Community Forests Prepare for Climate Change

Cities across the United States are feeling the heat as they struggle to integrate climate science into on-the-ground decisionmaking regarding urban tree planting and management.

At Balcones Canyonlands Preserve, managed by the city of Austin, adaptation measures to reduce erosion and increase water infiltration and storage include the use of berms and swales, application of organic matter and mulch, and seeding with native grasses and heat-adapted woody plants. Credit: Leslie Brandt

By Courtney L. Peterson, Leslie A. Brandt, Emile H. Elias, and Sarah R. Hurteau 11 February 2021

Trees benefit residents in communities around the world by mitigating pollution and other environmental impacts of contemporary society and by broadly improving livability in cities and towns. However, many locales are feeling the heat as urban, or community, forests—defined (https://www.fs.fed.us/ucf/supporting_docs/UCF-Brief-Jan2018.pdf) by the U.S. Forest Service as "the aggregate of all public and private vegetation and green space within a community that provide a myriad of environmental, health and economic benefits"—struggle against a multitude of stressors stemming from climate change.

Forest pests and diseases are expanding their ranges, for example, and heat, megadroughts, and shifts in the amounts and timing of precipitation are changing water availability—all contributing to a looming urban tree crisis. To maintain the many benefits that community forests provide for people and wildlife, we urgently need clear strategies to respond to such challenges and to help community forest managers adapt these unique and valuable ecosystems to current and anticipated effects of climate change.

An Underappreciated Resource

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The importance of urban trees is often overlooked. In the United States, community forests save an estimated $18.3 billion annually by providing ecosystem services like air and water pollution removal, carbon sequestration, carbon storage, energy savings for buildings, heat reduction, and avoided stormwater runoff [*Nowak and Greenfield* (https://doi.org/10.1093/jofore/fvx004), 2018]. But urban trees do more than provide these ecological necessities.

Urban trees provide human health benefits (https://eos.org/articles/how-to-turn-our-cities-into-treetopias) by promoting increased physical activity, improved mental health, enhanced community walkability, and improved safety of public transit (https://storymaps.arcgis.com/stories/c88755f465c748ae9da90f26c7376d86) [*Nesbitt et al.* (https://doi.org/10.1016/j.ufug.2017.05.005), 2017]. For example, attractive trees and landscaping encourage increased social interaction among neighbors and create a sense of ownership and safety.

An estimated 12,000 people—mostly from vulnerable populations, such as socioeconomically marginalized groups, the elderly, and people with existing health conditions that are worsened by high heat—die globally each year from heat-related causes, and this number will increase to an estimated 260,000 deaths over the next 30 years. At the same time, heat exacerbates chronic health issues such as diabetes, heart disease, lung disease, and obesity [*Ebi et al.* (https://nca2018.globalchange.gov/chapter/14/), 2018]. Studies show (https://www.nature.org/en-us/what-we-do/our-insights/perspectives/how-urban-trees-can-save-lives/?src=r.global.healthyair) that trees can provide localized cooling of up to 2.8°C because of increased shade and effects on evapotranspiration, mitigating health risks (https://forestadaptation.org/adaptation-strategies-climate-and-human-health-urban-forests) during extreme heat [*McDonald et al.* (http://www.nature.org/healthyair), 2016]. Yet urban trees are not equitably distributed across neighborhoods or communities. Those most vulnerable to and at risk from high heat, who are most in need of the ecological and human health benefits community forests provide, are least likely to have access to these forests and their cooling effects [*Hoffman et al.* (https://doi.org/10.3390/cli8010012), 2020].

The role urban trees play in reducing urban heat island (https://eos.org/articles/no-one-size-fits-all-way-to-combat-urban-heat-island-effect) impacts and stormwater runoff is well documented; however, we are still learning about the vulnerability of urban trees and how to adapt community forests to a changing climate [*Ordóñez and Duinker* (https://doi.org/10.1139/er-2013-0078), 2014]. Projected shifts (https://www.nrs.fs.fed.us/pubs/55870) in U.S. Department of Agriculture (USDA) hardiness zones (a planting guide map based on average annual minimum winter temperatures) and American Horticultural Society heat zones (a similar map based on the number of "heat days" experienced in a given area) provide a useful starting point in aiding species selection for adaptation measures. But the ways in which other factors that compound in urban settings—pests, extreme storms, extreme heat, disease, and soil compaction, to name a few—affect tree vulnerability with respect to climate change are less well studied [*Matthews et al.* (https://doi.org/10.2737/NRS-RMAP-9), 2018]. (Although adapting to increased wildfire is important in forests near the wildland-urban interface and rural areas, it is typically less of a concern in urbanized settings and in community forest management because of fire suppression efforts and reduced fuel loads.)

Some cities, such as those highlighted below, have started to address community forest vulnerability through adaptation actions, but examples are few. As research into climate adaptation in community forests develops, municipal foresters must make decisions now using their local management expertise and the limited available science.

Finding Solutions Through Dialogue

There is often limited exchange of knowledge between scientists exploring climate adaptation and community foresters implementing adaptation strategies on the ground.

One way forward in this limited-information environment is through knowledge coproduction, an iterative process in which resource managers and scientists develop research and solutions together. In practice, however, such goal-setting collaborations rarely occur. And there is often limited exchange of knowledge between scientists exploring climate adaptation and community foresters implementing adaptation strategies on the ground, if the foresters are thinking about climate adaptation at all.

Three U.S. cities, however, are, indeed, pursuing collaborative management frameworks to foster interaction between researchers and community forest managers: Albuquerque, N.M.; Austin, Texas; and Durango, Colo. These efforts were designed to identify the needs of community foresters and explore how evolving scientific knowledge could support climate-informed community forest management.

Albuquerque, N.M.

The city of Albuquerque is in a tree crisis: Today, most of its tree canopy comprises senescent trees of a single invasive species, the Siberian elm (*Ulmus pumila*). The city, located in a high desert environment, suffers an urban heat island effect that, on average, adds 2.8°C during the day and 4.4°C at night to its "ordinary" (baseline) temperatures. Thus, the species that local arborists have been planting for years, like the pinyon pine (*Pinus edulis*) and the Rocky Mountain juniper (*Juniperus scopulorum*), are no longer viable options. The dying canopy and the small number of newly planted trees making it to maturity add urgency to efforts to improve Albuquerque's resilience to climate change while maintaining its quality of life.

To address this problem, urban forestry experts worked together to translate a published research framework developed for California's Central Valley [*McPherson et al.* (https://doi.org/10.1016/j.ufug.2017.09.003), 2018] into a real-world example in Albuquerque. The group included representatives from New Mexico State Forestry, local government, nursery staff, landscape architects, county extension agents, university researchers, and The Nature Conservancy (TNC). They ranked 136 tree species on the basis of the species' abilities to thrive under the projected future climate in the metropolitan area.

A key goal was to identify which species Albuquerque should—and should not—be planting now and which species could be viable in the next decade that the city should start testing. Another aspect of the project was to work with the tree nursery industry to aid them in exploring new species to bring into production. Including nursery managers in the tree selection process ignited their interest in shifting from talking about future-adapted species to growing them for large-scale production.

Volunteers plant trees in Albuquerque, N.M. The Nature Conservancy is engaging youth in nature-based solutions to promote health and climate resilience in New Mexico's most populous urban area. Credit: Roberto Rosales

After a year of meetings, conversations, and debates totaling more than 300 hours collectively, the team reached a consensus on a finalized list (https://www.nature.org/content/dam/tnc/nature/en/documents/NM_ClimateReadyTrees.pdf) of 83 recommended species for planting in the Albuquerque area, now and in the future. The nuances encountered in generating a list for local residents that also accounted for climate change impacts were more complex than anyone imagined. For example, Albuquerque features steep elevation gradients, with more than 300 meters of elevation change from the bottom of the Rio Grande to the foothills of the Sandia Mountains, so recommending species that might work in all situations was difficult. Moreover, the group found that heat sensitivity for the species of interest was less well documented than their cold hardiness.

In the end, this process generated buzz in the community about climate change impacts, about how tree selection at the metropolitan area scale involves more planning than simply choosing something to plant in one's front yard, and about challenges in caring for aging trees. Albuquerque is now in the process of creating a video series (https://www.nature.org/en-us/about-us/where-we-work/united-states/new-mexico/stories-in-new-mexico/creative-conservation-in-albuquerque/?vu=newmexicotrees) to encourage community stewardship (http://www.nature.org/abq) of local trees. And the local water authority (https://www.505outside.com/) is exploring the idea of building a demonstration site to showcase climate-ready trees so local residents can see for themselves which species they like and to monitor which trees will really thrive in Albuquerque's arid climate.

Austin, Texas

The city of Austin has developed a city-wide urban forest vulnerability assessment that is informing adaptation actions in both developed and natural areas. This central Texas city, located in a transition zone between the deserts of the American Southwest and the wetlands of the Southeast, lost about 10% of its tree canopy following extreme drought in 2011. This canopy loss led the urban forestry community there to seek opportunities to reduce future risks.

Austin was one of the first cities in the country to complete its first full 5-year cycle of urban forest inventory and analysis [*Nowak et al.* (https://doi.org/10.2737/NRS-RB-100), 2016], providing an estimate of the species distribution across the city. The forest inventory, along with emerging concern regarding future climate risks, prompted stakeholders in Austin to seek support for climate change adaptation solutions.

Partners from the city of Austin, the Northern Institute of Applied Climate Science (NIACS), the USDA Forest Service, the USDA Southern Plains and Northern Forests Climate Hubs, Texas A&M Forest Service, and TNC came together to assess the vulnerability of the city's urban forests and to develop adaptation strategies.

Representatives of the city of Austin and partnering organizations meet in November 2019 to discuss the vulnerability of Austin's urban trees and develop adaptation strategies. Credit: Leslie Brandt

The group based their work on the Urban Forestry Climate Change Response Framework (https://forestadaptation.org/focus/urban-forests), developed originally for Chicago and now expanded to other regions. This framework has three main components: regional vulnerability assessments, local-scale assessments, and adaptation planning to help local managers adapt to the effects of climate change [*Brandt et al.*, 2016 (https://doi.org/10.1016/j.envsci.2016.06.005), 2017 (https://doi.org/10.5849/jof.15-147)].

The group assessed the vulnerability of 105 urban tree species present in Austin's developed and natural areas. They put the regional results into a more localized context by assessing the vulnerability of specific natural community types and neighborhoods using a collaborative expert panel approach (https://doi.org/10.5849/jof.15-147) [*Brandt et al.* (https://doi.org/10.5849/jof.15-147), 2017]. Upon completing the assessment, urban forest and natural area managers from Austin and surrounding areas attended a 2-day workshop based upon the NIACS Adaptation Workbook (https://adaptationworkbook.org/), a five-step process for incorporating adaptation strategies that address key climate change vulnerabilities while aligning with locally specific goals and objectives [*Swanston et al.* (http://dx.doi.org/10.2737/NRS-GTR-87-2), 2016] to develop actionable adaptation projects.

One outcome of the adaptation workshop was an adaptation project (https://forestadaptation.org/adapt/demonstration-projects/city-austin-balcones-canyonlands-preserve-vireo-preserve-restoration) for the Balcones Canyonlands Preserve. This 12,000-hectare (30,000-acre) system of habitats northwest of the city is jointly managed by the city of Austin and Travis County and has in recent years experienced intense heat and drought and erosion by heavy rains. The adaptation project involves selecting more heat- and drought-adapted native trees for south facing slopes, building berms of organic matter to capture rainwater, and making use of larger trees to shade vulnerable seedlings. The city of Austin is currently working to incorporate information from this effort into other projects, such as revising its recommended planting lists and developing interactive tools to visualize vulnerable areas on the landscape.

Durango, Colo.

In Colorado, the city of Durango, a high-altitude town of warm, dry summers and cold, snowy winters, is working with local partners to test the suitability of tree species native to areas farther south, anticipating that Durango's climate will become increasingly warm and arid. The collaboration also looks to arm local resource managers with new information and resources and to improve the adaptive capacity of local community forests.

Urban forestry stakeholders, including the city's Parks and Recreation Department and Sustainability Division and the Southwest Climate Hub, also used the NIACS Adaptation Workbook process [*Swanston et al.* (http://dx.doi.org/10.2737/NRS-GTR-87-2), 2016] to identify climate change impacts and potential adaptation strategies that can be integrated into real-world, on-the-ground forest management projects.

Durango community forest managers and partners discuss climate-adaptive strategies that can be integrated into the city's management efforts at a meeting in December 2019. Credit: Courtney Peterson

The resulting Durango Community Forest Management Plan aims to increase diversity in tree species and ages to improve the long-term health of the city's community forests. The plan includes a provision to plant enough trees to keep pace with community growth and to offset tree removal. However, climate change impacts pose significant challenges to meeting these local community forest management goals [*U.S. Global Climate Change Research Program* (https://doi.org/10.7930/J0J964J6), 2017]. Such impacts include an increase in mean temperatures of about 1.1°C–5.6°C, a projected 10%–20% increase in heavy-precipitation events, and a lengthening of its frost-free season—from late March through early November to early March through late November (that is, from USDA hardiness zone 6b to 7b)—by the end of the century.

Durango's community forestry managers have realized that tree-planting efforts must consider future-adapted species and that business-as-usual management practices will not be enough to maintain a diverse forest canopy that provides social and economic benefits to the city under projected future climate conditions.

In addition, local partners in the city, including the city of Durango, the Durango Botanical Society, and the Mountain Studies Institute, are revising tree and shrub guides to include species like *Pinus ponderosa* genotypes from southern seed zones that are adapted to warmer future climates and using seed mixtures to account for uncertainty. The partners are also working with the city parks department and schools to test the suitability of such future-adapted tree species.

A Work in Progress

These three examples highlight how practitioners and scientists are beginning to work collaboratively to implement urban forest climate change adaptation strategies. Many other communities can similarly pursue climate-adaptive strategies, building upon the examples from Albuquerque, Austin, and Durango and creating partnerships between practitioners and scientists. However, even in communities where such work has begun, many scientific knowledge gaps and uncertainties about future-adapted urban tree species still need to be addressed to adequately support climate-informed planting.

A tag with tree care information from The Nature Conservancy hangs from a limb of a newly planted tree in Albuquerque. An alliance of organizations called Let's Plant Albuquerque is working to plant climate-ready trees to address a current tree crisis and support climate-informed community forest management. Credit: Roberto Rosales

For example, practitioners need more information about the heat and drought tolerance of specific urban tree species and how habitats of urban trees will shift in the future. They also need to know more about how urban forest disturbances, such as pests, pathogens, and extreme storms, may uniquely affect different species and cultivars planted in urban settings.

Nursery mangers and growers need to be more involved in the discussions around future tree needs, as cities are often limited in what they can plant on the basis of what is locally available. Offering a new tree species commercially requires a long lead time to establish production. Particularly for cities along the southern U.S. border, growers may need to explore source seed collections internationally to keep pace with the geographical shift of increasing temperatures and drought.

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One rapid solution to support community forest climate adaptation is to learn from other similar cities that have already begun the process. Documenting urban forestry successes and failures in peer-to-peer knowledge exchange is one means of sharing the knowledge. A three-pronged approach of filling scientific knowledge gaps, supporting knowledge exchange, and capitalizing on collaborative practitioner-scientist adaptation efforts will help communities maintain the ecological, social, and economic benefits that their forests provide and ensure stewardship of the forests into the future.

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