

# Chronic climate perils and stranded communities

What could happen to communities and the municipal bond market if portions of the U.S. become unlivable?

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When it comes to climate disasters, event-driven, or acute perils, like hurricanes, wildfires, and floods, tend to make headlines and dominate the collective imagination and popular discourse. Because they are perceived as one-off events “that pass” and are often insured, or de facto insured by state and/or federal relief and bailout mechanisms, their impact is largely muted.<sup>1,2</sup> Arguably more impactful and with effects that can be more long-term are the ongoing chronic perils of drought, heat stress and water stress. These hazards can often be essentially uninsurable and could potentially create conditions that make significant parts of the United States unlivable in the near future. For the municipal bond market, first order effects could be vast and drastic; the potential follow-on impacts could include climate migration and displacement on a large scale, with greater impact on communities with fewer socioeconomic resources, as well as political and civil conflict.

This analysis explores two scenarios that occupy different “plausible” ends of the spectrum to get an early sense of the scale and scope of the *who and what* is at-risk. Even a narrow criteria “best-case” scenario suggests that over 800,000 people could be displaced and more than \$7 billion in current outstanding municipal debt market principal could be at risk. Meanwhile a “worst-case” scenario (projected impact is broadened) is an order of magnitude more severe; at least 18 million people and hundreds of billions in principal are at-risk and that’s not even considering potential ripple effects.

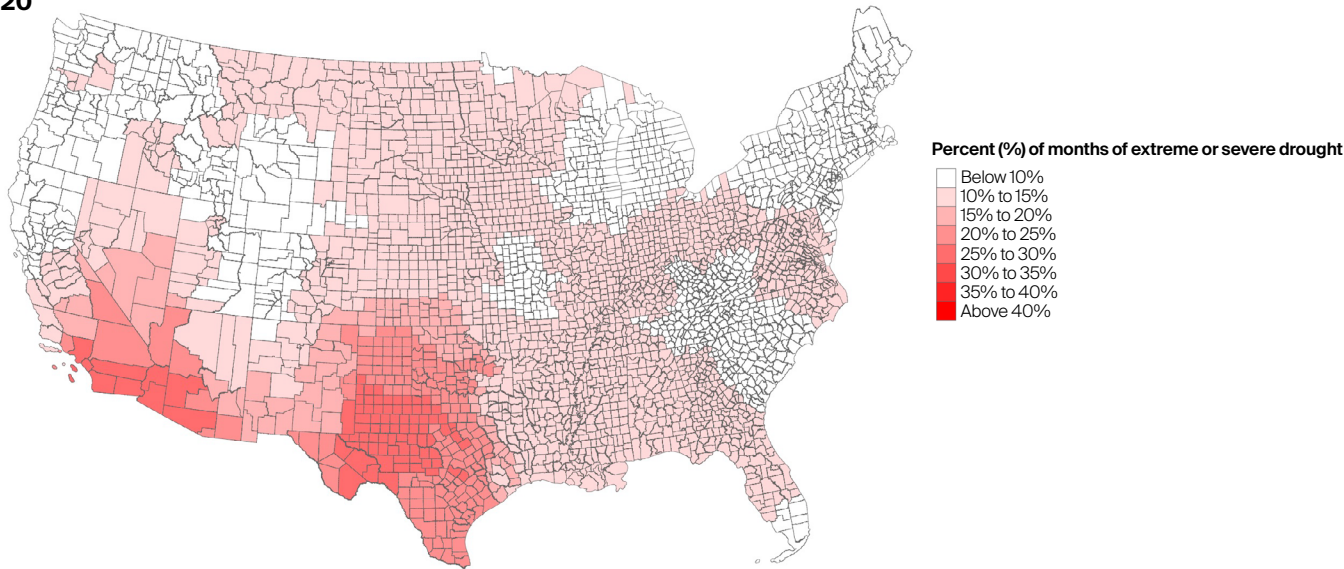


# The pervasiveness of drought and heat stress

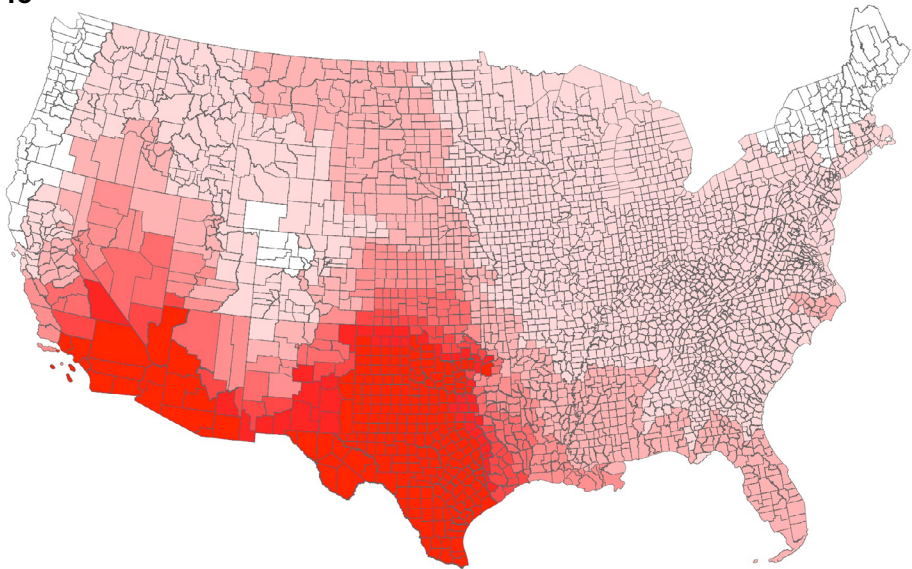
As indicated in Figure 1, ICE models indicate that drought conditions will likely [intensify significantly](#) in the future if greenhouse gas emissions continue as they are today.<sup>3</sup> By 2060, ICE Sustainable Finance climate models employing a business-as-usual Representative Concentration Pathway (RCP8.5) scenario project that much of the U.S. southwest will be in severe drought at least twice as often as it is today.

## Drought

2020



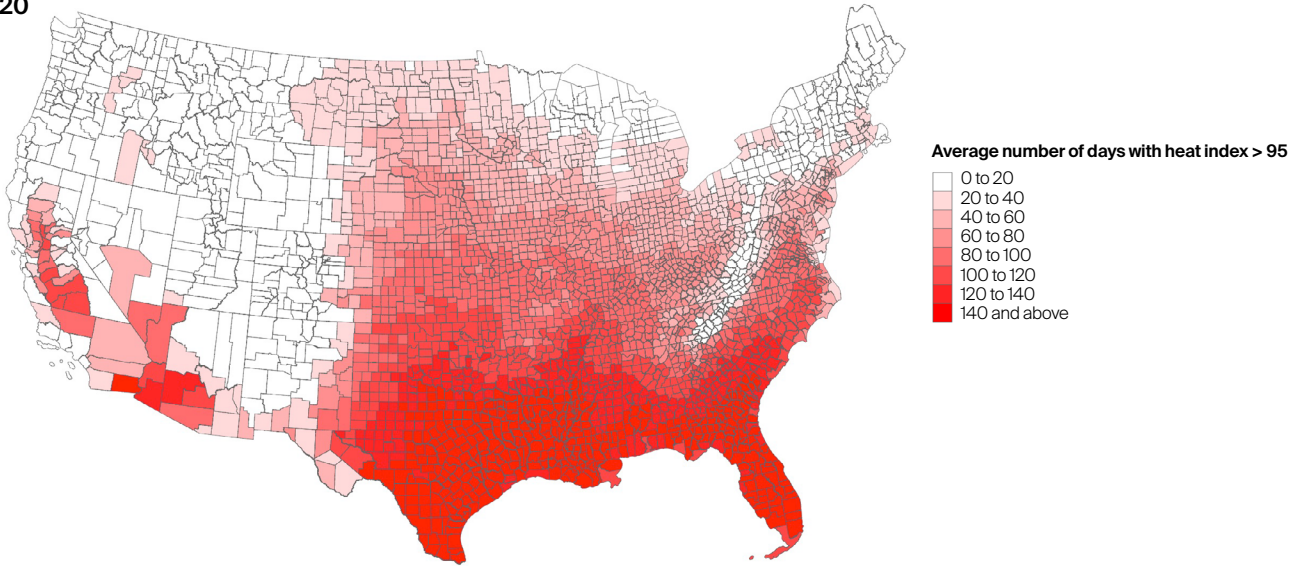
2040



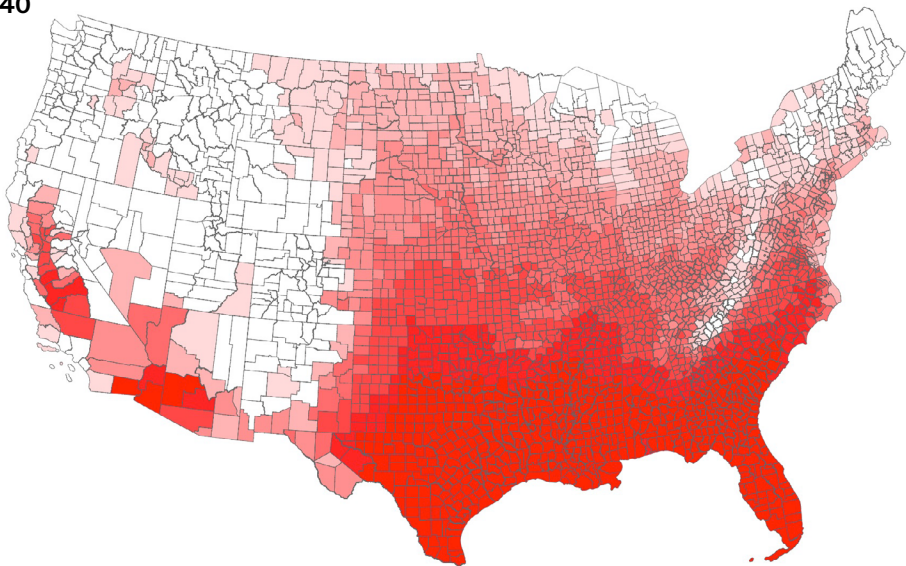
**Figure 1:** Drought peril map 2020 compared to 2040 based on projections under the RCP8.5 scenario  
**Source:** ICE Sustainable Finance, 2023

Heat stress

2020



2040



**Figure 2:** Heat stress peril map for 2020 and 2040 projections under the RCP8.5 scenario  
**Source:** ICE Sustainable Finance, 2023

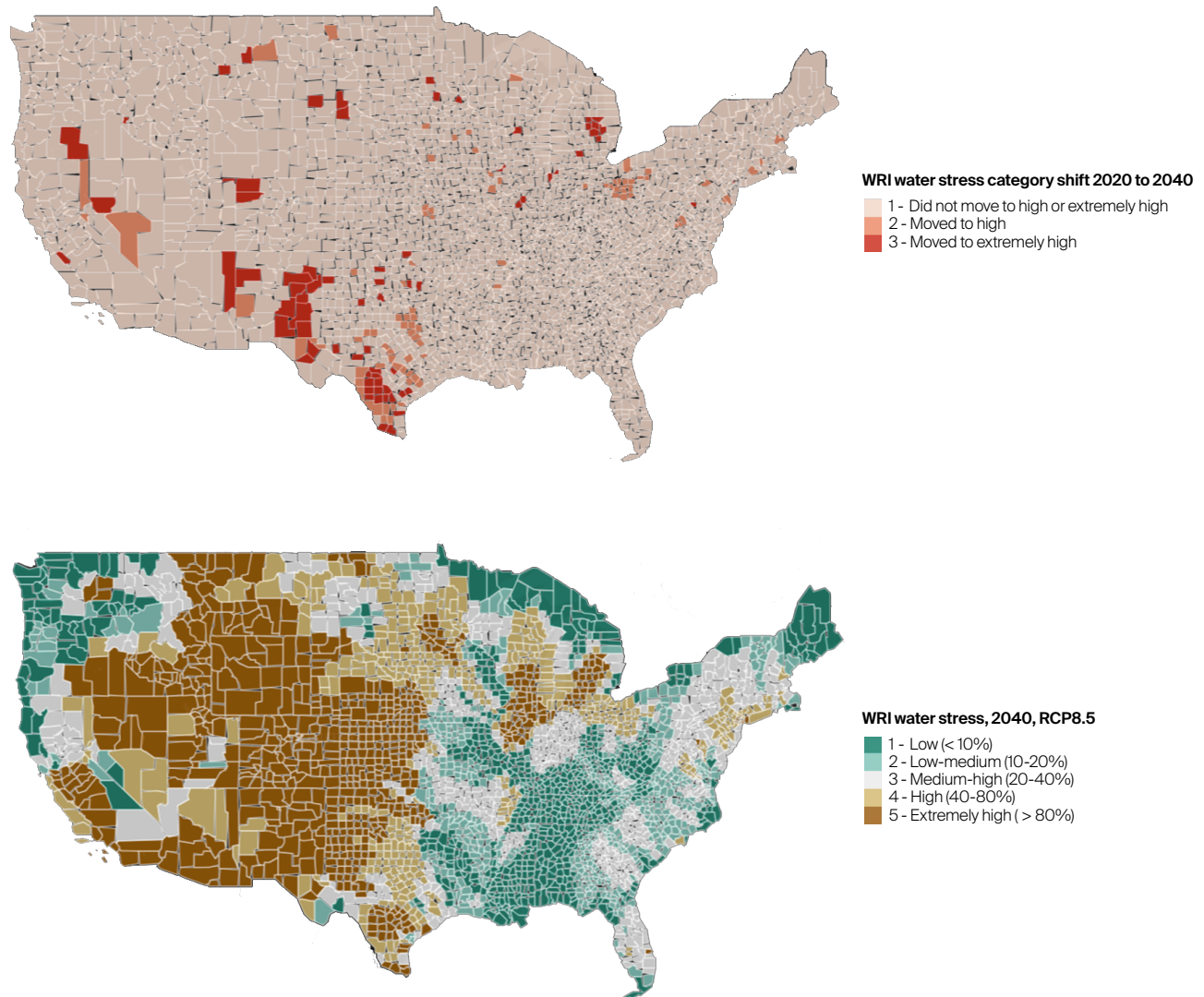
As indicated in Figure 2, ICE models also suggest that heat stress will likely [intensify significantly](#).<sup>4</sup> Death Valley National Park is known as one of the hottest and most arid places on earth. In 2021 it was the site where the hottest temperature ever recorded by a human (135°F) was documented. Looking at heat stress data between 1981 and 2010, ICE Sustainable Finance, [Climate Core Capital](#) and resources from the Harvard Graduate School of Design devised the Death Valley Index, which is a measure of when [heat index](#) values will exceed 95°F for an average of 161 days per year. The chart (Figure 3) shows how old a child born in 2021 will be when certain urban areas will experience Death Valley climate conditions. Most telling are Houston, Orlando, and Miami where children aged 5 and under are already on the brink of living under Death Valley conditions.

| City        | Year      | A child born in 2021 will be... |
|-------------|-----------|---------------------------------|
| Orlando     | Achieved  | N/A                             |
| Houston     | 2021-2026 | 0-5 years old                   |
| Miami       | 2021-2026 | 0-5 years old                   |
| Austin      | 2022-2027 | 1-6 years old                   |
| Tampa       | 2024-2029 | 3-8 years old                   |
| Phoenix     | 2033-2038 | 12-16 years old                 |
| Dallas      | 2063-2068 | 42-47 years old                 |
| Las Vegas   | 2020+     | 60+ years old                   |
| Los Angeles | 2020+     | 60+ years old                   |
| Atlanta     | 2020+     | 60+ years old                   |

**Figure 3:** Death Valley Index projections  
**Source:** risQ/ ICE Sustainable Finance, Climate Core Capital, Lending Tree

## Water stress and scarce resources

These chronic perils combined with recent population growth in many southern states add notable supply and demand stress on water resources. Water stress is generally expected to intensify where chronic peril vulnerability is the highest. Figure 4 below shows both the projected changes in water stress categorization and the 2040 water stress vulnerability under the RCP8.5 climate scenario.



**Figure 4:** Water Stress Category shift 2020-2040, and Water Stress 2040 under RCP8.5 (business-as-usual) scenario projection.

**Source:** [World Resources Institute](#)<sup>5</sup>

At the forefront in the conversation about aridification and water stress is the Colorado River. The southwest artery, which runs 1,450 miles from the Rocky Mountains of Colorado to the Gulf of California in Mexico, is a crucial source of water for millions of people and supports a significant amount of agriculture ([estimated at 80% use](#)<sup>6</sup>) and industry in a region that includes Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. Overseen by the Bureau of Reclamation, the Colorado River, at risk of full resource depletion, is [the canary in the coal mine](#)<sup>7</sup> when it comes to aridification and water stress. As shown in Figure 4, the World Resources Institute (WRI) projects that by 2040, in many areas of the seven states reliant on the Colorado River, the demand for water will significantly exceed supply. Currently the river supplies water to [~40 million people](#)<sup>8</sup> with nearly half residing in southern California. The 31<sup>st</sup> state is a major agriculture producer and is currently entitled to 4.4 million acre-feet of water annually (more than any other single state in the Colorado River basin). Other industries directly impacted by the aridification and water stress are tourism and recreation (i.e., boating, fishing, and camping).

Efforts outlined to remediate future imbalances in supply and demand by the Bureau of Reclamation, [including desalination and reuse measures](#)<sup>9</sup>, won't be available for decades. Some more immediate efforts underway include [cloud seeding](#)<sup>10</sup> to increase precipitation, but these measures may only add 3-15% to the supply. Last year the U.S. Department of the Interior announced [conservation measures](#)<sup>11</sup>, and further, more formal, measures from Congress could follow.

## Too dry and hot to live here? Two scenarios

In the U.S., owing to a combination of factors, including historical racial injustices, communities with fewer socioeconomic resources are disproportionately exposed to physical climate risks. For example, ICE Sustainable Finance [research](#) shows that Latino and Indigenous populations are disproportionately exposed to wildfire risk.<sup>12</sup>

[Recent ICE research](#) has also shown that communities with high socioeconomic vulnerability have significantly less access to municipal bond market capital, which correlates strongly with adverse educational outcomes and increased poverty.<sup>13</sup> This implies that, absent an intervention, communities with higher ICE Social Impact Scores (a scale of 0-100, where a higher score denotes greater socioeconomic vulnerability) will be the ones that will struggle the most to respond to chronic climate risks, financially or otherwise, and thus have a higher likelihood to become “stranded.”

Figure 5 below details the two scenarios created to explore the potential scope and scale of how much of the U.S. could become unlivable by today's standards. The “best-case” scenario considers communities with the most extreme heat stress, drought and water stress conditions as well as the highest socioeconomic vulnerability (Figure 5), whereas the “worst-case” scenario widens these filters to examine a broader range of impacted communities. For each scenario, Table 1 estimates the number of people that would be directly impacted as well as the total current outstanding municipal debt principal at-risk.

## Two scenarios for defining communities at risk of stranding

### “Best-case” scenario

Narrow criteria that only consider communities that are more rural and have extremely high chronic risk and very high levels of socioeconomic vulnerability:

- Severe to extreme drought **>= 40%** of the time by 2040
- **>= 90%** percentile heat stress
- **Extreme water stress** by 2040
- **Only non-urban communities** considered
- Highest socioeconomic vulnerability (ICE Social Impact Score **>= 80**)

### “Worst-case” scenario

Looser criteria that imagine less severe conditions could leave communities stranded, and/or that external factors amplify the impact of climate stressors faster:

- Severe to extreme drought **>= 25%** of the time by 2040
- **>= 70%** percentile heat stress
- **Medium-high water stress** by 2040
- **All communities** considered
- Medium socioeconomic vulnerability (ICE Social Impact Score **>= 60**)

**Figure 5:** Scenario Definitions. “Non-urban” communities are defined as communities with populations densities of less than 1000 people per square mile. Percentiles refer to national percentiles. Extreme and Medium-High water stress refer to categories defined by the Water Resources Institute.  
**Source:** ICE Sustainable Finance, 2023 and the Water Resources Institute.  
**Note:** These scenarios are not intended as predictions but two of many plausible scenarios.

| Scenario     | Population-at risk    | Current outstanding municipal debt exposed (% of ~\$3.9 trillion market total)<br>% by State |
|--------------|-----------------------|----------------------------------------------------------------------------------------------|
| "Best-case"  | ~838,000 people       | ~\$7-8 billion (0.2%)<br>TX: 90%, CA: 10%                                                    |
| "Worst-case" | ~18-19 million people | ~\$187 billion (5%)<br>TX: 81%, AZ: 8%, CA: 6%, OK: 4%, KS: 1%                               |

**Table 1:** Stranded Community Statistics.

**Source:** ICE Sustainable Finance as of 2/13/2023.

**Note:** These are not intended as predictions but two of many plausible scenarios.

The results suggest a vast range of potential outcomes. What may be the most striking statistic is that 838,000 people represents a plausible lower bound on the number of people that could become climate refugees, just within the U.S. This would be an unprecedented scenario of climate-driven displacement: for context, Hurricane Katrina displaced more than a million people, most of them temporarily. This "best-case" scenario represents a collection of locations that could become uninhabitable permanently, thus effectively rendering \$7-8 billion in current outstanding municipal debt worthless and potentially wreaking significant havoc on the financial markets. (While not in the scope of this analysis, real estate assets situated in these same regions would also be at risk).

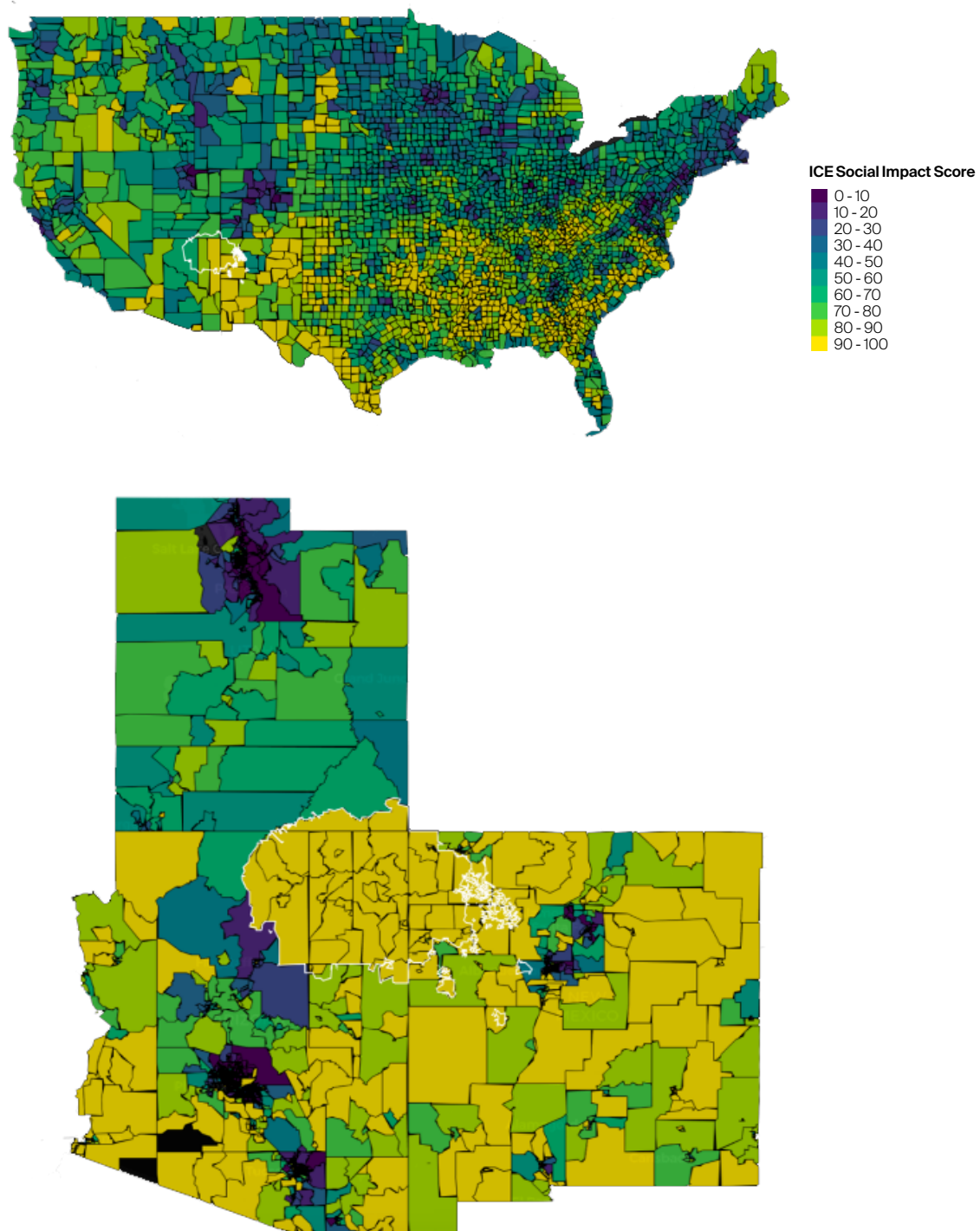
The plausible upper bound of more than 18 million people displaced ("worst-case") is virtually unimaginable in scope, scale, and potential cascading impacts.

ICE Sustainable Finance stresses that these scenarios are not, and cannot, be predictive as to what locations may become unlivable and when. Driven by the physical realities of water stress and heat as well as sociological factors (e.g., agribusiness and other large employers exiting in anticipation of extreme aridification before land is deemed unlivable), the process of abandonment is likely to be an ongoing one spanning years.

This analysis is intended as an initial problem sizing exercise. There are multiple key factors not considered that ideally should be integrated, including but not limited to:

- [Water rights](#)<sup>16</sup>: the legal and idiosyncratic priority order for which entities are entitled to what and how much water in the Western U.S. This could be a crucial dimension in deciphering when specific communities may become unlivable.
- Sea level rise: the other major climate hazard that is predicted to permanently reshape the coasts and could render even more communities unlivable. While permanent inundation and [sunny day flooding](#)<sup>17</sup> may come to mind, saltwater intrusion could also corrode existing drinking water infrastructure, requiring enormously costly replacement and upgrading.
- A global view: the U.S. is in a relatively privileged position with respect to its vulnerability to climate change. Of course, scenarios like those described above will not happen in isolation from global dynamics and climate events. [Climate migration](#)<sup>18</sup> is already underway in the Global South (Latin America, Africa, and the Asia-Pacific) as vulnerable people seek refuge from intensifying climate conditions. This is likely to accelerate and add significant complexity to the scenarios outlined above that focus solely on the U.S. The [sovereign debt market](#)<sup>19</sup> is likely to be adversely impacted by the climate crisis and related migration before the U.S. is, and more intensely.

Furthermore, there are whole communities inherently at-risk because of land laws, namely Native American tribes who reside on boundary defined reservations, many of which are in some of the most arid areas of the U.S. One flagship example is the Navajo Nation, which is situated in Arizona, New Mexico, and Utah in the Colorado River basin. The Navajo Nation states that 30% of its people do not have running water and claims it has never received its fair water rights as promised in the 1868 Treaty brokered by General William Sherman that defined the Nation's boundaries and land use. They are also one of the most socioeconomically vulnerable communities in the river basin (Figure 6). Recently the [Navajo Nation sued the state of Arizona](#) over its water rights.<sup>20</sup> Given the Colorado River's increasingly scarce resources, and the possibility that conservation measures could shift from voluntary to mandatory (federal regulatory action), there may be more legal action over water rights.



**Figure 6:** ICE Social Impact Score nationally by county and ICE Social Impact Score at the tract level for the Navajo Nation.  
**Source:** ICE Sustainable Finance, 2023

## What can municipal bond market participants and stakeholders do?

More analytical work is needed to achieve a higher fidelity picture of what parts of the U.S. and the globe could become unlivable, by when, and how climate migration could play out in a “no coherent global migration plan” scenario. This work would help provide a solid starting point for the construction of a [proactive global climate migration strategy](#) that recognizes potential benefits of migration, versus one that is reactive and potentially inclined toward civil and political conflict when significant migration occurs. International organizations like the International Monetary Fund, the World Bank, the United Nations, the International Panel on Climate Change, and others could be part of this effort; arguably more importantly, leaders and organizations representing the Global South and Indigenous Peoples should be centrally involved, as they are on the frontlines of the unfolding dual debt and climate crisis.

ICE Sustainable Finance [research](#) from 2022 showed no evidence that event-based physical climate risk was yet priced into municipal bond yields, likely owing to a combination of low-risk perception (bonds rarely default, and state and federal level relief and bailout mechanisms have historically protected investors) and to supply-demand issues (in recent years, there is more demand for tax exempt issuances than supply). If (when) bond investors do begin consistently to price in climate risk, this could in part help motivate urgency for issuers to act. Credit rating agencies are the single biggest market lever in terms of inducing new market behavior; [a recent rating upgrade for Miami](#)<sup>22</sup> suggests credit agencies might not be there yet since Miami is one of the most exposed cities in the U.S. to physical climate risk. Pricing climate risk into the market could create a contagion effect in the financial system if it happens all at once, after an extreme weather event or climate shock—the earlier that pricing in of climate risk happens, the more time participants in the market will have to adapt and adjust.

Conversely, “pricing signals” could exact a significant toll on frontline communities, exacerbating already entrenched problems with access to capital and perpetuating structural injustice and inequality. State and federal policymakers, as well as engaged agencies, and philanthropies, should begin to explore possibilities for offering relocation assistance programs for at-risk communities. States and cities with relatively less chronic climate risk (e.g., the American Midwest) looking for tax-base growth opportunities could offer incentives targeted at recruiting people and businesses from at-risk communities. In other words, states and cities can choose to view likely climate migration pressure as an opportunity rather than as a political risk. States that have high levels of chronic climate risk (e.g., Arizona) could launch programs to support people in rural, socioeconomically vulnerable areas who may wish to relocate to denser urban areas within the same state. This could help bolster a state’s tax base in aggregate while simultaneously decreasing pressure on water resources that suburban and rural sprawl creates.

All of this said, relocation efforts have a long and cruel history in the United States. The first Native American reservation was established in 1786. Only a few decades later, the Removal Act in 1830 forced Native Americans to settle west of the Mississippi. Any relocation efforts related to chronic climate stress would have to be done with the full participation of local communities and a nuanced understanding of historical injustices and their impacts.

An alternative approach could focus on adaptation, repurposing the vast areas of land in the Western United States that are exposed to high chronic climate risks. The most chronically stressed land could be used for solar and wind farms; other areas could be given back to and/or managed in collaboration with Indigenous communities alongside adaptation grants. Land management practices based on Traditional Ecological Knowledge and Indigenous Knowledge<sup>23</sup>—terms that broadly refer to the deep knowledge of ecosystems and sustainable land management practices accumulated over thousands of years by Indigenous communities—are associated with positive ecological impacts.<sup>24</sup> Ancient Indigenous practices related to intentional bush fires, for example, have been linked ecosystem health in Australia<sup>25</sup> and wood and fire use by ancestors of the Jemez Pueblo in New Mexico is associated with fewer extensive burns.<sup>26</sup> Vertebrate biodiversity has also been shown to be slightly richer in lands managed by Indigenous communities compared to conservation areas across the Australia, Brazil, and Canada.<sup>27</sup>

Conservation groups and governments are starting to take notice. In 2013, the Australian government bought back over 84,000 hectares of land along with the water rights in a damaged wetlands area of New South Wales. The Nature Conservancy is managing the wetlands restoration project in partnership with the Nari Nari Tribal Council.<sup>28</sup> In the United States, there are four national parks formally co-managed with Tribes as of 2022: Canyon de Chelly National Monument in Arizona, Glacier Bay National Park and Preserve in Alaska, Grand Portage National Monument in Minnesota, and Big Cypress National Preserve in Florida.<sup>29</sup> Some private land trusts are working in partnership—or transferring ownership—to Tribes as well.<sup>30</sup> The evidence for the positive impacts of land management practices based on Traditional Ecological Knowledge suggests that an expansion of these sorts of efforts could help to maintain and protect ecosystems across the United States.

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