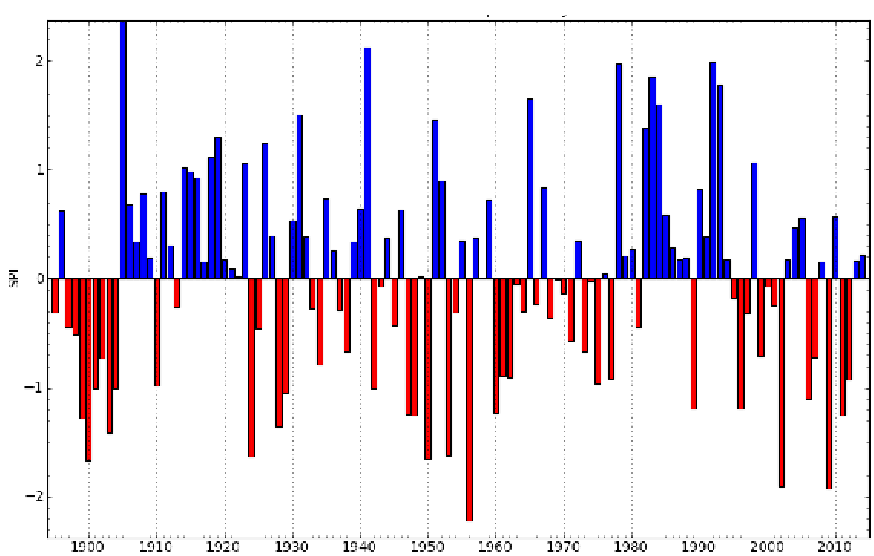
For more details and to use this viewer, go to https://www2.usgs.gov/climate_landuse/clu_rd/nccv.asp.

County-level historic data

Given the challenges of converting global projections into local values, the process-oriented discussion on the previous pages is worth keeping in mind. It also may be useful to become familiar with past fluctuations in precipitation and temperature. They can capture some of the ongoing changes, as with the temperature rise, or the lack of a recognizable shift, as with precipitation.

The Western Regional Climate Center allows internet visitors to create graphs of past precipitation and temperature at a variety of scales with a Web tool they call the West-Wide Drought Tracker. The results show that Arizona counties typically are showing an ongoing increase in average annual temperature, while annual precipitation rates by county continue to fluctuate without a detectable long-term pattern.

For more details on how to use this tool, go to http://www.wrcc.dri.edu/wwdt/current.php?folder=spi3&region=ww.



Annual precipitation for 1895-2014 in relation to the long-term average for Arizona's Maricopa County. Graphic created via the WestWide Drought Tracker.

Harvesting water helps trees thrive

Taking advantage of water harvesting options to support edible trees is one of the best ways to adapt to Arizona's changing climate.

Digging basins to collect water for trees as they mature is a practice that can help keep edible trees viable in a warming climate.

Rainfall fluctuates, as a glance at city or county records indicates. So dry spells will continue to be interspersed with heavy rains, but droughts may well be hotter. As noted, precipitation in general is likely to become more intense, so the types of heavy storms that occur during future monsoons and other storm events may produce more bursts of bountiful water.

The good news? Rainwater harvesting from roofs and pavements can make a big difference for sustainability of edible trees in Arizona. This is especially true in urban areas, where streets and buildings can provide water for trees on nearby landscapes.

Historically, civilizations have turned to water harvesting in its more conventional sense of diverting water from streams and other natural sources. Yet society can falter if these streams dry up once a large population is depending upon them.

Many parts of Arizona depend on water diverted from nearby rivers, such as the Salt, the Verde and, of course, the Colorado. Yet the amount of water actually reaching these rivers during a rainfall or snowmelt event is much smaller than the amount of precipitation that initially hits the ground.

The landscape soaks up much of the bounty, and evaporation takes a toll before and after the falling rain reaches a river or reservoir.

Catching rainwater locally from rooftops, streets and the landscape means collecting it before evaporation rates have a chance to kick in. This makes the biggest difference in dry years.

For example, after several years of research, scientists estimated that only about 3 percent of the water falling in Colorado's Douglas County actually reaches the Colorado River in an average year.[15]

The share of water reaching the river topped off at about 15 percent in wet years, when the landscape received more than it could hold. But it dropped to essentially zero in a drought year. The parched landscape was absorbing virtually all the moisture it could, with evaporation taking the rest.

Meanwhile, a homeowner with a decent roof could collect 80 to 90 percent of that rainfall in any kind of year—before the water has much chance to evaporate. Even channeling water from the landscape to trees helps keep soil moist longer.

Being able to harvest rainwater may become especially crucial during times of drought. Ironically, the time periods when the rivers are not receiving their usual share of rainfall—during drought years—are also the time periods when cities are most likely to restrict water use for irrigation.

Another ongoing source of water unlikely to face restrictions involves household water from bathtubs, washing machines and other home systems. This source is known as "graywater."

Graywater from air conditioners, too, can help fill gaps. Air conditioners extract water from the air as they cool it, yielding a source of distilled water. What's more, the amount of air-conditioning use, and thus extracted water, generally increases as temperatures rise.

Thus, keeping water harvesting and household graywater options in mind when selecting trees is an ideal way to prepare for climate change.

Temperature swings pose problems

Caring for edible trees could become more challenging in some years, including for reasons described below, as climate patterns change with overall climate.

Winter 'chill hours' declining

Many edible trees from temperate zones—such as apples, almonds, pears and peaches—require a certain number of "chill hours" for fruit to set properly. Chill hours tally the amount of time that temperatures fall above 32 degrees but below 45 degrees Fahrenheit. The number of chill hours needed varies by species and even cultivars within the species. To some degree, this allows for some flexibility when selecting varieties.

A California study estimated an overall decrease in chill hours by 14 to 33 percent by mid-century compared to 1950, before the world's warming trend had begun.[16]

Challenges exist when considering projections for chill hours, so no projection is fail-proof. For one thing, temperatures below freezing do not contribute to chill hours, so projections have to consider days shifting from freezing to above-freezing. Also, temperatures above 60 or 70 degrees in the middle of winter can negate some of the chill hours, running the tally in reverse.

Still, it makes sense to select edible tree varieties that are not currently at the edge of their chill-hour requirement. Planting trees in shady spots and seeking out other cool pockets on the landscape can also help.

Photo by Ann Audrey

Arizona residents wishing to grow tropical trees such as citrus, or temperate trees like apples, must be prepared for ongoing cold spells and freezes. Meanwhile, temperate trees might falter from lack of snow or "chill hours."

Cold blasts to continue

Warm winter temperatures also can be a problem if they initiate early flowering or budding, and then a frost or freeze follows. And, despite the trend toward warmer temperatures, there's no indication that cold spells will be completely eliminated, even in low desert.

Even as Arizona faces higher temperatures and hotter droughts, residents still have to be prepared for frosts and freezes. That's important to keep in mind for those wishing to grow tropical trees, such as citrus varieties. Tropical trees can be damaged from temperatures below 45 degrees Fahrenheit, and sometimes killed if left exposed to freezing temperatures.

There are several reasons cold spells are likely to remain in the picture.

- The climate system is complex, and cannot be expected to shift in a smooth fashion.
- An overall decrease in frost-free days does not directly translate into a decrease in the threat of frosts or hard freezes.
- Melting sea ice in the Arctic might be spurring on a "wavy" jet stream pattern that brings cool air down from the Arctic.[17]

Different varieties and even individual trees may have different tolerances for heat and cold. Shade cloth can help moderate heat during heat waves or hot spells, while old sheets or other coverings can help trees stay warmer during winter nights. So it can help to keep these items on hand to make sure edible trees make it through the cold of night or the heat of day.

Helping trees handle the heat

In general, trees are more vulnerable to sudden drops in temperature at inopportune times than they are to excess temperature. But there are limits to this, especially given the hotter droughts and stronger heat waves projected for the future.

Both summer heat waves and mid-winter warm spells are expected to occur more frequently in coming decades. Arizona residents living in the higher elevations can also expect to see more of their future precipitation falling as rain rather than snow in the course of a year.

Arizona's native trees tend to have small leaves, an adaptation to dry heat.

Watch out for heat waves

While trees can use water to help stay cool, they can also suffer from thermal death if they are facing full-on summer sun while dealing with excessively high temperatures—such as above 115 degrees Fahrenheit—for days on end.[18] In the Southwest, the biggest temperature jumps are expected to occur in fall and summer—often in the form of longer, hotter heat waves. So stretches of days topping 115 degrees Fahrenheit are a real possibility.

It should be noted that a tree's optimum temperature for growth increases as levels of carbon dioxide in the air rise.[7] This would seem to suggest that a tree's window of tolerance for high temperatures would also increase in an atmosphere with higher carbon dioxide levels. Still, even when it's not fatal, intense heat can take a toll on fruit production.

Be alert for early snowmelt

Warm spells during winter can turn snow into meltwater. In some areas, trees have enough water to grow partly because some water remains in cold storage until spring. For deciduous trees that shed their leaves for winter, earlier snowmelt or intermittent melting throughout the winter can mean that the trusted bank of snow is no longer delivering this precious fluid when spring greening begins. Supplemental water may be needed during such years. Early snowmelt also has been linked to an increase in the number of "large" wildfires—meaning the hard-to-control blazes that exceed 1,000 acres.[19] This poses problems particularly in mountainous areas of Arizona, where forests thrive under cooler temperatures and higher precipitation rates. Residents in fire-prone areas can decrease their individual risk by keeping areas around structure clear of debris and employing other FireWise practices.

Capture rain

An increase in rainfall compared to snowfall, along with the expectation for more extreme precipitation events, helps explain why harvesting water from rooftops, pavement and the surrounding landscape is likely to remain a viable way of supporting trees in the Southwest even as climate continues to change. This is especially true if some of that water is captured and stored in tanks.

Avoid chemicals when hot

To avoid putting unnecessary stress on trees, avoid using commercial fertilizers or pesticides when temperatures are high. Applications of nitrogen or chemicals can sometimes tip the scale toward mortality for heat-stressed trees.

Water when needed

Unlike most people, trees cannot escape into air-conditioned buildings. Given enough water, though, trees generally can continue to act as evaporative coolers for themselves and the surrounding area.

Keeping trees well-watered will help give them the resources to battle heat stress in most case. Water also helps keep soil, and thus roots, cooler. Watering trees during cooler times of the day, such as mornings or evenings, will suit trees better and help ensure that this key ingredient will find its way to roots instead of evaporating.

12 ways to deal with climate change

Plant trees

Increasing the canopy of native trees is one way to improve global climate and local temperature. Trees cool the environment directly through evaporative cooling and indirectly by providing shade while pulling carbon dioxide, a powerful greenhouse gas, out of the air. As possible, choose species or cultivars that are adapted to drought and higher temperatures.

Grow smaller trees

Selecting edible species or cultivars with smaller stature can save water. Generally, the bigger the crown of leaves, the more water it takes to support the tree, within a given category. Choosing a tree from a low- or medium- water-use category over a high-water-use tree will also help reduce irrigation needs. Pruning trees regularly to reduce canopy size can help cut them down to size, and also make fruit easier to reach.

Water trees

Hotter drought in Arizona might be challenging even for native mesquite. So keep in mind that non-native fruit trees may require even more irrigation, whether from rainwater stored in tanks, graywater from the household, or potable water from the well or faucet. This is especially true during the hot, dry months of May and June, when Arizona rainfall is at its lowest and evaporative pull is at its strongest. Moist soil also helps build soil organic matter.

Mix natives with cultivars

Nitrogen-fixing bacteria live in root nodules of mesquite and other native “bean” trees that have the valuable skill of converting airborne nitrogen into fertilizer. In addition to improving soil with their beneficial bacteria, these natives shed leaves that are nourishing for other plants. What’s more, these trees often serve as “nurse trees” to young cactus and non-native trees, providing shade and protection from Arizona’s weather extremes.

Encourage living soil

Healthy soil contains its own circle of life, with mites and microbes, and fungus and bacteria. Think of beneficial bacteria as probiotics for the soil, and fungus as the kombucha of the natural world. If possible, avoid using pesticides or other poisons that might harm soil life. Living soil is more resilient to the changes around it, to the benefit of the vegetation rooted in it.

Add leaves and other organic matter

One good way to boost soil organic matter is to sprinkle compost, old manure or other organic matter over the soil. Covering soil with a layer of leaves from healthy trees or other types of organic mulch also can help. Some of the organic matter will endure in the soil, actually improving its ability to store water and share it with roots.

Mulch areas around trees

Wood chips and pruned branches help improve soil and hold down soil particles so they don't erode. Commercial wood chips work, as does using local material pruned off nearby woody plants—as long as they're not diseased or placed where they increase fire hazard. Wood doesn't heat up the way rock does, so wooden mulch keeps the soil shaded and protected without warming it up. Mulch goes on top of soil.

Harvest rainwater

Be ready for dry times by harvesting rainwater from your roof and other hardscapes to support your edible trees. For a climate-hardy food forest, consider how much water you can harvest and store when deciding what to plant.

Seek the perfect planting site

When deciding whether and where to plant apples, pears and other cool-climate trees, choose varieties that are not near the edge of the chill-hour requirements, and plant them in shady spots or other relatively cool pockets.

When planting heat-sensitive trees, avoid areas with a lot of hardscape, such as pavement or asphalt, as these materials collect and emit heat. Tropical species can survive in some of Arizona's lowlands, especially if planted near walls that can radiate nighttime heat, but be prepared to cover them to protect them from cold blasts.

Divert household water to trees

Instead of sending water from bathtubs and washing machines into the sewage system, use graywater to irrigate trees. This sanitary household water provides a reliable supply of water, even if cities enforce watering restrictions during dry times. Use liquid rather than powder soap.

Add a cistern for water storage

Investing in a larger cistern than current climate conditions require may be reasonable preparation to take advantage of the more intense storms expected as climate continues to warm. A larger sized cistern will also provide longer storage capacity to help withstand subsequent dry spells or droughts.

Capture AC water

If you use an air conditioner, direct the water created in the air-conditioning process toward trees. This "condensate" is basically distilled water. It can be corrosive when applied in large quantities, so mixing it with tapwater or rainwater (such as in a cistern) can help. Air conditioners tend to run most during the hottest time of the year, right when trees need the most water.

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