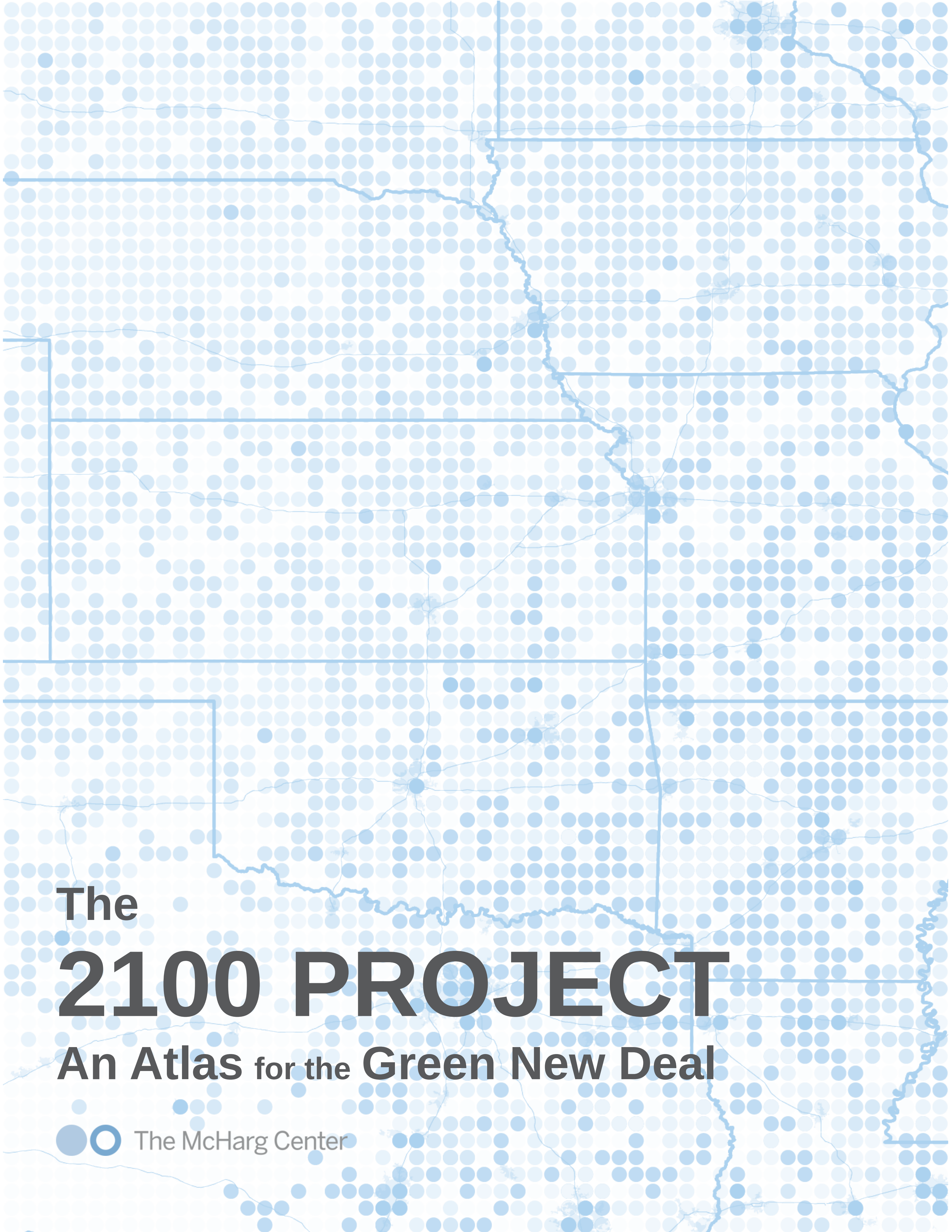

The

2100 PROJECT

An Atlas for the Green New Deal

The McHarg Center

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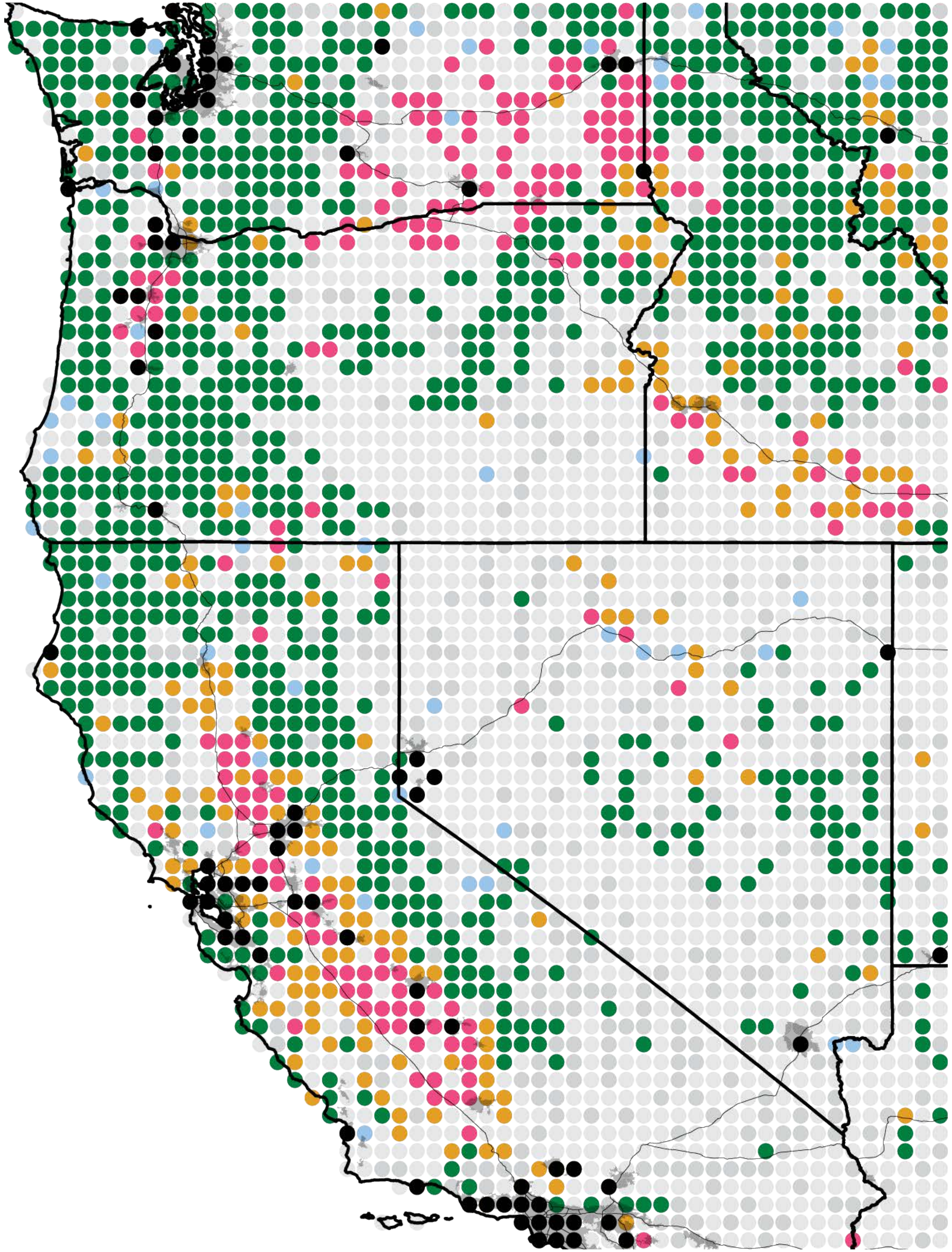


An Atlas for the Green New Deal

This atlas was conceived in relation to three intersecting issues. First, excess carbon in the atmosphere is changing the world's climate: sea levels are rising, temperatures are increasing, and destructive weather events are becoming more frequent. Second, because it is our own systems of extraction, production, and consumption that are causing this climate crisis, an incremental approach to the future is not an option. Third, the US population is expected to grow by at least 100 million people this century, adding significantly to what is already the world's most consumptive, high-carbon economy.

> "What will be lost—economically, culturally, psychologically, physically—should the climate crisis continue unabated? How can we begin to come together around a response to the crisis that will reshape how and where we live?"

Taking on these challenges requires that we ask some big—and unsettling—questions. What will be lost—economically, culturally, psychologically, physically—should the climate crisis continue unabated? How can we begin to come together around a response to the crisis that will reshape how and where we live? How can we begin to think about investments in the built environment as a catalyst for the broader aims of decarbonization, adaptation, and social justice at a meaningful scale?

The Green New Deal does not pretend to have all the answers, but it's a bold and necessary start. Because it connects social change with environmental change, and because it recalls the ambitious spirit of the original New Deal, the Green New Deal is the only set of ideas on the table that is scaled to the challenges we face. If realized, the Green New Deal would revolutionize our systems of production, our ways of life, and the places we inhabit, enabling us not only to adapt to the climate crisis, but to address its root causes.

But right now the Green New Deal is still embryonic, represented only in the abstract set of goals laid out in H.R. 109. Its outline of a sustainable future needs to be filled in—to be developed, debated, and designed. To that end, this Atlas for the Green New Deal brings together a vast and diverse array of information in the form of maps and datascapes: tools to help us understand the spatial consequences of the climate crisis—not so that we may be frightened by them, but so that we may be mobilized around a response to them.

Introduction

Certainty is on the tip of every climate activist's, scholar's, and writer's tongue these days. We are certain that we have only until 2030 to rapidly decarbonize the economy. We are certain that even if we do manage to meet this ambitious goal, sea levels will still rise another foot or so—demanding either that our cities do the same or that their people are relocated away from our shifting shorelines. We are certain that things are getting worse—promised, even, that they are somehow worse than we've imagined.

We are so certain, in part, because we have so many models telling us so many things about our now certain damnation. There are physical models of the Earth's systems, showing how we can expect oceanic and atmospheric forces to change under the various emissions-based scenarios developed by the IPCC. There are projective models of who might be displaced—and where they might go—as sea levels rise, temperatures increase, and the climate refugee crisis becomes impossible to ignore. There are predictive models of how various forms of climate adaptation might perform, often as instruments of flood risk mitigation. There are financial and economic models of how we might pay for a set of planetary transformations like decarbonization and adaptation. Increasingly, there are also simulation models of what it might mean to geoengineer the Earth's systems, either by spraying sulfates into the stratosphere or by rapidly deploying negative-emissions technologies that remove carbon from the air. We have seen the future, and it works—so long as the assumptions in our models are set just right.

Each model brings a new degree of precision and clarity to our climate imaginary. They help us make sense of which outcomes are probable and which are possible—and they imply their own ideas about desirability in the process. That winnowing of potential futures and choices can bring with it a sense of heightened certainty about how, when, and where things might unfold on a planet devoured by capitalism.

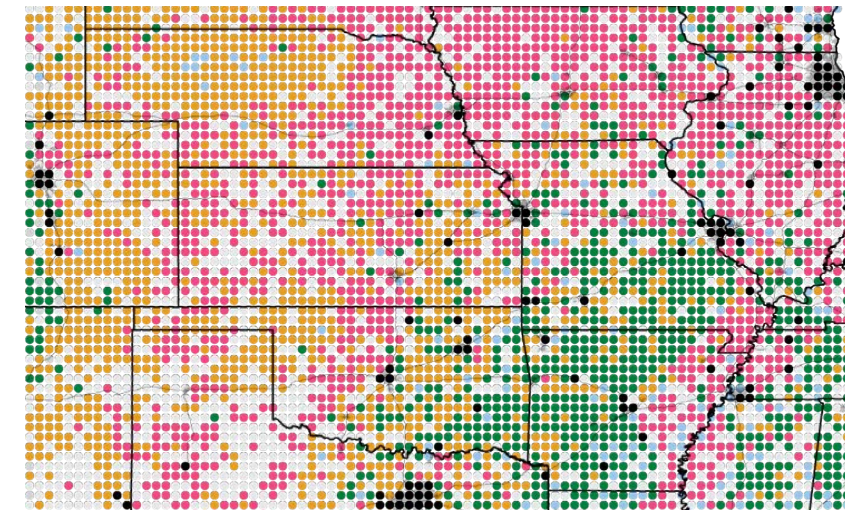
> **"The climate crisis is existential, replete with uncertainty, and happening all around us, all the time. Though we have mapped it extensively in this atlas, maps alone cannot tell this story."**

Though these models are an important tool for understanding how the future could or should be made manifest, they are not the only tool—even if we (designers, journalists, and broader publics beyond the climate science community) tend to treat them as such. We do this despite the vast degrees of uncertainty present in even our most basic physical models, to say nothing of our inability to model and imagine the sociopolitical, technical, and economic forces that will, ultimately, determine how much warming, mitigation, and adaptation we will have to live with.

The climate crisis is existential, replete with uncertainty, and happening all around us, all the time. Though we have mapped it extensively in this atlas, maps alone cannot tell this story. We need more tools: for making sense of the changing climate; for envisioning alternative futures that foreground what we might gain instead of only what we'll lose; and for stoking public imaginations and actions in ways that models, at least on their own, cannot. To adapt David Wallace-Wells's apocalyptic "The Uninhabitable Earth": it is, we promise, better than you think. Or at least it can be.

This need for a more pluralistic approach to how we navigate through and respond to the climate crisis is what the 2100 Project aims to address. Though physical, sociotechnic, and simulation models of the future will remain an important part of this conversation, our intervention is not about the precise forecasting of a future world reshaped by varying degrees of carbon emission. Rather, it is about backcasting—a method of scenario modeling working backwards from an ideal outcome or future—as a way of understanding a different set of potential futures that the models might be missing.

As the authors of this Atlas for the Green New Deal, the first component of the 2100 Project, we had three primary rationales for assembling this research. The first rationale relates to the idea of backcasting as it pertains to the principal historical analogues of the Green New Deal: FDR's New Deal and JFK's moon shot. We remain convinced that the window for massive, national-scale action on climate will open again soon, and we aim to use this project as a vehicle for generating new research into how those transformations might unfold. The second rationale is tied to the paucity of spatial design expertise and imagination within the current Green New Deal movement. Though it has necessarily been led by organizers, economists, policy experts and advocates, and others, the Green New Deal is the biggest design and environmental idea in a century, with the potential to revolutionize our buildings, landscapes, and public works in ways yet to be conceived. As faculty and graduate students at a prominent school of design, we feel an obligation to engage with the Green New Deal along these lines. And our third rationale for this atlas, and for the 2100 Project as a whole, is that no one else has attempted anything like it—to assemble all of the spatialized climate, land, and social models of the future in one place, synthesized and tightly curated, contextualized and coherently packaged. We also felt compelled to use this project to critique the notion of precision and certainty embedded in these models by representing them through pixelated maps. After all, the future is fuzzy. Our models should be too.



[Land Use]

It's important to begin this work where the Green New Dealers have directed us, in the last two eras of true national-scale mobilization around a set of shared goals and ideals: the New Deal and the moon shot. The New Deal is often viewed as a single, coherent organizing framework developed by FDR and his advisers at the start of his administration—as a set of boxes to be checked as they rolled through the 1930s. But this is a fundamental misunderstanding of the improvisational and experimental nature of FDR's presidency. As Richard Hofstadter notes, "The New Deal will never be understood by anyone who looks for a single thread of policy, a far-reaching, far-seeing plan. It was a series of improvisations, many adopted very suddenly, many [of them] contradictory. Such unity as it had was in political strategy, not economics." It was a grand experiment in social democracy, one in which new agencies were created, new authorities and powers promulgated, and new financial resources marshaled to tackle the overlapping ecological, economic, and political crises of the day: the Dust Bowl and its forced migration of over three million farmers from the Midwest; the Great Depression; and the rise of fascism across the globe. Some initiatives, like the Tennessee Valley Authority, proved wildly successful and continue operating today. Other experiments failed or outlived their usefulness, folding during the mobilization for World War II. Some of these, including the Civilian Conservation Corps, which put more than 500,000 young people to work on soil restoration and other public lands projects at its peak; the Works Progress Administration, which built hundreds of airports, bridges, college campuses; and other public works projects; and the Resettlement Administration, which oversaw the Dust Bowl migration and built a series of pilot "greenbelt" towns, helped make the New Deal a built environment revolution in the United States.

This proved to be the last period in which strong national planning—including an expansive design bureaucracy—would be realized in the United States. Much of the rest of the 20th and 21st centuries was left up to the market. Within this market-driven context, newly elected President John F. Kennedy traveled to Houston in May 1961 to deliver his famous moon shot speech at Rice University. He implored the country to "choose to go to the Moon. . . not because it [it is] easy, but because [it is] hard." That speech, and the machinations that followed, set a wildly ambitious national goal without any clue how it might be achieved. Little of the technology necessary to make the trip existed in 1961. So, at JFK's direction, the federal government issued research and procurement contracts and reorganized NASA around the aim of getting to the Moon by the end of the decade, unsure of how—or if—it might ever truly become possible.

Of course, we did go to the Moon. One of the many spoils of the trip was Earthrise—an image of the Earth as an object and thus the first photographic evidence of the planet's physical boundaries. It would prove to be an iconic image, arriving in a milieu defined by Rachel Carson's Silent Spring (1962), Ian McHarg's Design With Nature (1969), and perhaps the largest and most sustained mass mobilization of the environmental movement in American history—a movement proving so strong that it compelled Richard Nixon to usher in what became known as the "environmental decade," when the National Environmental Policy Act, the Clean Air Act, the Clean Water Act, and the Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund") Act were all passed.

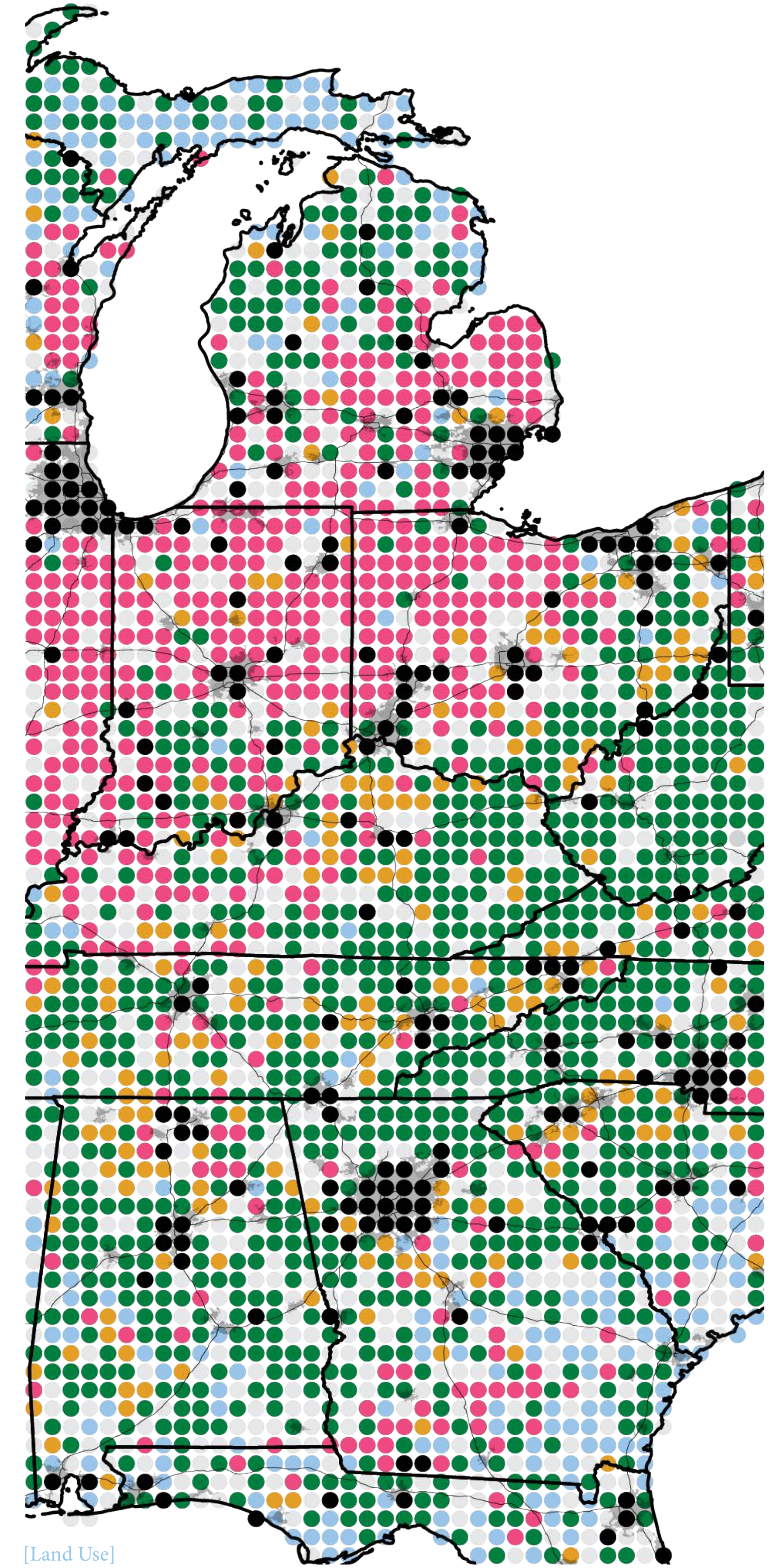
It's in this space where the Green New Deal seems likely to land—in the massive expansion of government as a force for good in the everyday lives of most people (like the New Deal), and in the marshalling of public procurement and standards to drive the private sector towards a shared set of goals (like the moon shot). It requires that we know the destination, but not the path; it requires a bit of backcasting.

This brings us back to the genesis of the 2100 Project. A window is about to open, forced ajar by young climate activists, for the mass mobilization of resources called for by the Green New Deal. When it does, we must be in a better position than we were in 2009 when the American Recovery and Reinvestment Act (ARRA, Barack Obama's "stimulus package") passed. ARRA required that investments in the built environment be tied to "shovel-ready" projects—a caveat that sounds reasonable until you realize that the only shovel-ready projects at the time were those that had been sitting on the books for years, unbuilt largely because they were bad ideas that no one wanted. We don't expect to develop all—or even any—of the Green New Deal's potential projects on our own. But we do hope that this atlas can serve as a platform to support those who will.

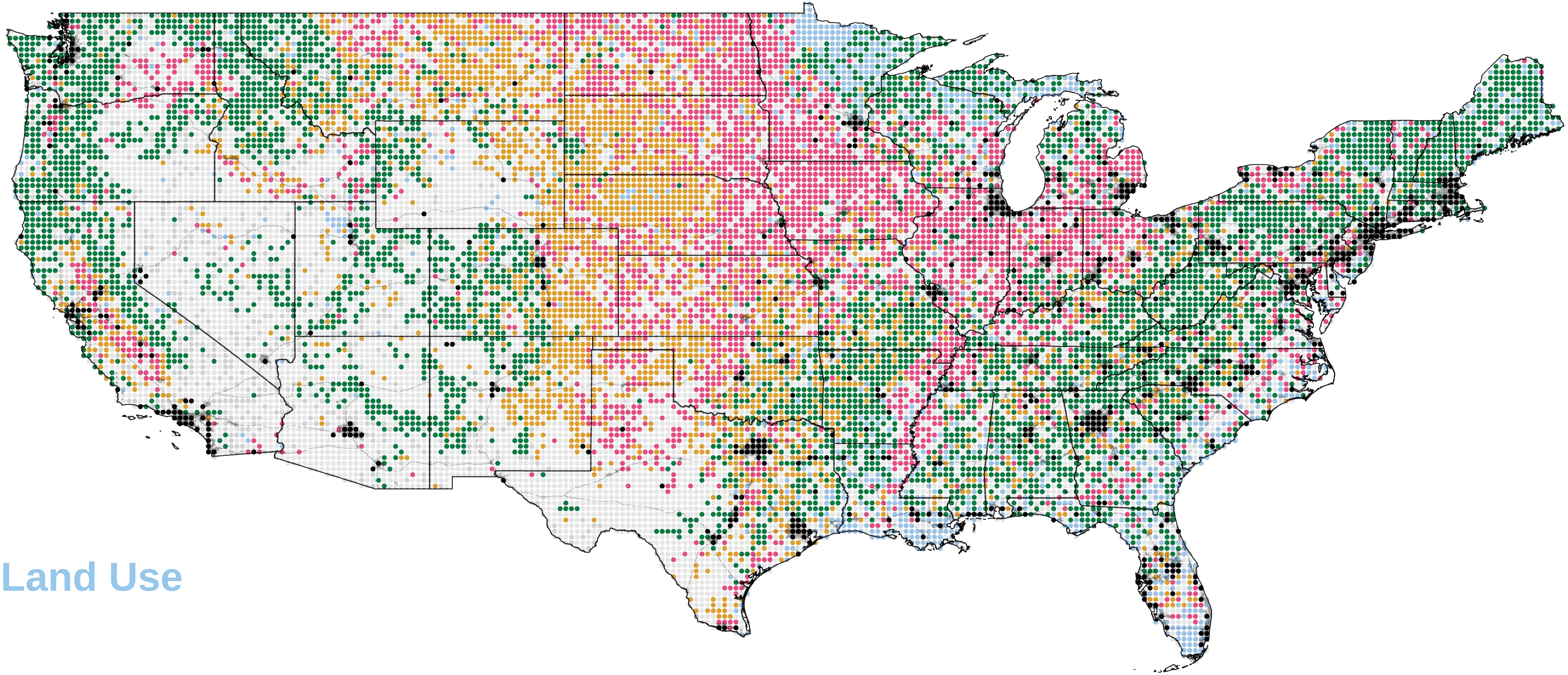
We also feel compelled to note that while we would have much preferred to build an atlas encompassing more than just the conterminous United States—one that could include Hawaii and Alaska, as well as Puerto Rico and the other territories—the spatial and climate data available to us simply did not permit it. As we continue to expand the 2100 Project, we're eager to find partners who can help us close these gaps and develop a richer understanding of how the climate crisis will transform all of the places where we live.

This Atlas for the Green New Deal is a product of our own milieu—the overlapping crises we find ourselves living through in 2020. For New Dealers, it was the environmental crisis of the Dust Bowl, the economic crisis of the Great Depression, and the political crisis of fascism that forced open the window for bold, national action. Green New Dealers face the environmental crisis of climate change, the economic crisis of late capitalism, and the political crisis of resurgent fascism across the globe and even here in the United States.

We're constantly told to go slow, to think small, and to tweak systems rather than transform them; that we are doomed, and all that's left to decide is the extent of our collective destruction. But the Green New Deal offers something more: a chance to go fast and to think big; to transform the structures that gave us the climate crisis and inequality; and to imagine a world in which things are, we promise, better than you think.



[Land Use]

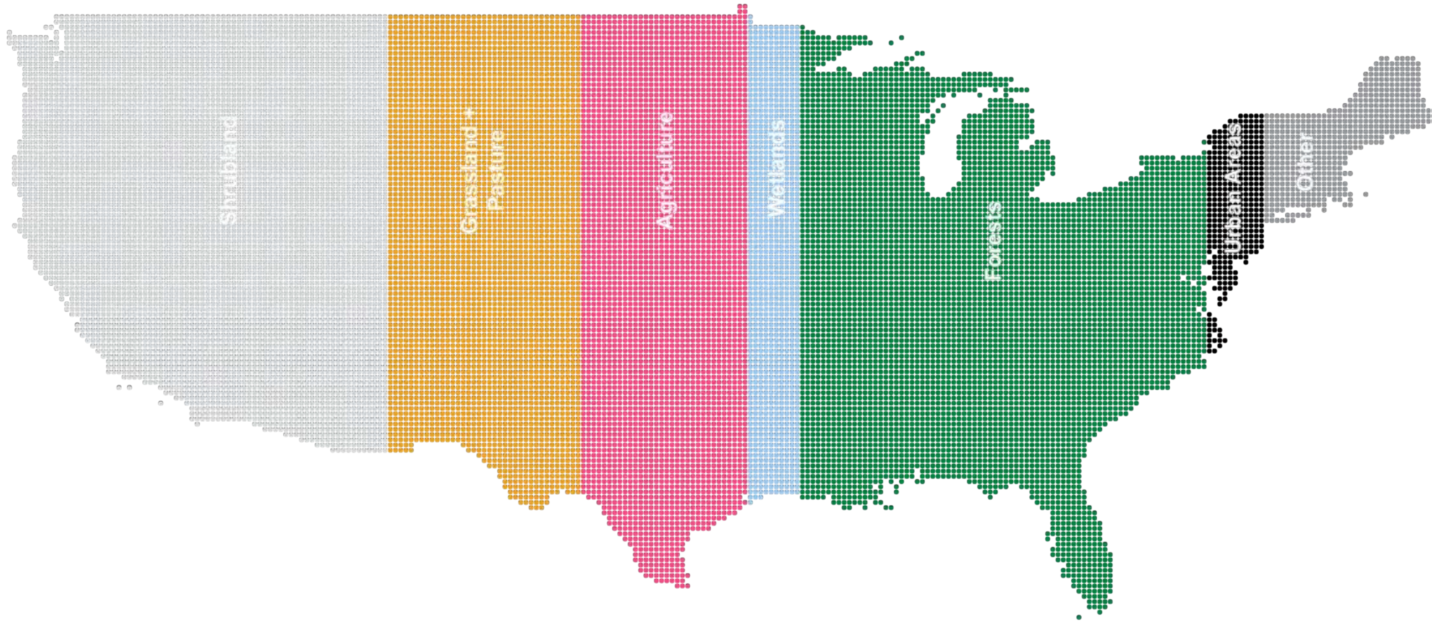


Land Use

The land area of the conterminous US is approximately 2.9 million square miles, or 1.9 billion acres. It can be broadly divided into seven land use categories: forest, shrubland, grassland + pasture, agriculture, wetlands, urban areas, and other uses. This map illustrates the nation's land composition as of 2017, revealing clear settlement and use patterns at the national scale; each pixel represents 98,765 acres. Along the East and West Coasts, forests and urban areas are prevalent. In the Midwest and the Great Plains, agriculture predominates, along with areas of grassland + pasture. Many of the nation's wetlands are concentrated in the Great Lakes and Gulf Coast megaregions.

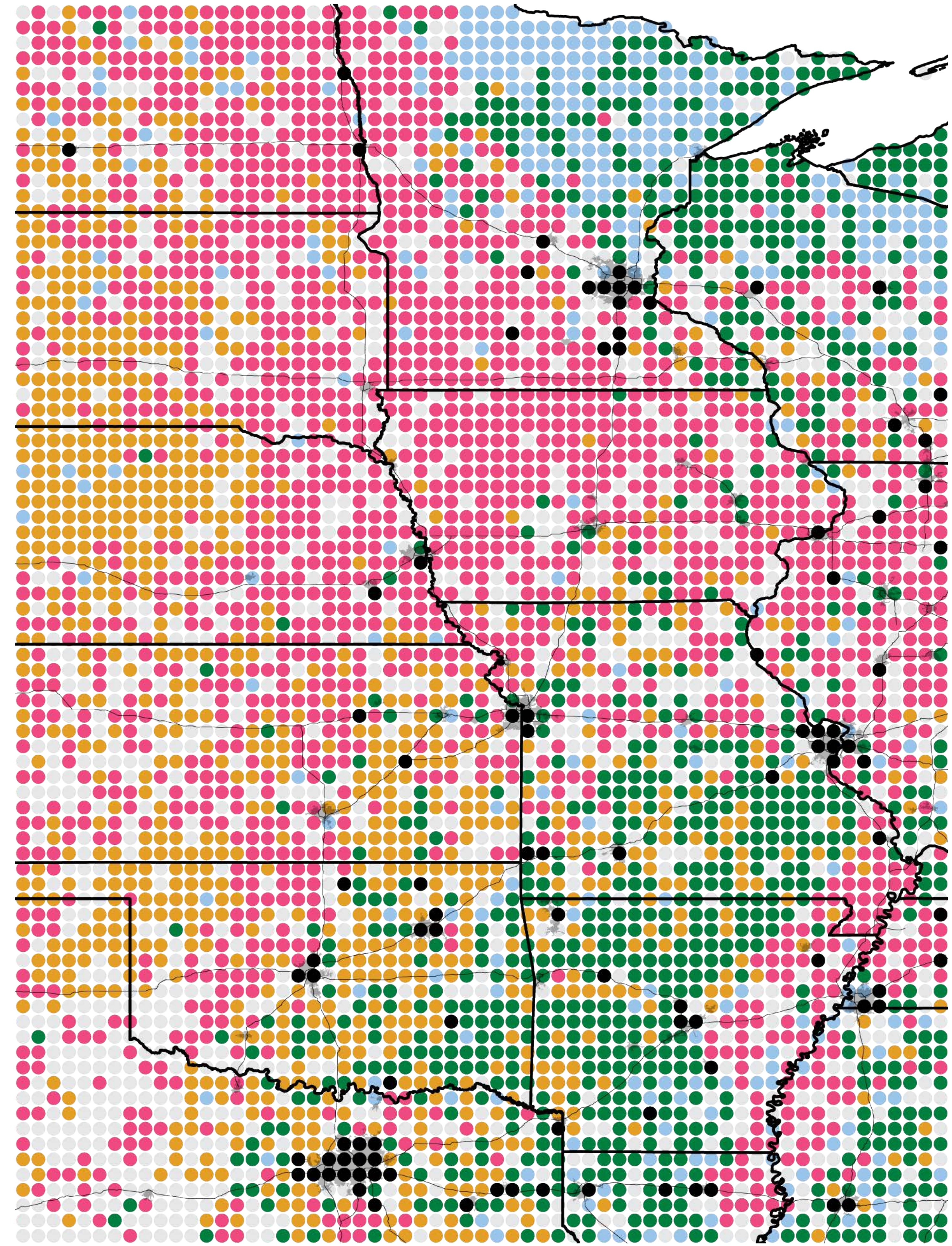
These seven land use divisions are defined as follows: forest (land with trees greater than 5 meters tall and with a cover density of 20% or more); shrubland (areas with low woody vegetation); grassland + pasture (respectively, areas of primarily graminoid plants and areas of legumes and grasses planted for animal grazing, feed, or seed crops); agriculture (land dominated by crop production); wetland (areas where the water table is at, near, or above the land surface for part of most years); urban areas (urbanized areas of 50,000 or more people and urban clusters of between 2,500 and 50,000 people; and "other" land use categories, including desert and mountainous areas.[1]

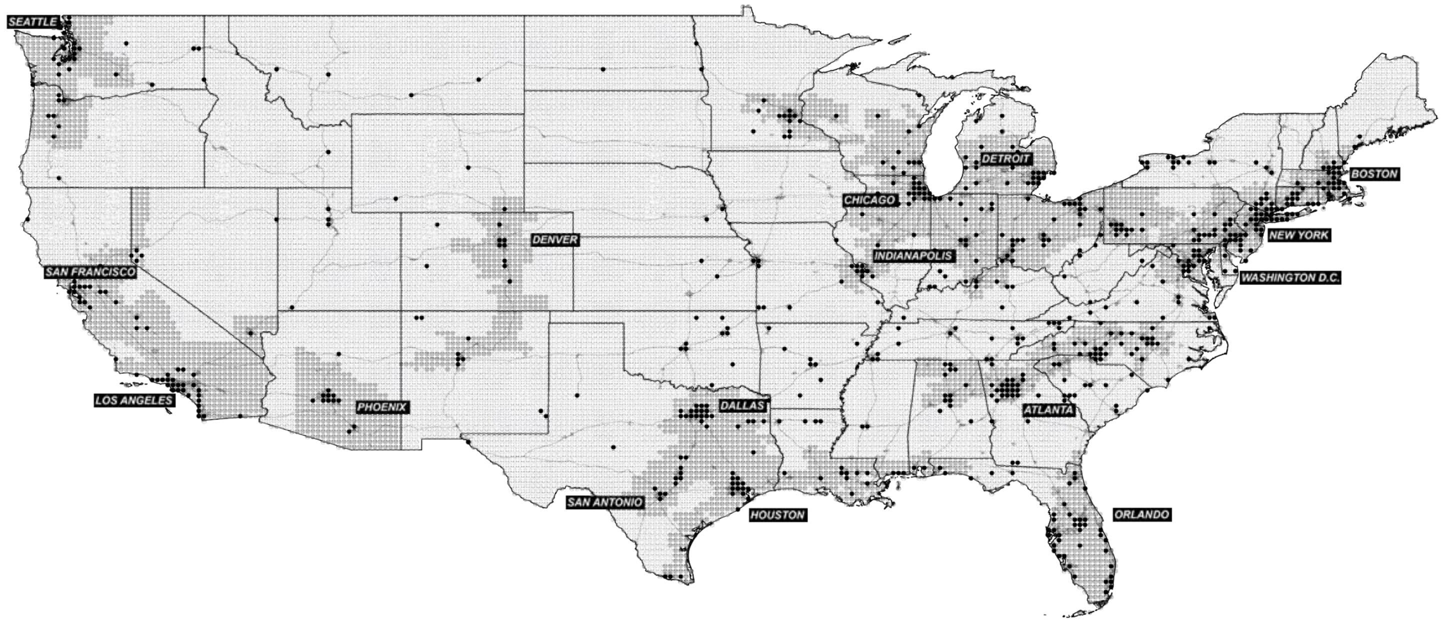
[1] For a more detailed breakdown of US land cover, see Multi-Resolution Land Characteristics Consortium, "National Land Cover Database 2016," MRLC.gov, accessed July 22, 2019, https://www.mrlc.gov/data.



Land Use

This map arranges the seven land use categories by their overall proportion of the total US land area. Over one third of the US is classified as grassland + pasture or agriculture, much of it used either to feed humans and nonhuman animals or to produce biofuels. Urban areas make up the smallest total area but hold the most humans.





Urban Areas

Until the 1920 census, most people in the US lived in rural areas. Since then, the population in urban areas has steadily increased, both in total number and as a percentage of the national population. As of 2016, 82% of the US lived in urban areas—roughly 270 million people.[2] These urban areas make up around 2% of the US land area, with densities ranging from 27,781.2 people per square mile in New York City down to 1,000 people per square mile, the minimum density required for an urban designation.[3] In some areas (especially the Southwest), annexation is driving urban population growth rather than in-migration or an increase in density. Most urban areas are coastal or river port cities, continuing the historical pattern of human settlement along major bodies of water for ease of travel and trade; a minority of the US population lives in rural areas disconnected from historical water trade routes.

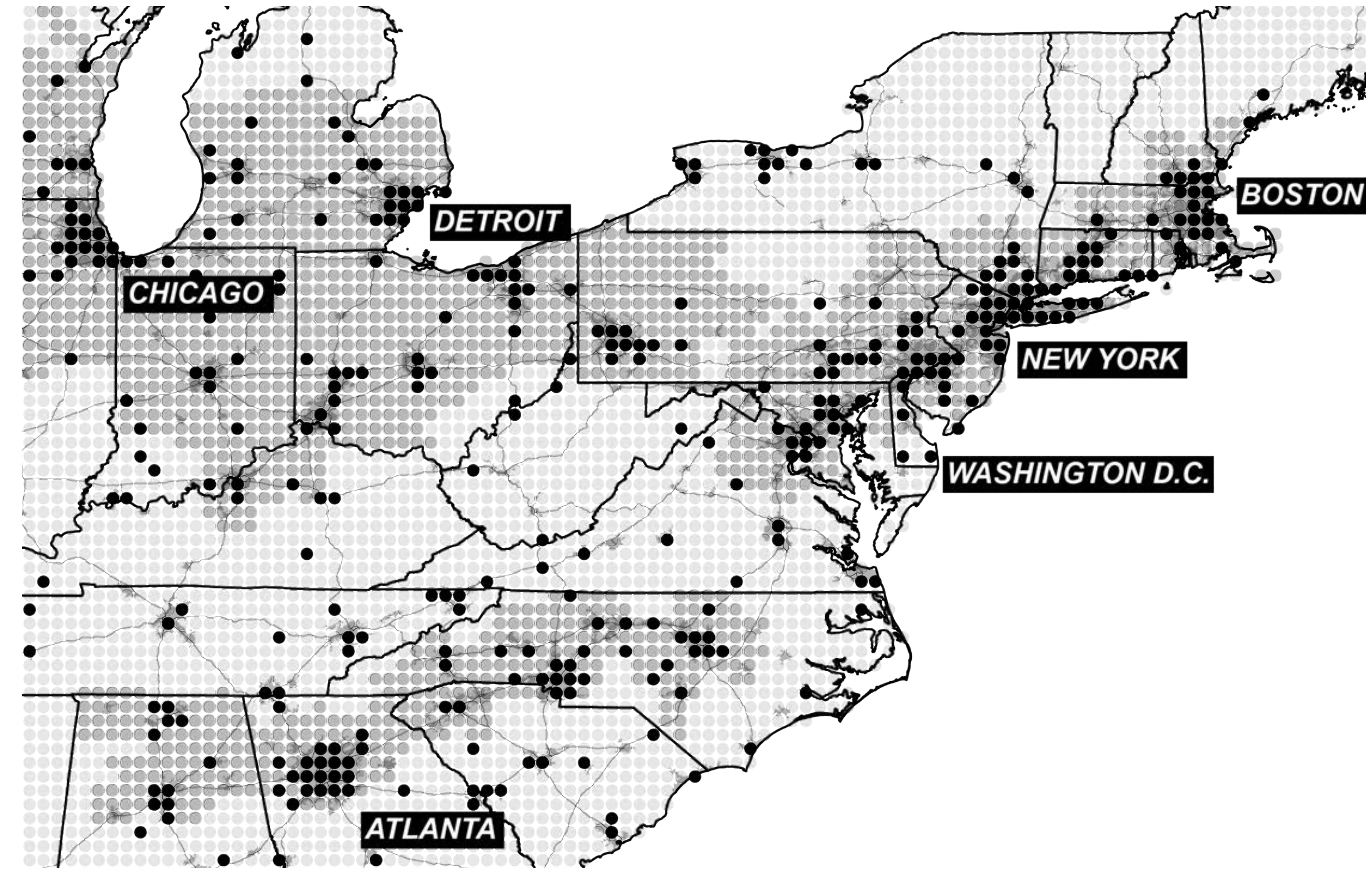
Rural areas are those territories not included within an urban area. Approximately 18% of people in the US live in rural areas; those who do are more likely to own their home, to live in their state of birth, and to have served in the military than their urban counterparts. They are also older, less likely to live in poverty, and less likely to have an advanced degree.[4] Since 1910, the rural population has remained stable in absolute terms, while the urban population has nearly quadrupled.

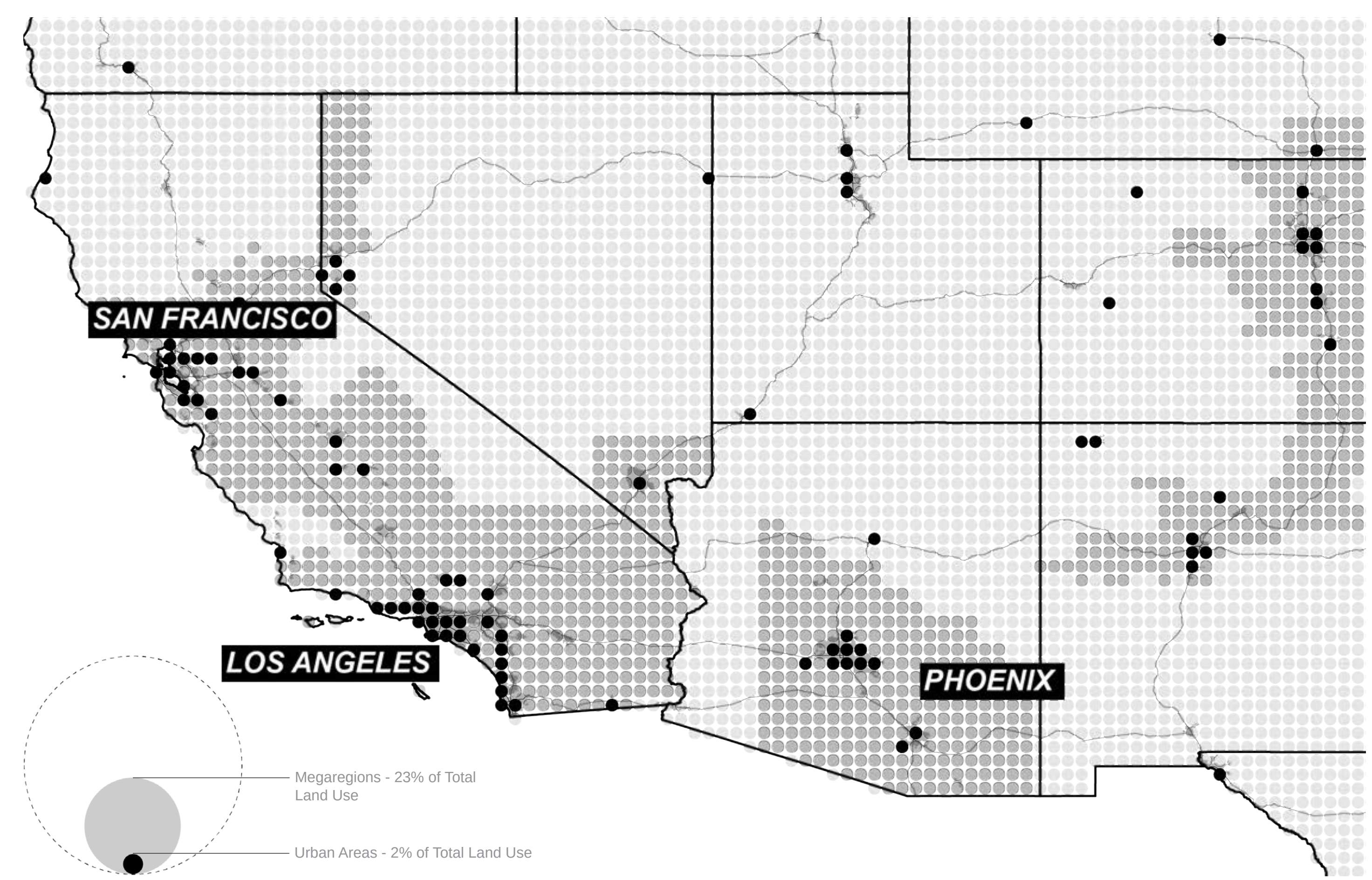
Much of suburbia is incorporated in the "urban" land use category. The justifications for this simplification from ease of data collection for the Census Bureau to socioeconomic theories of regional economic development that tie commuting patterns and wealth together. While these rationales are justified, they leave us with a highly imperfect measure of the character, quality, and function of the US built environment. Many of these suburban areas are treated as urban by the Census Bureau and the various federal agencies that demarcate funding and financing programs based on coarse definitions of urban and rural; yet their failure to capture the vast suburbanized landscape limits our ability to truly comprehend the spatial dimensions of most of the country. By some measures, suburbia is the most populated settlement type in the US; and yet the Census Bureau does not recognize it.

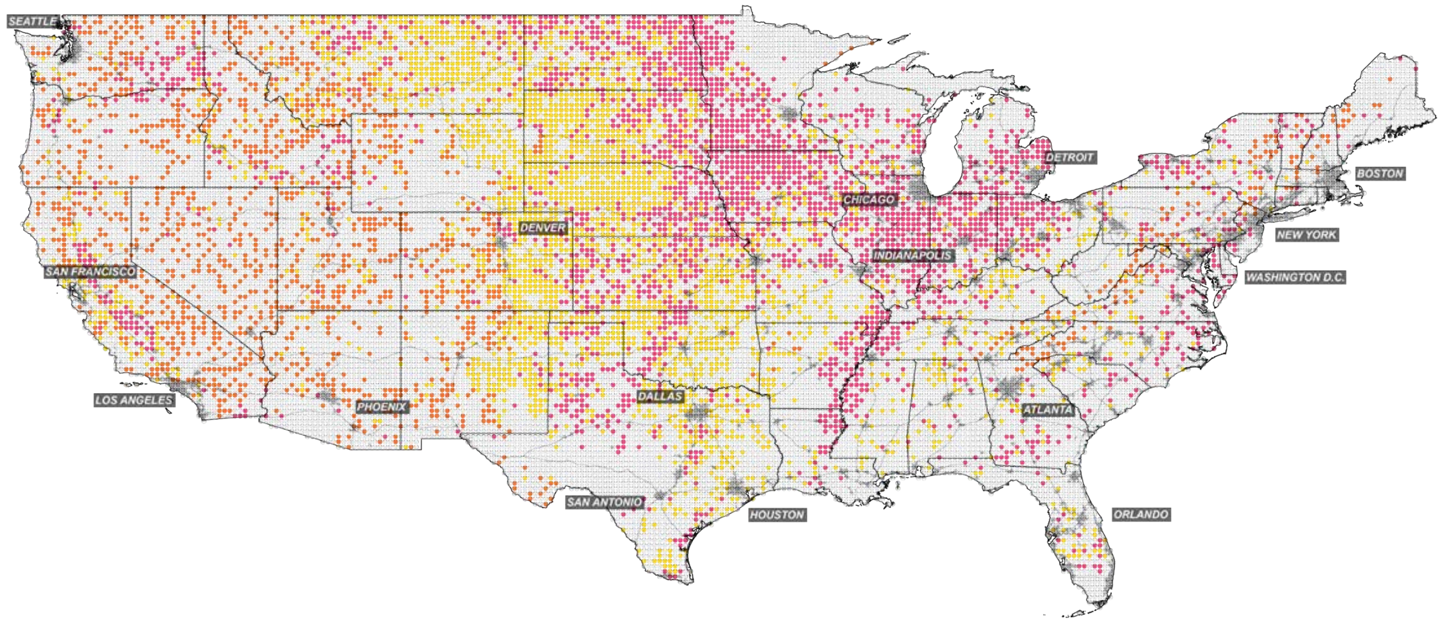
[2] "Urban Population (% of Total Population)." World Bank Group. Accessed July 12, 2019. United Nations Population Division. World Urbanization Prospects: 2018 Revision. https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS.

[3] Cohen, Darryl T., Geoffrey W. Hatchard, and Steven G. Wilson. Population Trends in Incorporated Places: 2003 to 2013. US Department of Commerce, Economics and Statistics Administration, US Census Bureau, 2015.

[4] US Census Bureau. "New Census Data Show Differences Between Urban and Rural Populations." American Community Survey: 2015. December 30, 2016. Accessed July 12, 2019. https://www.census.gov/newsroom/press-releases/2016/cb16-210.html.



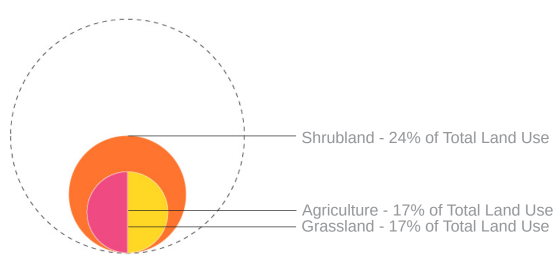




Productive Lands

Agriculture accounts for approximately 16.7% of US land use; the largest subsets are wheat and corn cultivation at 5.3% and 5.0%, respectively, followed by soybeans and cotton at 3.3% and 1.7%, according to 2015 data. Grassland and pasture makes up slightly more at around 16.9%.[5] Both agriculture land and grassland + pasture are concentrated in the middle of the country on the most productive soils; shrubland is mainly present in the western third of the country. Though agriculture takes up nearly 17% of land use, farms contributed only $136.7 billion to the national GDP (about 1%) in 2015.[6]

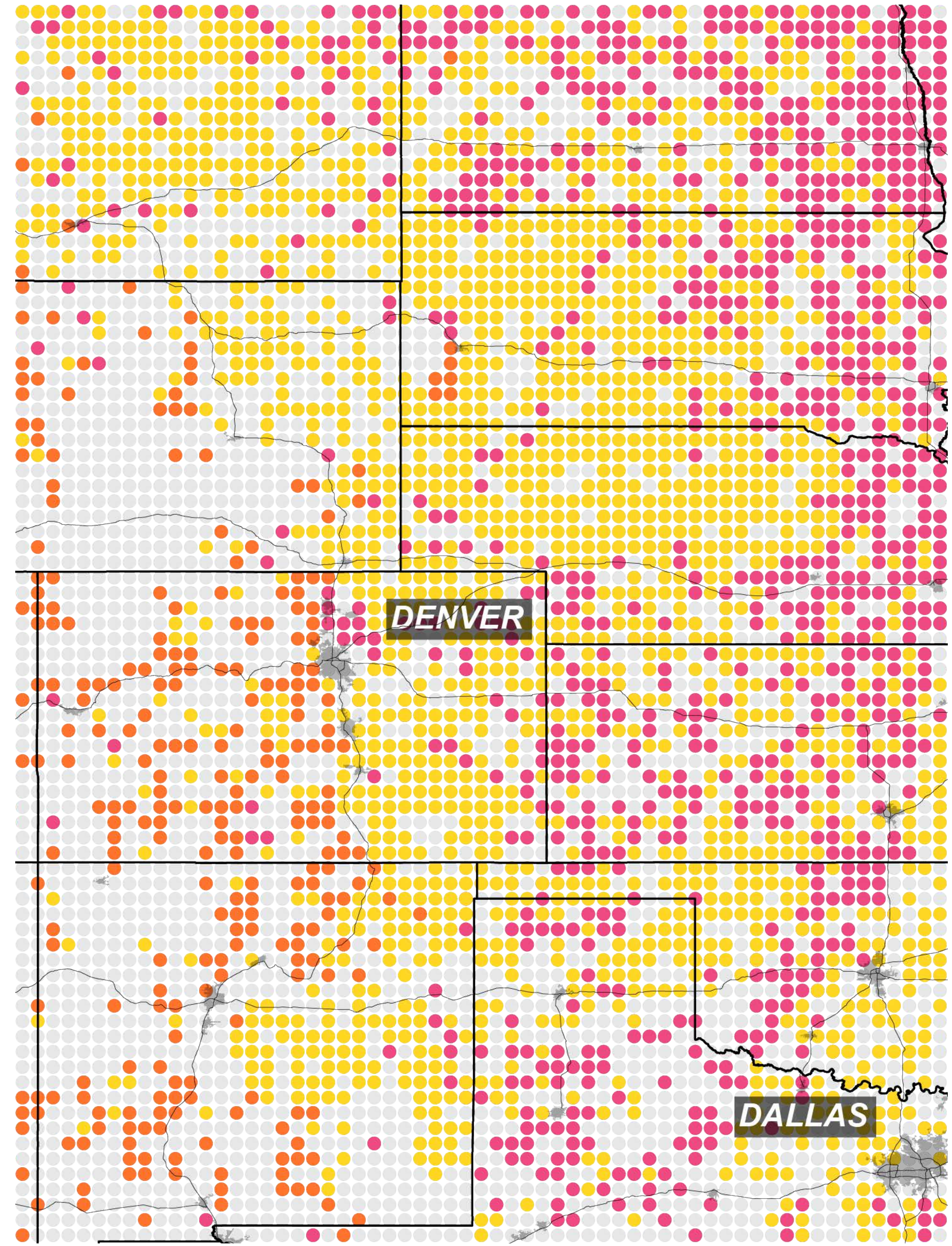
Like other major industrial sectors, American agriculture is moving through a period of hyper-consolidation. In 2001, farms of 1,000 acres or more represented only 5.6% of total farms but controlled 46.8% of all US cropland. By 2011, the proportion of large farms had remained steady at 5.6%, but their holdings had increased to 53.7% of total cropland.[7] (The stability of total farms is linked to the rise of "hobby farms"—small plots producing little in the way of commercially viable agricultural products, whose recent popularity has helped stabilize the number of small farms, as measured by the US Department of Agriculture.) An ever increasing share of the nation's food production is derived from large industrial farms. This consolidation and corporatization of agriculture has tracked with the doubling of the nation's food production since World War II and its growth into the largest exporter of food in the world.

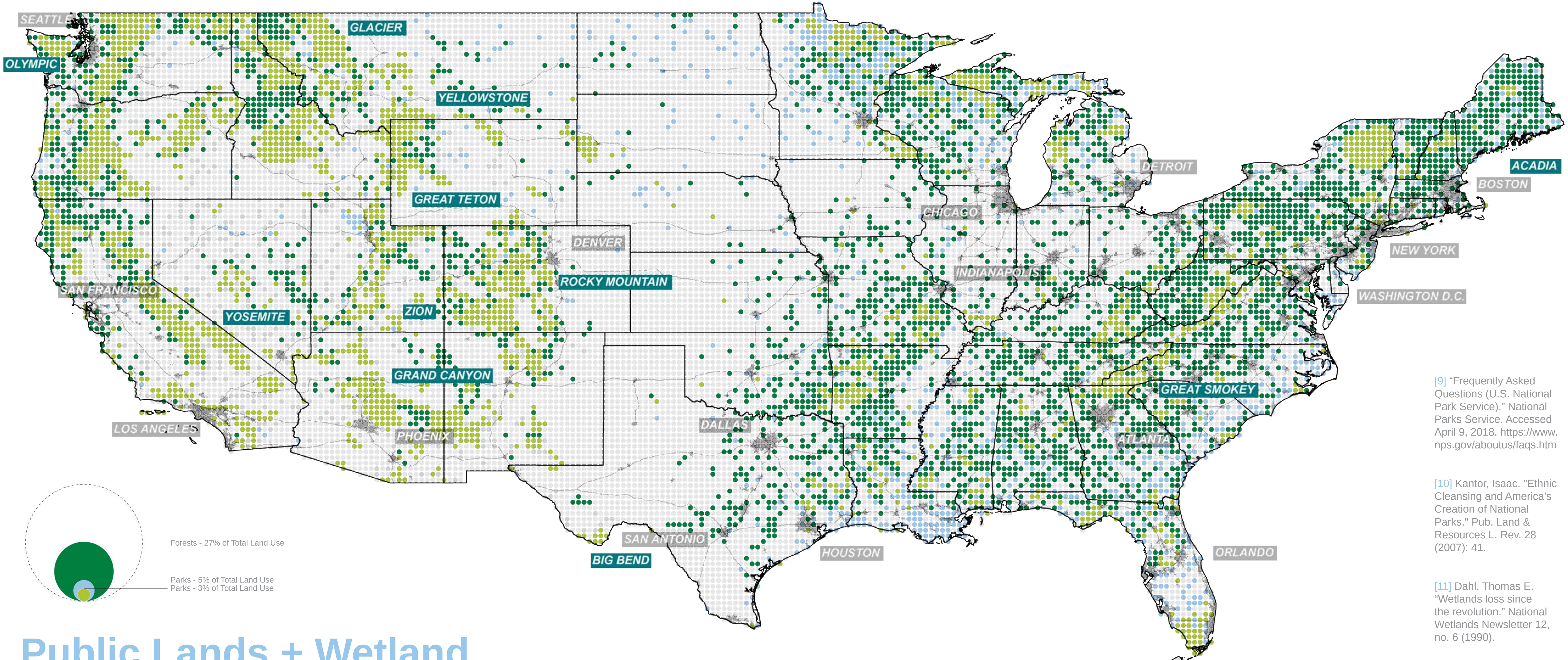


[5] NASS, USDA. "USDA National Agricultural Statistics Service Cropland Data Layer." CropScape - NASS CDL Program. U.S. Department of Agriculture. Accessed November 2, 2017. https://nassgeodata.gmu.edu/CropScape/.

[6] Glaser, L., and R. M. Morrison. "Ag and food sectors and the economy." USDA ERS - Ag and Food Sectors and the Economy. October 18, 2017. Accessed April 9, 2018. https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/ag-and-food-sectors-and-the-economy/

[7] Koerth-Baker, Maggie. "Big Farms Are Getting Bigger and Most Small Farms Aren't Really Farms at All." Fivethirtyeight. Accessed September 8, 2019. https://fivethirtyeight.com/features/big-farms-are-getting-bigger-and-most-small-farms-arent-really-farms-at-all/





Public Lands + Wetland

Roughly a quarter of the entire US land area is covered in forest; around 5 percent is wetland, and around 3 percent is protected land. The forest is roughly equally divided between deciduous and evergreen; 0.1%, about 121,600 acres, is planted for Christmas trees.[8] Many of the national parks are located near or in areas categorized as forest.

The National Park System is comprised of 419 sites covering 84 million acres; the parks range in size from 13.2 million acres (the Alaskan wilderness of the Wrangell–St. Elias National Park and Preserve) to under 1,000 square feet (the Thaddeus Kosciuszko National Memorial, an eighteenth-century townhouse).[9] The creation of many of these large wilderness spaces involved the forced removal of the Indigenous populations residing on the lands; in some cases, entire tribes were forcibly removed to make way for new public lands and western homesteading programs.[10]

Wetlands have similarly been decimated following colonization; by one estimate, the United States lost over half of its wetlands between the 1780s and the 1980s. One third of the total lost wetland area is in the Great Lakes megaregion, with much of the land having been drained and converted to agriculture. Today, a significant portion of the Great Lakes and Gulf Coast megaregions remains wetlands, whereas the eastern US is predominantly forested. Protected land is relatively scarce in the central US; only 1.04% of Iowa, 1.6% of Nebraska, and less than 1% of Kansas is publicly owned.

[8] NASS, USDA. "USDA National Agricultural Statistics Service Cropland Data Layer." CropScape - NASS CDL Program. U.S. Department of Agriculture. Accessed November 2, 2017. https://nassgeodata.gmu.edu/CropScape/.

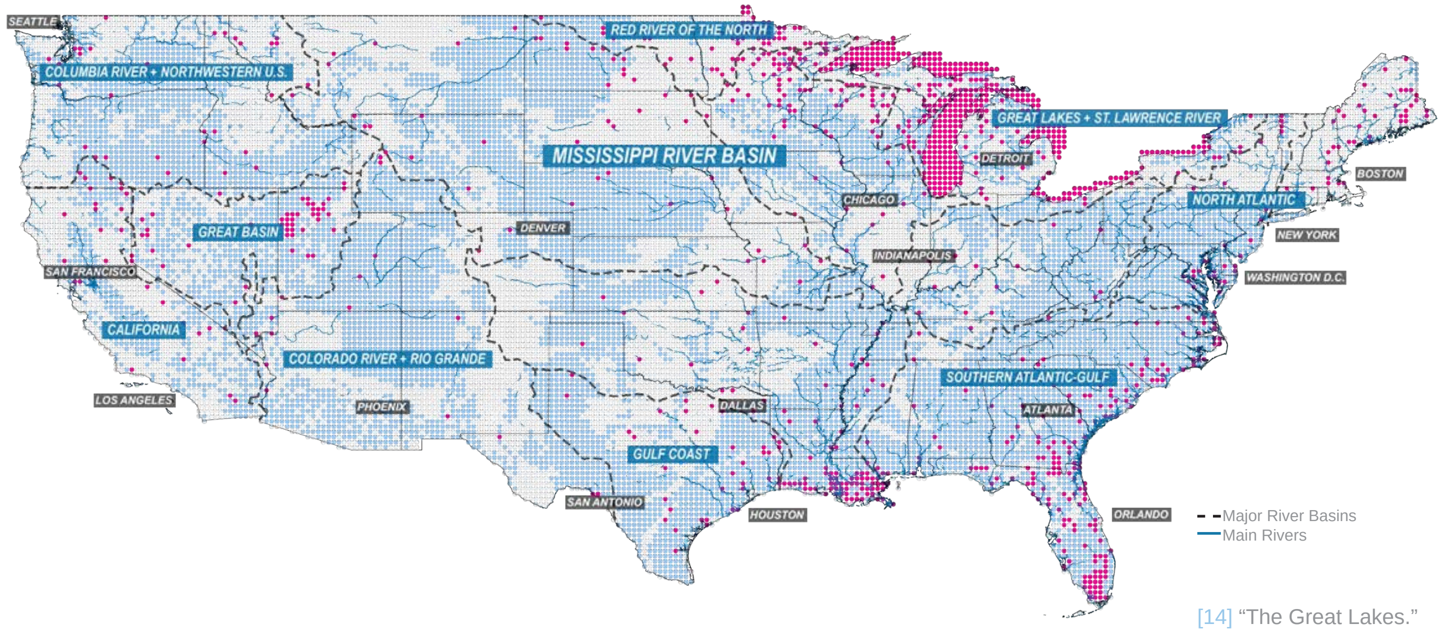
[9] "Frequently Asked Questions (U.S. National Park Service)." National Parks Service. Accessed April 9, 2018. https://www.nps.gov/aboutus/faqs.htm

[10] Kantor, Isaac. "Ethnic Cleansing and America's Creation of National Parks." Pub. Land & Resources L. Rev. 28 (2007): 41.

[11] Dahl, Thomas E. "Wetlands loss since the revolution." National Wetlands Newsletter 12, no. 6 (1990).

[12] Dahl, Thomas E. "Wetlands loss since the revolution." National Wetlands Newsletter 12, no. 6 (1990).

[13] All data taken from the Natural Resources Council of Maine, which aggregates and analyzes data from the Bureau of Land Management, the U.S. Forest Service, the U.S. Fish and Wildlife Service, and the Department of Defense. Summary tables available at https://www.nrcm.org/documents/publiclandownership.pdf



Water Sources

The bulk of the US population's water supply comes from surface water sources; however, most of the country's land area is only supplied by underground aquifers. Unique in its reliance on surface water is the Great Lakes megaregion, which gets its name from the Great Lakes themselves—the largest system on Earth of surface freshwater by area, so large that it behaves in some ways more like a sea than a series of lakes.[14] The lakes cover 60,320,000 acres and contain about 21% of the world's surface fresh water, supplying more than 30 million people in the US with drinking water. This number is likely to grow both through increasing and in-migrating populations and through weakening of the Great Lakes Compact, the legal agreement which regulates the management and use of water within the Great Lakes Basin.[15] Immediately south of the Great Lakes is the Mississippi River Basin, the largest major drainage basin of the ten that cover the conterminous US.[16] Overall, 68% of the US population, mostly urban, relies on surface waters, while rural populations tend to rely on groundwater.[17]

In addition to providing drinking water for rural populations, groundwater supplies over 50 billion gallons to agriculture every day—one of the major contributors to groundwater decline and depletion.[18] Overall, agriculture accounts for 36.7% of total annual withdrawal, while public and self-supplied consumption make up only 13.1%.[19] The single greatest withdrawal is for thermoelectric power, at 41.3% of the total.[20] This water, which helps cool equipment and produces steam for spinning turbines, is used by nearly every power facility in the country. If the water is not cooled before it is released into the environment, the heat can cause damage to receiving ecosystems.[21]

Aquifer depletion is becoming a major issue in the US, with impacts that range from land subsidence to deterioration of water quality. One particularly vulnerable aquifer is the High Plains or Ogallala aquifer, which provides the water for 30% of all US irrigation.[22] If current withdrawal practices continue, this aquifer will be depleted by 2040.[23]

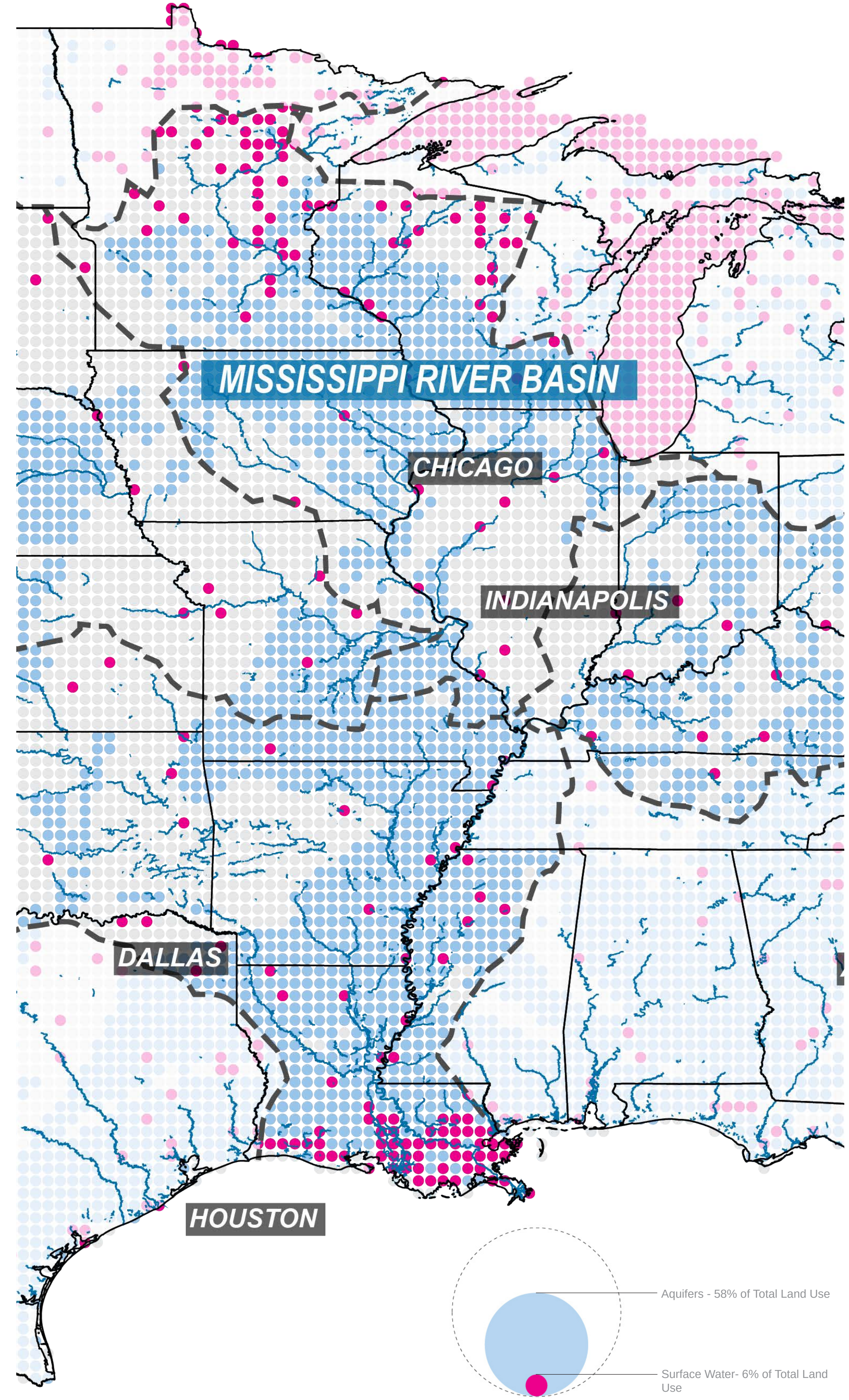
[14] "The Great Lakes." EPA. May 15, 2019. Accessed July 12, 2019. https://www.epa.gov/greatlakes

[15] "Great Lakes-St. Lawrence River Basin Water Resources Council." Great Lakes-St. Lawrence River Basin Water Resources Council. Accessed July 29, 2019. http://www.glslcompactcouncil.org/.

[16] "U.S. River Basins." National Climatic Data Center. Accessed August 17, 2019. https://www.ncdc.noaa.gov/monitoring-references/maps/us-river-basins.php.

[17] "Water Sources | Public Water Systems | Drinking Water | Healthy Water | CDC." Centers for Disease Control and Prevention. Accessed July 12, 2019. https://www.cdc.gov/healthywater/drinking/public/water_sources.html.

[18] "Groundwater Decline and Depletion." U.S. Geological Survey. Accessed July 12, 2019. https://www.usgs.gov/special-topic/water-science-school/science/groundwater-decline-and-depletion?qt-science_center_objects=0#qt-science_center_objects



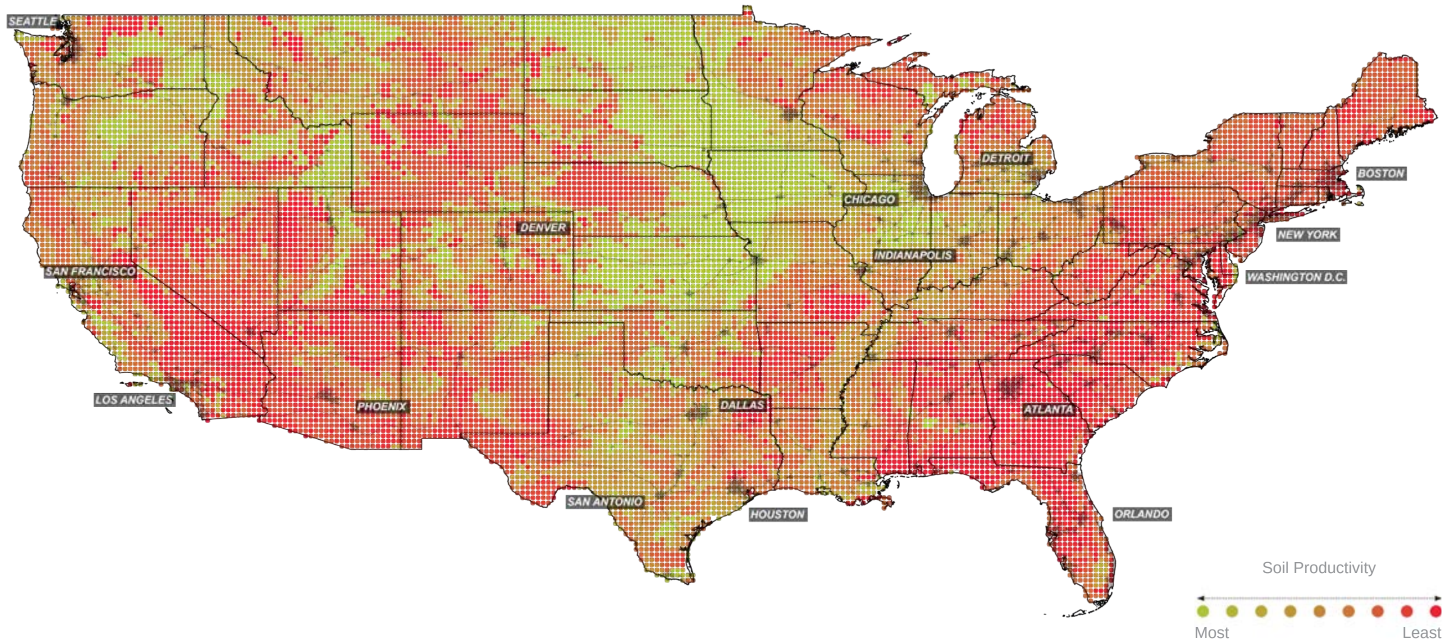
[19] "U.S. Water Supply and Distribution Factsheet." U.S. Water Supply and Distribution Factsheet | Center for Sustainable Systems. 2018. Accessed July 12, 2019. http://css.umich.edu/factsheets/us-water-supply-and-distribution-factsheet.

[20] "U.S. Water Supply and Distribution Factsheet." U.S. Water Supply and Distribution Factsheet | Center for Sustainable Systems. 2018. Accessed July 12, 2019. http://css.umich.edu/factsheets/us-water-supply-and-distribution-factsheetumich.edu/factsheets/us-water-supply-and-distribution-factsheet.

[21] "Thermoelectric Power Water Use." Thermoelectric Power Water Use. U.S. Geological Survey. Accessed July 12, 2019. https://www.usgs.gov/special-topic/water-science-school/science/thermoelectric-power-water-use?qt-science_center_objects=0#qt-science_center_objects

[22] Frankel, Jeremy. "Crisis on the High Plains: The Loss of America's Largest Aquifer – the Ogallala." University of Denver Water Law Review at the Sturm College of Law. May 17, 2018. Accessed July 12, 2019. http://duwaterlawreview.com/crisis-on-the-high-plains-the-loss-of-americas-largest-aquifer-the-ogallala/

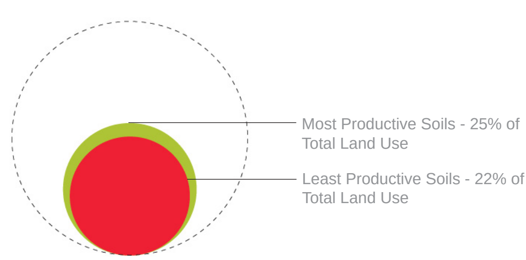
[23] Steward, David R., Paul J. Bruss, Xiaoying Yang, Scott A. Staggenborg, Stephen M. Welch, and Michael D. Apley. "Tapping Unsustainable Groundwater Stores for Agricultural Production in the High Plains Aquifer of Kansas, Projections to 2110." PNAS. August 21, 2013. Accessed July 12, 2019. http://www.pnas.org/



Soils

The productivity index of soil uses "taxonomic features or properties that tend to be associated with natural low or high soil productivity to rank soils."[24] The index considers organic matter content, cation-exchange capacity (CEC), and clay mineralogy. Only around a third of US soil is categorized as most productive, characterized by high organic matter content, high CEC, and the presence and activity of clay. While this soil is present throughout the US, it is concentrated in the upper Great Lakes megaregion and in areas of Washington, Oregon, and Idaho. One order of productive soils, found in the grassland ecosystem between the Front Range and Great Lakes megaregions, is known as the "Mollisols." Mollisols are highly fertile soils with high levels of organic inputs caused by deep-rooting grasses. These grassland soils account for only 7% of ice-free land globally but make up approximately 21.5% of US soils.[25]

The productivity index does not account for soil contamination, which is a major issue in US soil health. The EPA created the Brownfields Program to identify and treat highly contaminated sites, for which "the expansion, redevelopment, or reuse. . . may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant."[26] The US has an estimated 425,000 brownfield sites totaling 5 million acres of abandoned industrial land.[27]

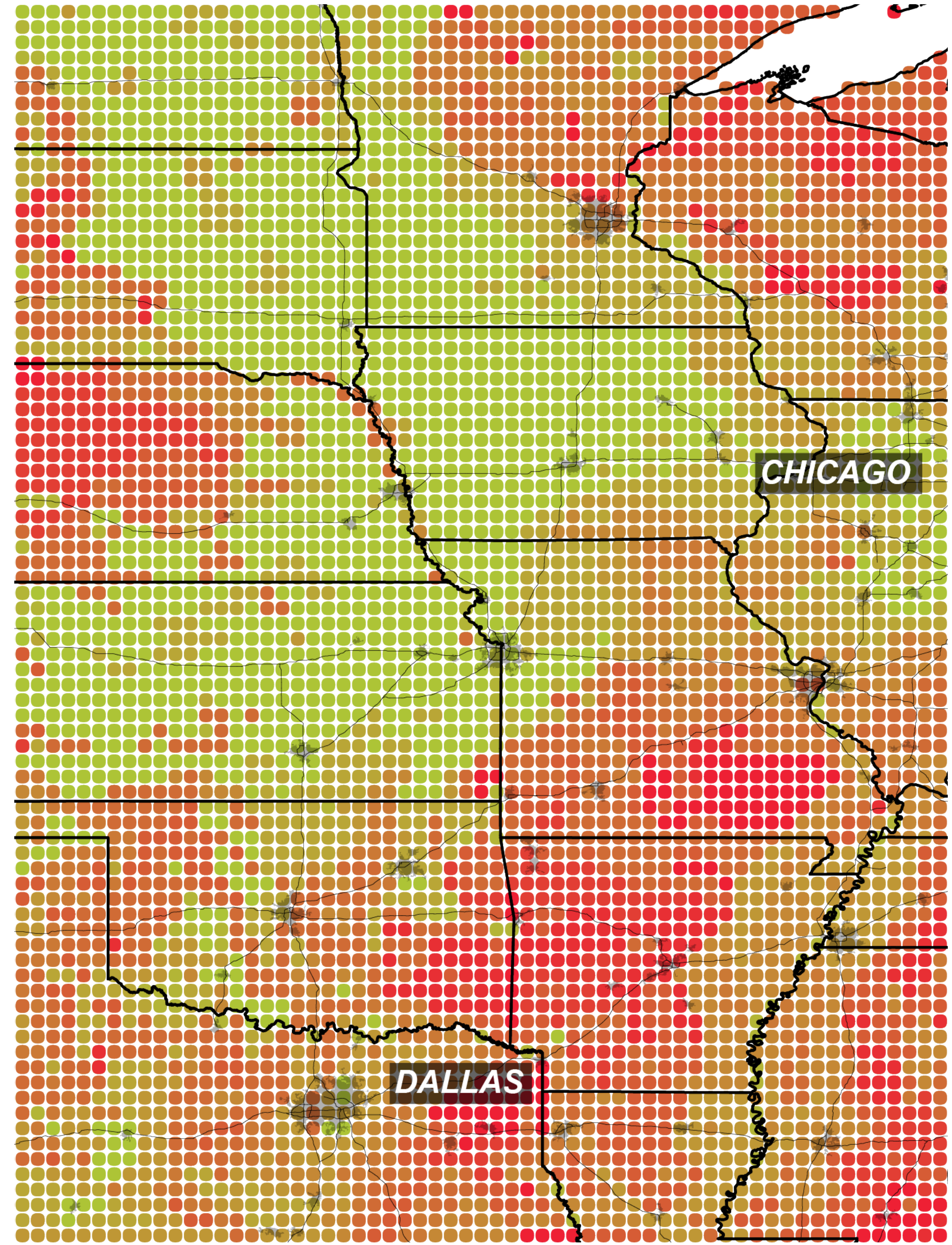


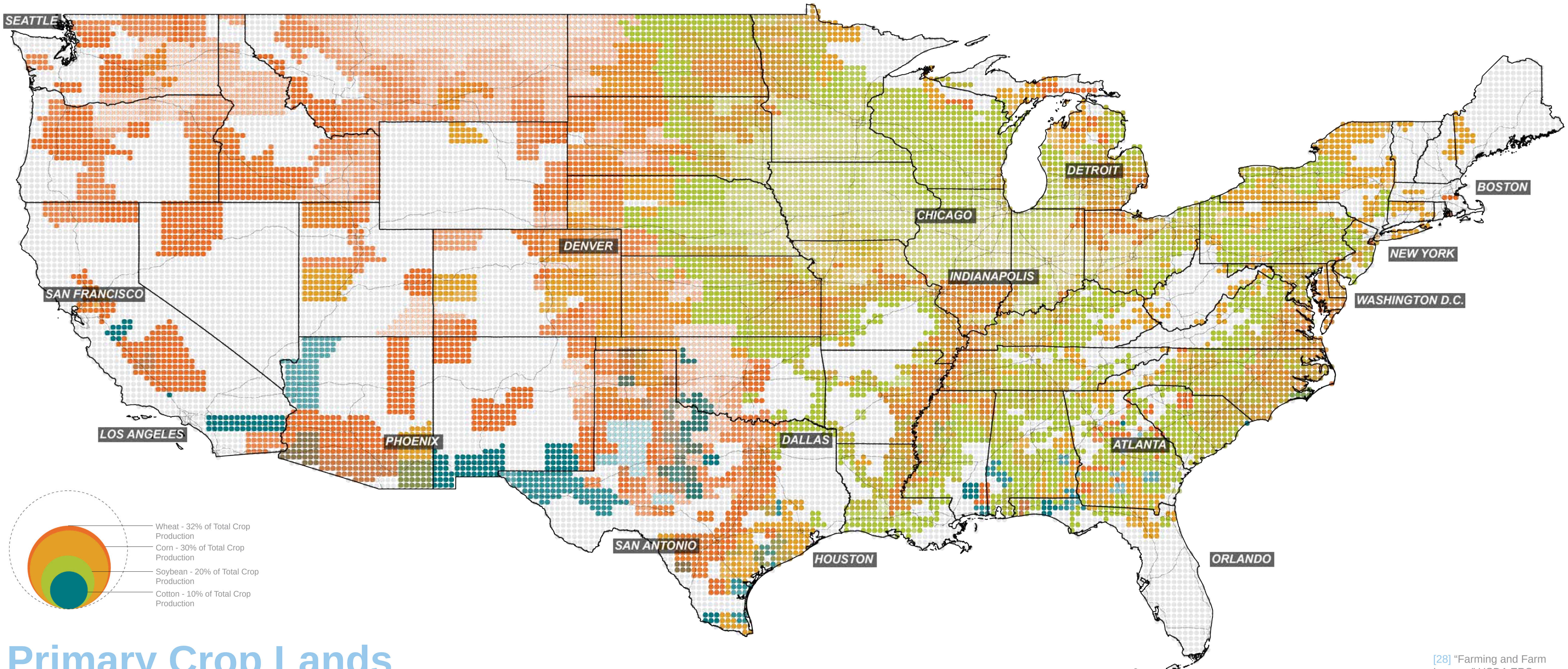
[24] Schaetzl, R.J., F.J. Krist Jr., and B.A. Miller. 2012. A taxonomically based ordinal estimate of soil productivity for landscape-scale analyses. Soil Science. 177:in press.

[25] "Mollisols." Mollisols - Department of Soil and Water Systems - College of Agricultural and Life Sciences - University of Idaho. Accessed July 12, 2019. https://www.uidaho.edu/cals/soil-orders/mollisols.

[26] "Overview of EPA's Brownfields Program." U.S. Environmental Protection Agency. Accessed July 12, 2019. https://www.epa.gov/brownfields/overview-epas-brownfields-program.

[27] "Brownfields FAQs." HUD Exchange. U.S. Department of Housing and Urban Development Accessed July 12, 2019. https://www.hudexchange.info/resource/3180/brownfields-frequently-asked-questions/





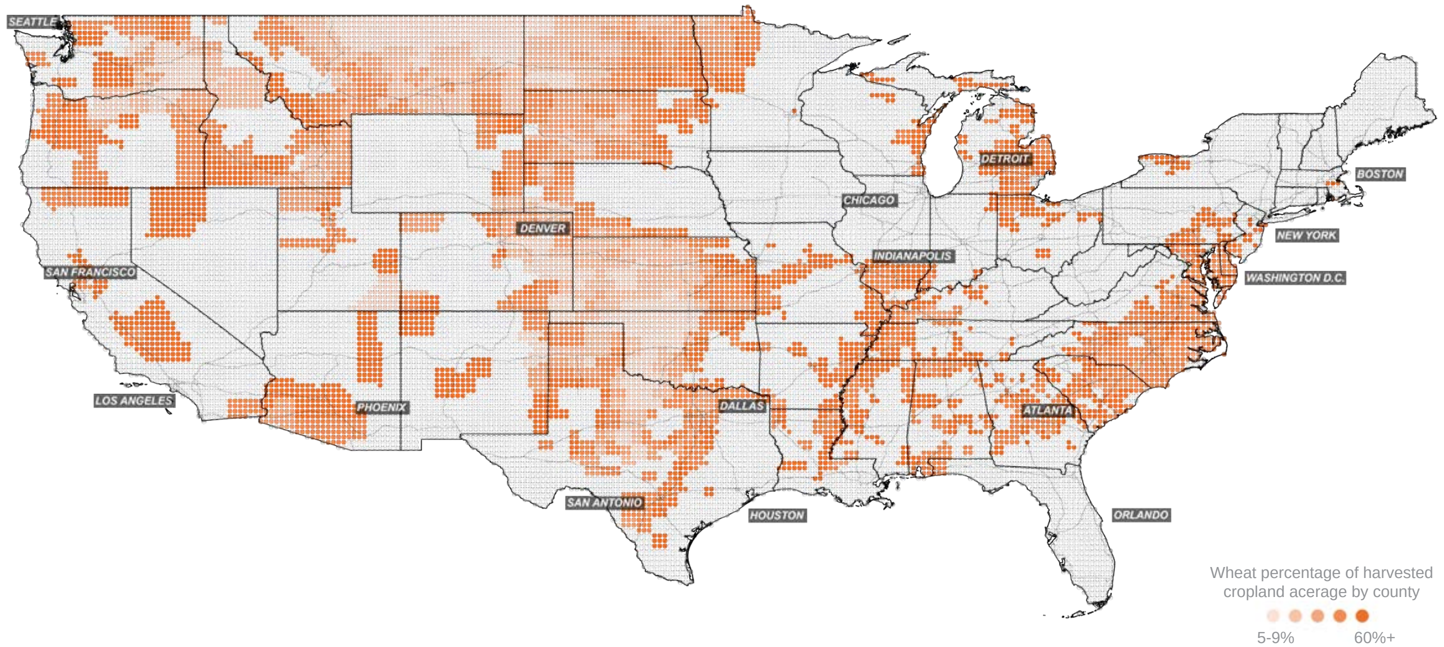
Primary Crop Lands

The four most common subsets of US crops are wheat, corn, soybeans, and cotton. Wheat, the most common crop by land area, predominates in the western half of the country. Soybean cultivation occupies 20% of agricultural land and is widespread throughout the Midwest, mid-Atlantic, and Southeast. There is a clear relationship between the relative productivity of US soils and the quantity and variety of crops planted in their regions.

Since 1935, the number of farms has decreased while their average size has increased, a phenomenon described as the consolidation of US agriculture.[28] As of the 2017 USDA census of agriculture, the 900 million acres of US farmland were distributed between 2.04 million farms, for a mean size of 441 acres; farms between 1 and 9.9 acres account for just 13.4% or the total farm operations, while farms greater than 2000 acres account for 4%.[29]

[28] "Farming and Farm Income." USDA ERS - Farming and Farm Income. U.S. Department of Agriculture. Accessed July 12, 2019. https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/farming-and-farm-income/

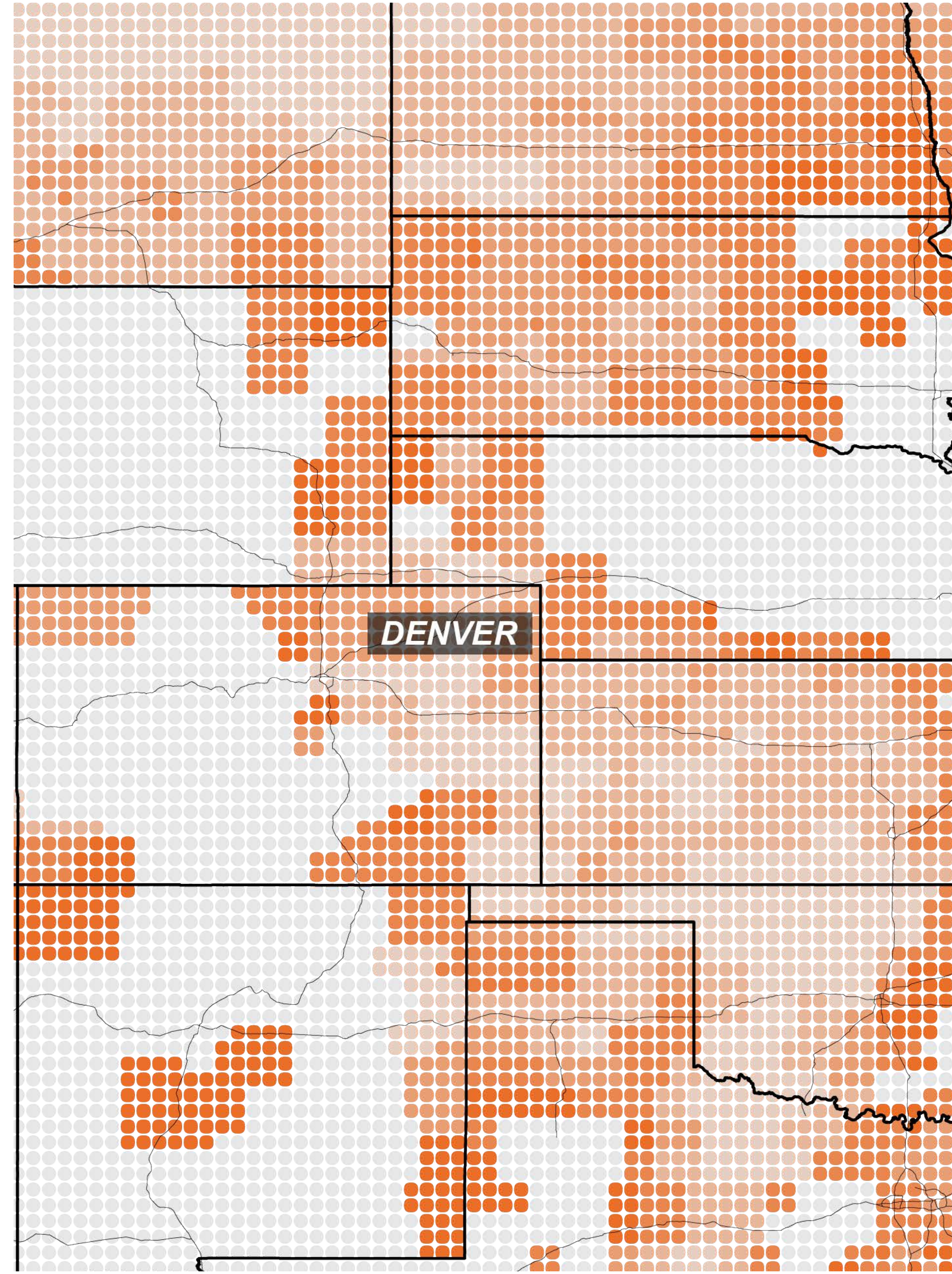
[29] U.S. Department of Agriculture. "Table 1. Historical Highlights: 2017 and Earlier Census Years." 2017 Census of Agriculture. Accessed July 12, 2019. https://www.nass.usda.gov/AgCensus/.

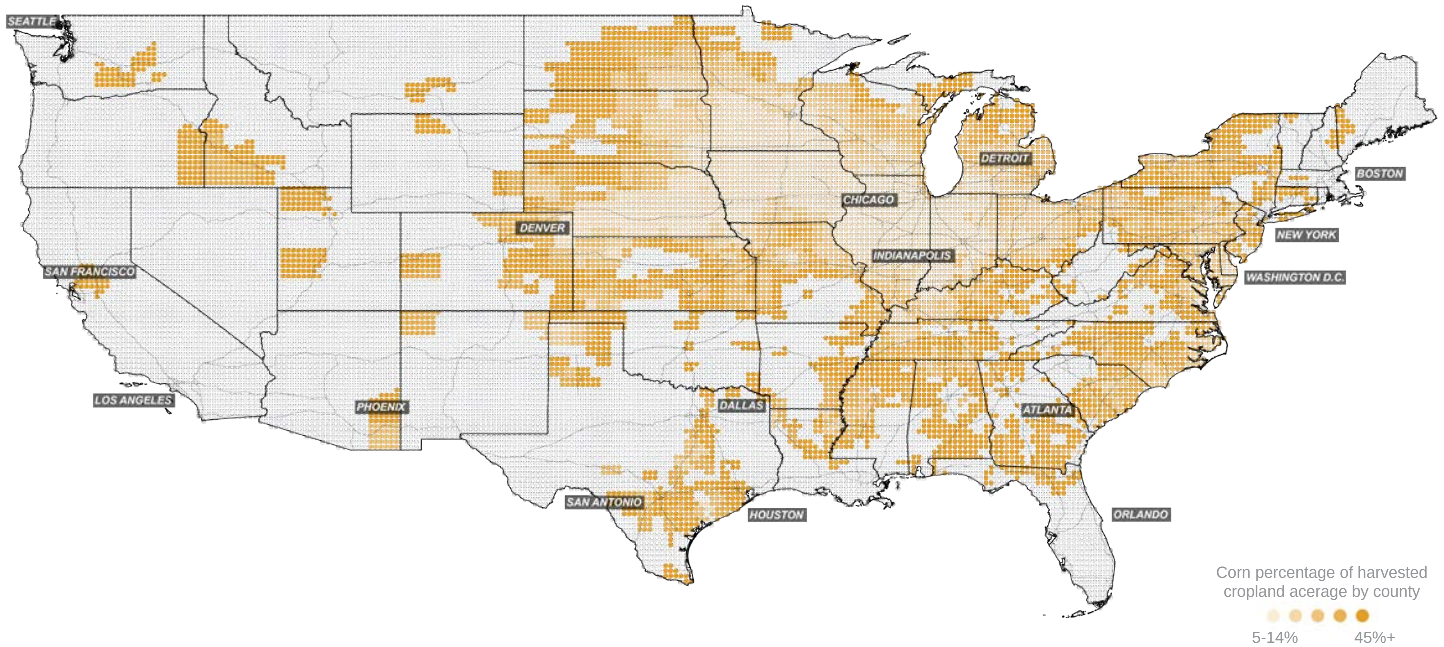


Crop Types: Wheat

Wheat is the most planted crop in the US by acreage. Wheat is present throughout the US, but often at relatively low intensities. In 65% of counties, wheat makes up less than 25% of crops by acreage; whereas it makes up 60% or more in only 3.2% of counties (making it the most geographically concentrated out of the four major crops). The US exports about half of its wheat crop, representing 15% of total global wheat exports.[30]

[30] "Overview." USDA ERS - Wheat. U.S. Department of Agriculture. Accessed July 12, 2019. https://www.ers.usda.gov/topics/crops/wheat/.





Crop Types: Corn

Corn is grown most intensely in and near the Great Lakes megaregion and across the eastern US. While corn generally represents less than 25% of the cropland in a given county, and makes up less than 5% of cropland in 41% of US counties, it remains the nation's second-largest crop by acreage. In its areas of highest concentration, corn is not grown as exclusively as wheat; the highest-producing counties typically devote only up to around 45% of their cropland to corn. On the other hand, corn production is relatively regionally concentrated; the states of Iowa and Illinois account for about 33% of all US-grown corn.[31] Corn agriculture contributes to pressures on water supplies; "87 percent of irrigated corn is grown in regions with high or extremely high water stress," according to World Resources Institute data.[32]

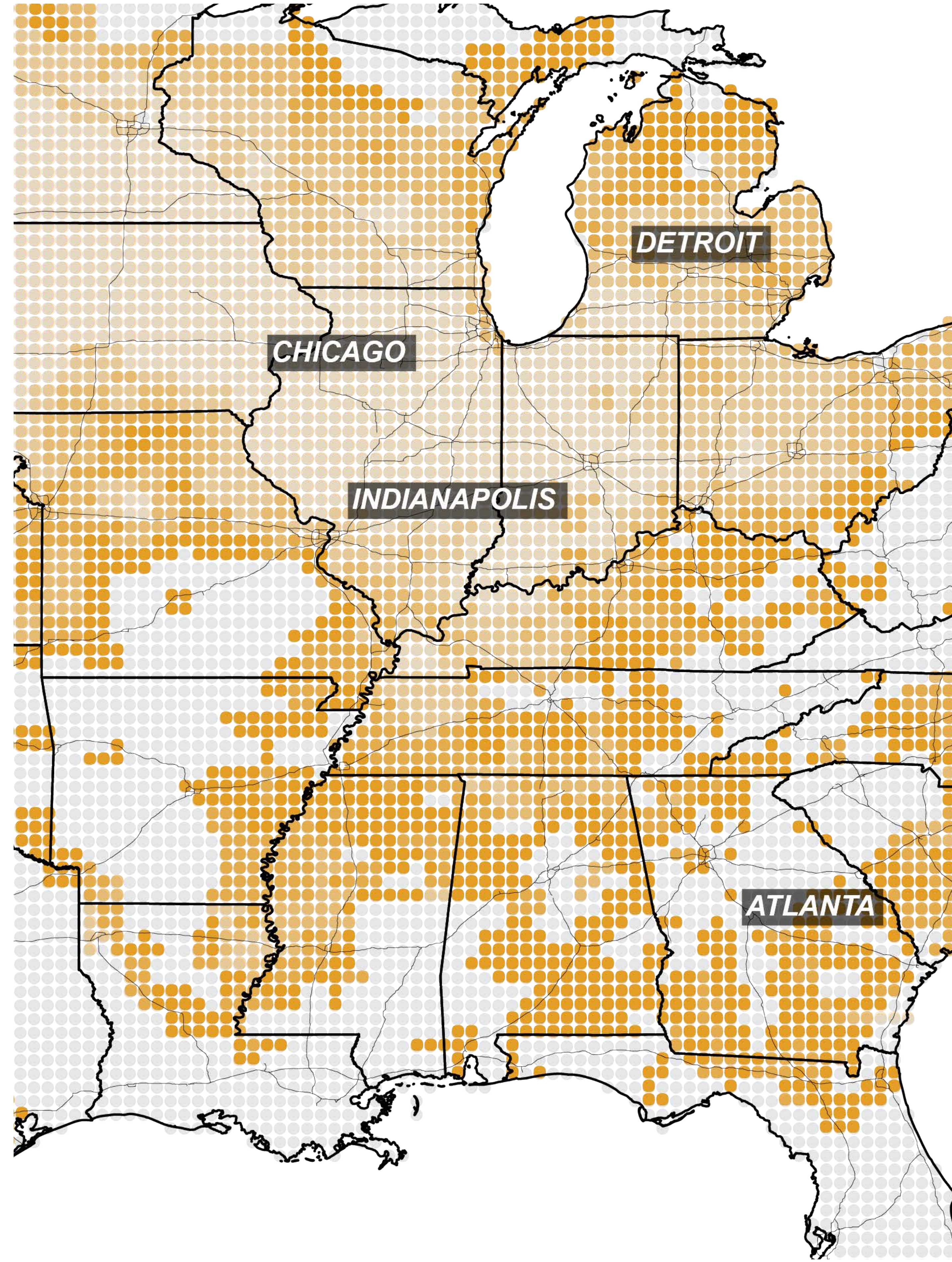
The majority of the 90 million total acres of US corn is used to produce either livestock feed or biofuels; ethanol production alone accounts for nearly 40% of total corn use.[33] The remainder is processed into food and industrial products, including sweeteners. Between 20% and 30% of the annual corn crop is exported.[34]

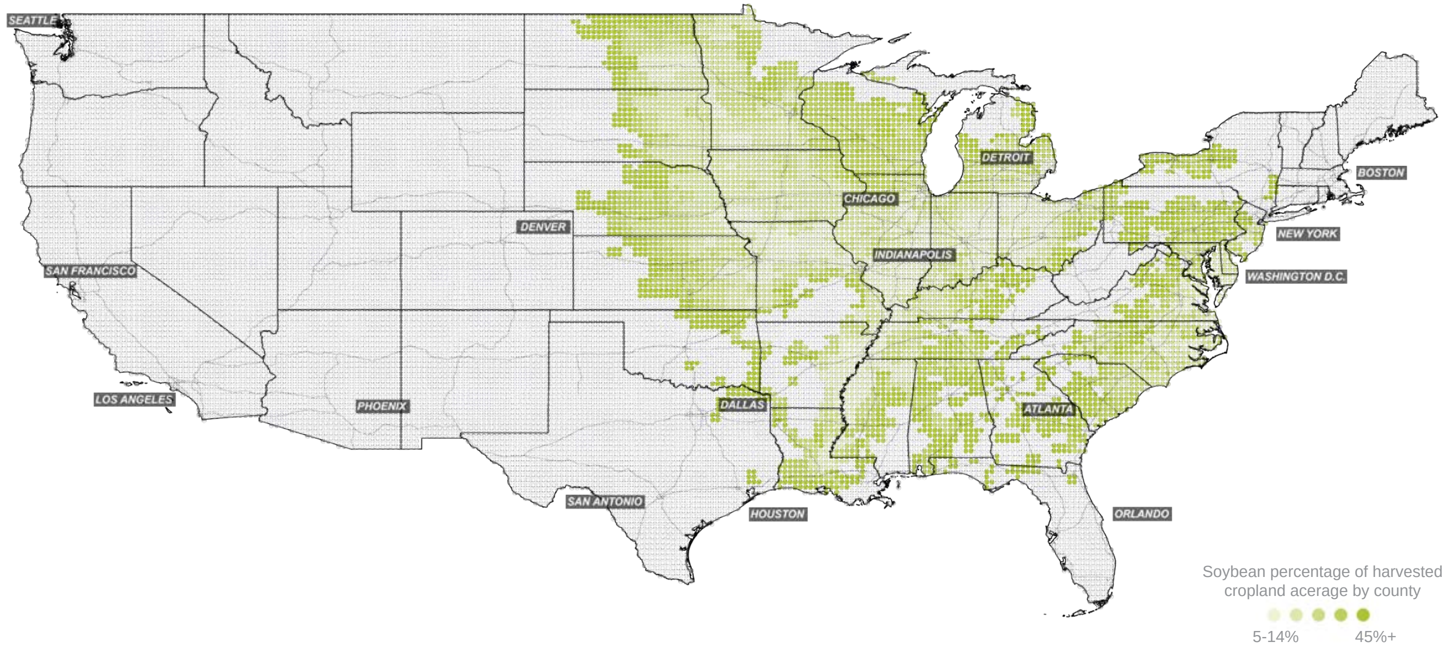
[31] "Feedgrains Sector at a Glance." USDA ERS - Feedgrains Sector at a Glance. U.S. Department of Agriculture. Accessed July 12, 2019. https://www.ers.usda.gov/topics/crops/corn-and-other-feedgrains/feedgrains-sector-at-a-glance/

[32] Barton, Brooke, and Sarah Elizabeth Clark. Water & Climate Risks Facing U.S. Corn Production How Companies & Investors Can Cultivate Sustainability. Report. June 2014. Accessed July 12, 2019. https://www.ourenergypolicy.org/wp-content/uploads/2014/06/ceres-corn.pdf

[33] "Feedgrains Sector at a Glance." USDA ERS - Feedgrains Sector at a Glance. U.S. Department of Agriculture. Accessed July 12, 2019. https://www.ers.usda.gov/topics/crops/corn-and-other-feedgrains/feedgrai....12, 2019. https://www.ers.usda.gov/topics/crops/corn-and-other-feedgrains/feedgrains-sector-at-a-glance/

[34] "Feedgrains Sector at a Glance." USDA ERS - Feedgrains Sector at a Glance. U.S. Department of Agriculture. Accessed July 12, 2019. https://www.ers.usda.gov/topics/crops/corn-and-other-feedgrains/feedgrains-sector-at-a-glance/



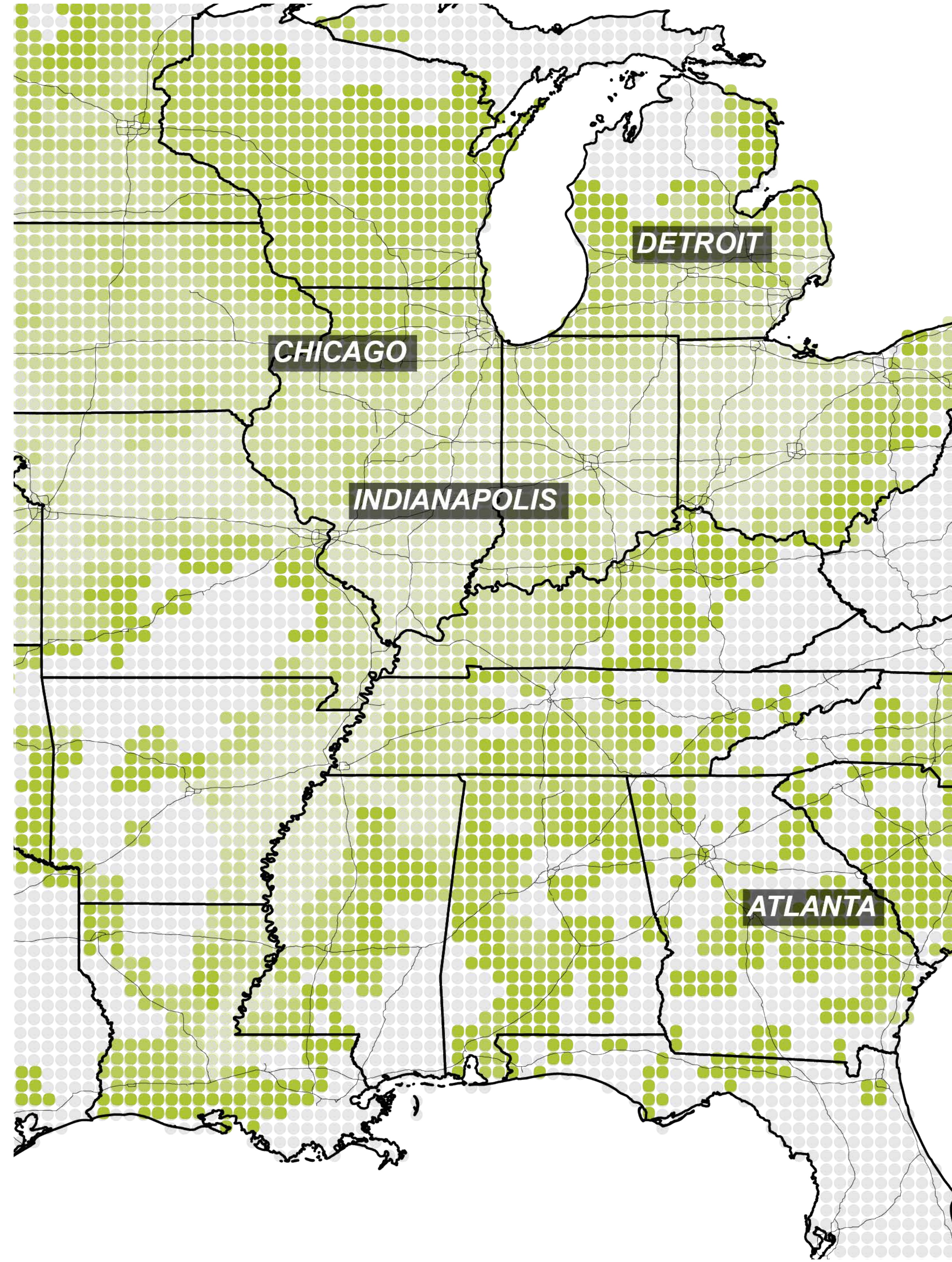


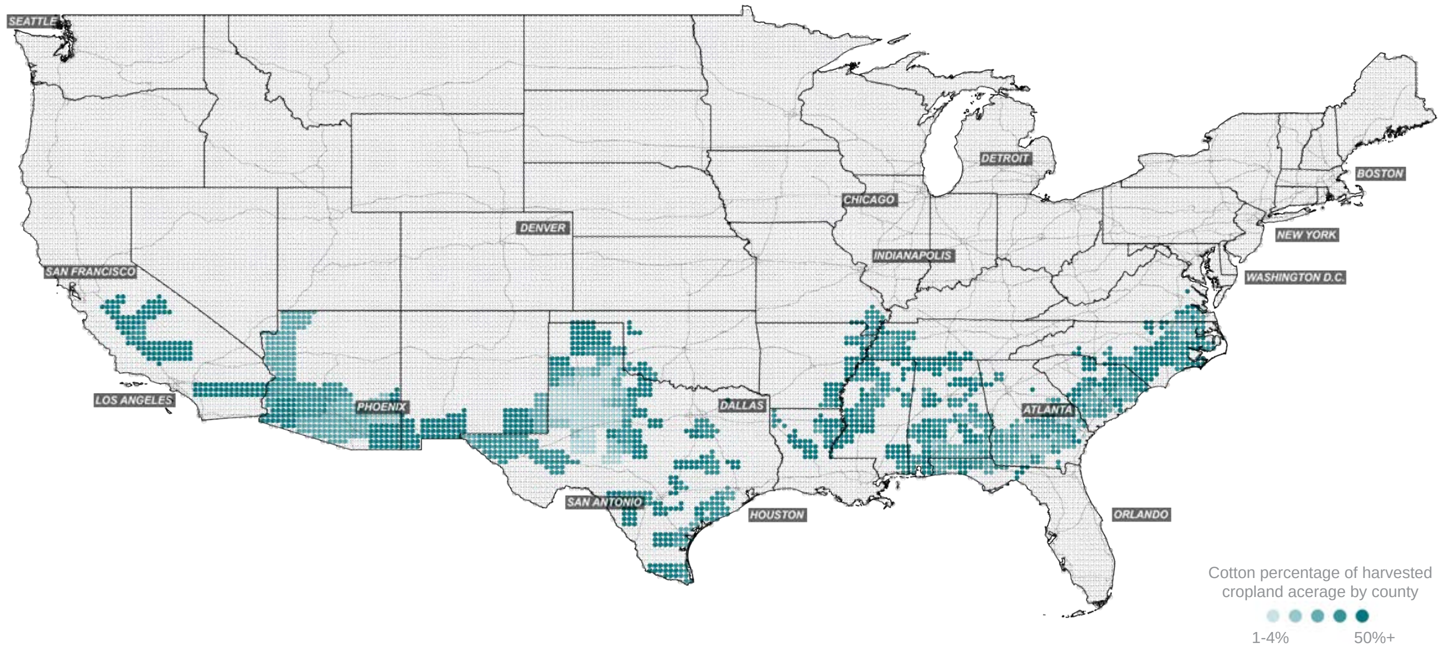
Crop Types: Soybeans

Introduced to the US in the twentieth century, the soybean is farmed for both food and oil, accounting for 90% of US oilseed production.[35] One of the more concentrated crops, soybean planting makes up less than 5% of cropland in nearly 50% of counties. Maximum soybean concentration is similar to that of corn, generally peaking at around 45% of crop acreage in a given county (though this peak only occurs in 9.2% of US counties). Soybean production is concentrated in and near the Great Lakes megaregion, home to more than 81% of production by acreage in 2018.[36] Soybean planting is increasing in the US, partially due to its common fifty-fifty planting on shared fields with corn crops.

[35] "Oil Crops Sector at a Glance." USDA ERS - Oil Crops Sector at a Glance. U.S. Department of Agriculture. Accessed July 12, 2019. https://www.ers.usda.gov/topics/crops/soybeans-oil-crops/oil-crops-sector-at-a-glance/

[36] "Oil Crops Sector at a Glance." USDA ERS - Oil Crops Sector at a Glance. U.S. Department of Agriculture. Accessed July 12, 2019. https://www.ers.usda.gov/topics/crops/soybeans-oil-crops/oil-crops-sector-at-a-glance/





Crop Types: Cotton

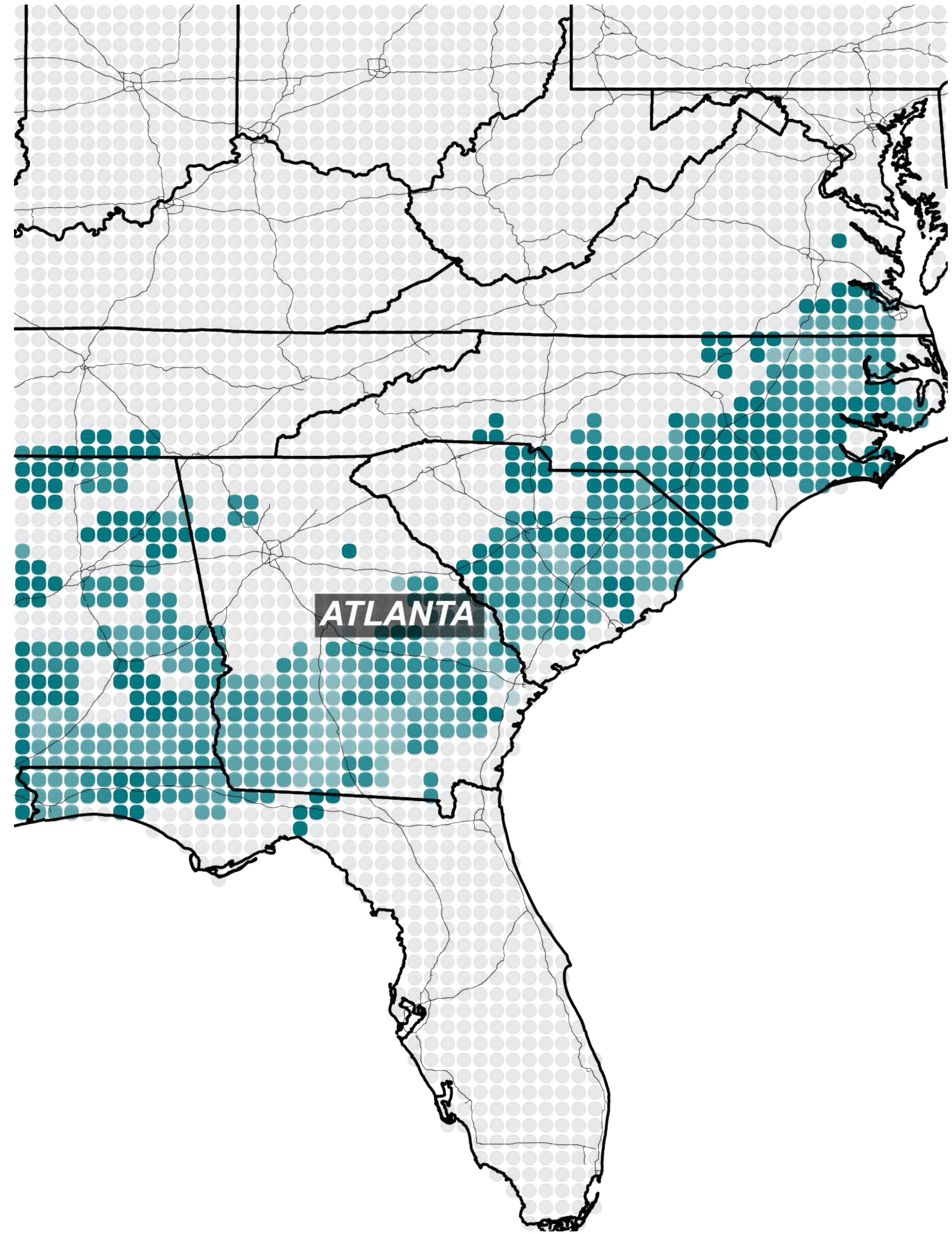
Cotton is a common textile fiber, accounting for a quarter of total world fiber use.[37] Cotton is the most concentrated of the four common US crops, making up 1% or more of total cropland in only 18% of counties and 30% or more in only 4.6% of counties. These high-cotton counties are primarily concentrated in the southern US, where cotton remains prominent due to shared environmental and sociopolitical histories—the cotton-friendly soil and environment and the legacy of slavery and the plantation system.

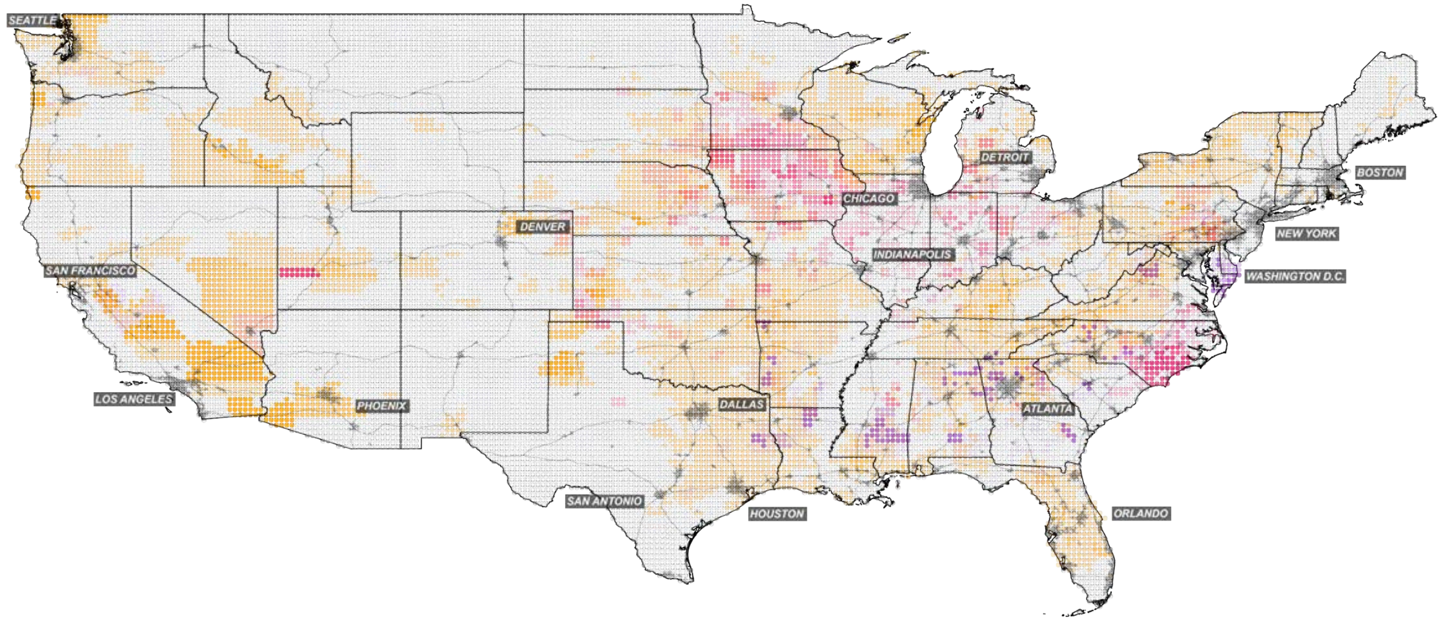
Water availability is a major issue facing cotton production; it takes 10,000 liters of water to produce 2.2 pounds of cotton (the amount required to produce a T-shirt).[38] In comparison, it takes only about 1,500 liters of water to produce 2.2 pounds of wheat.[39] Compounding this pressure, cotton is most commonly grown in some of the hottest and water-scarce regions of the US.

[37] "Overview." USDA ERS - Cotton & Wool. U.S. Department of Agriculture. Accessed July 12, 2019. https://www.ers.usda.gov/topics/crops/cotton-wool/.

[38] "Cotton." WWF. Accessed July 12, 2019. https://www.worldwildlife.org/industries/cotton.

[39] Global Food: Waste Not, Want Not. Report. Institution of Mechanical Engineers. January 2013. Accessed July 19, 2019. https://www.imeche.org/docs/default-source/reports/Global_Food_Report.pdf

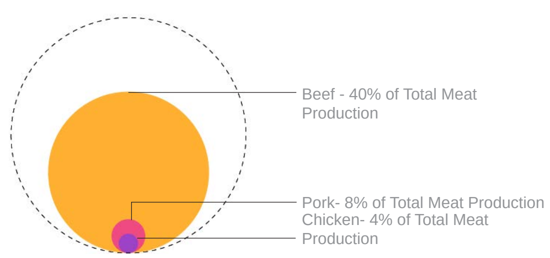




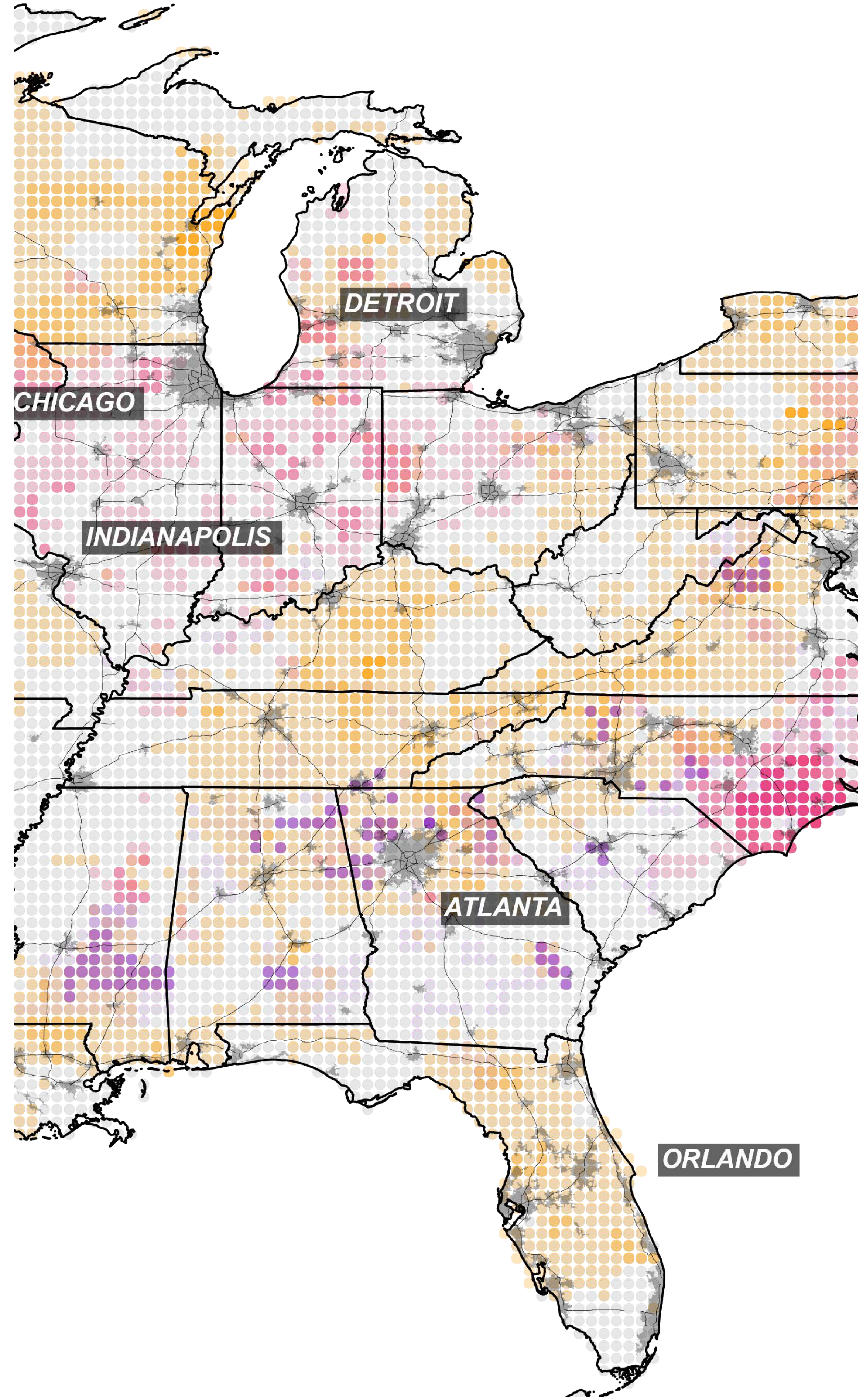
Meat Production Lands

Over half of US agricultural cash receipts come from livestock and poultry. While all meat production requires large amounts of land and water and emits greenhouse gases, beef production is particularly environmentally detrimental, requiring approximately seven times more land and emitting seven times more greenhouse gases than chicken production.[41] Per pound, beef requires 1,799 gallons of water, pork requires 575 gallons, and chicken requires 470 gallons.[42] In 2013, the US consumed 254.2 pounds of meat per person, almost three times the global average of 94.8 pounds per person.[43] Meat production is widespread throughout the US, with beef production occurs in 40% of counties, pork production in 8%, and chicken production in 4%.

The population of meat animals in the US has grown over time, linked with the rise of concentrated animal feeding operations (CAFOs), or factory farms.[44] Coincident with increased concentration is a general decrease in animal health and welfare as well as negative physical and mental impacts on nearby human communities.[45] One major environmental externality is the buildup of animal waste, which is kept in lagoons or sprayed onto neighboring fields, carrying not only a repulsive odor but also pathogens, heavy metals, and, potentially, antibiotic resistant bacteria.[46] The negative correlation between density of animals and environmental health can be seen in the water, air, and land pollution reports that accompany accounts of feedlots in the US.[47]



[40] "Animal Products." USDA ERS - Animal Products. U.S. Department of Agriculture. Accessed July 21, 2019. https://www.ers.usda.gov/topics/animal-products/.



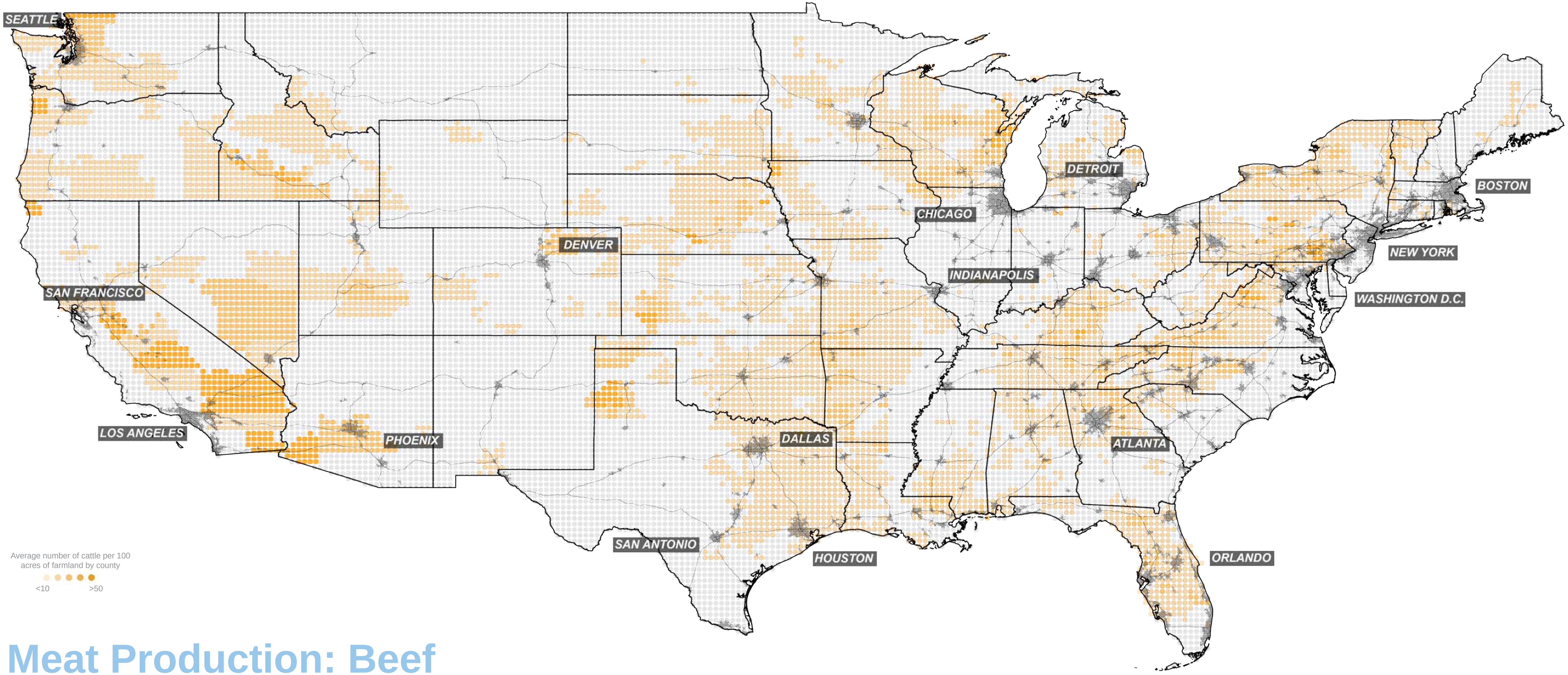
[41] Waite, Richard. "2018 Will See High Meat Consumption in the U.S., but the American Diet Is Shifting." World Resources Institute. September 26, 2018. Accessed July 21, 2019. https://www.wri.org/blog/2018/01/2018-will-see-high-meat-consumption-us-american-diet-shifting.

[42] "Why Meat Eats Resources." Water Footprint Calculator. December 14, 2018. Accessed July 21, 2019. https://www.watercalculator.org/footprints/why-meat-eats-resources/.

[43] Ritchie, Hannah, and Max Roser. "Meat and Seafood Production & Consumption." Our World in Data. August 25, 2017. Accessed July 21, 2019. https://ourworldindata.org/meat-production#per-capita-trends-in-meat-consumption[44] "1 Overview of U.S. Livestock, Poultry, and Aquaculture Production in 2010 and Statistics on Major Commodities." Demographics 2010. U.S. Department of Agriculture. Accessed 21 July 2019. https://www.aphis.usda.gov/animal_health/nahms/downloads/Demographics2010_rev.pdf

[45] "Understanding Concentrated Animal Feeding Operations and Their Impacts on Communities."[46] Nicole, Wendee. "CAFOs and environmental justice: The case of North Carolina." (2013): a182-a189.

[47] "Concentrated Animal Feeding Operations." National Conference of State Legislatures. Accessed 21 July 2019. https://www.ncsl.org/research/agriculture-and-rural-development/concentrated-animal-feeding-operations.aspx



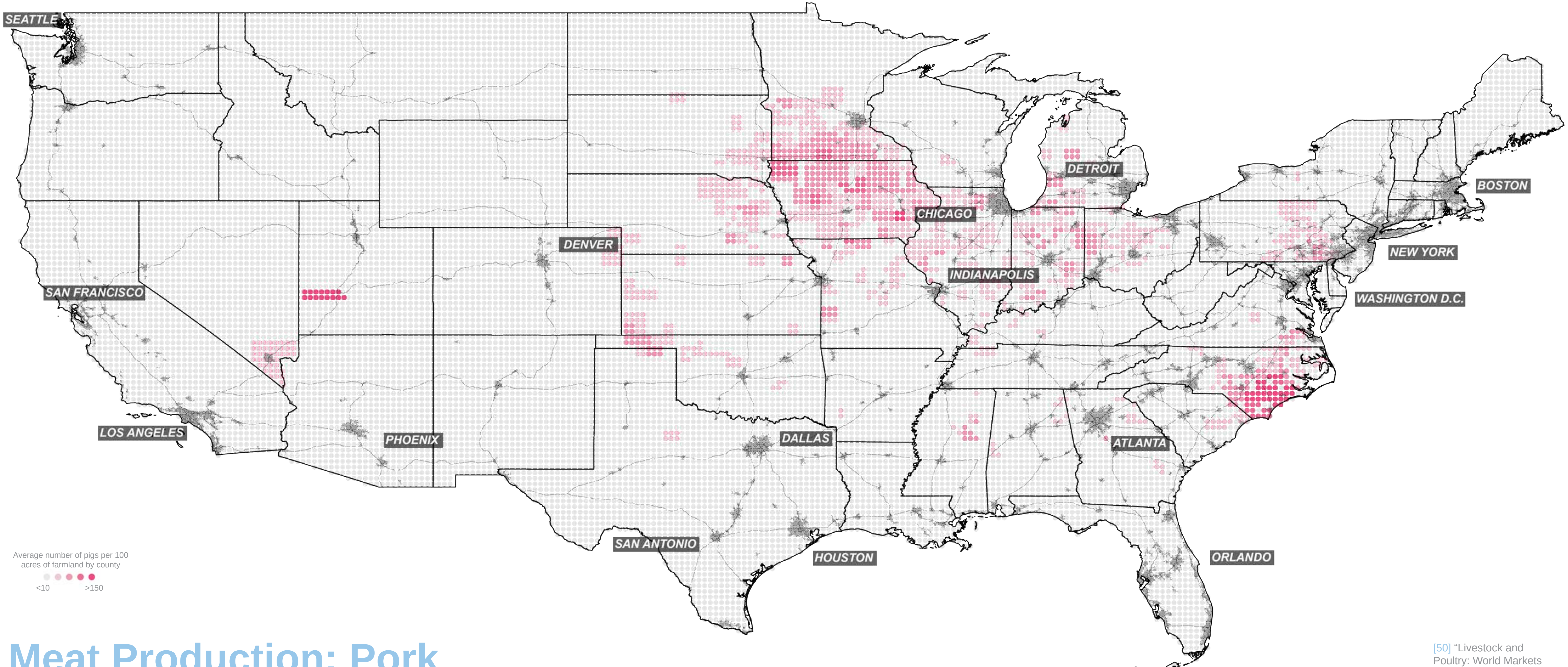
Meat Production: Beef

The US has the largest fed-cattle industry in the world and is the largest producer of beef for both export and domestic use; yet it is a net beef importer.[48] The industry can be divided into two sectors: cow-calf (which feature permanent breeding herds of female cows) and cattle feeding. Cow-calf operations are commonly located on range and pasture lands not appropriate for crop production. Cattle are widespread throughout the US, often at low densities, with feedlots concentrated west of the Great Lakes megaregion.[49]

In 82.9% of counties there are fewer than 20 cattle per 100 acres; in less than 1% of counties are there more than 50 cattle per 100 acres. The county with the highest concentration, San Bernardino County in California, has 195.5 cattle per 100 acres. The consolidation seen in crop agriculture is also occurring in the beef sector, with a general trend toward fewer, larger, and more intensive operations.

[48] "Cattle & Beef." USDA ERS - Cattle & Beef. U.S. Department of Agriculture. Accessed July 21, 2019. https://www.ers.usda.gov/topics/animal-products/cattle-beef/.

[49] "Sector at a Glance." USDA ERS - Sector at a Glance. U.S. Department of Agriculture. Accessed July 21, 2019. https://www.ers.usda.gov/topics/animal-products/cattle-beef/sector-at-a-glance/



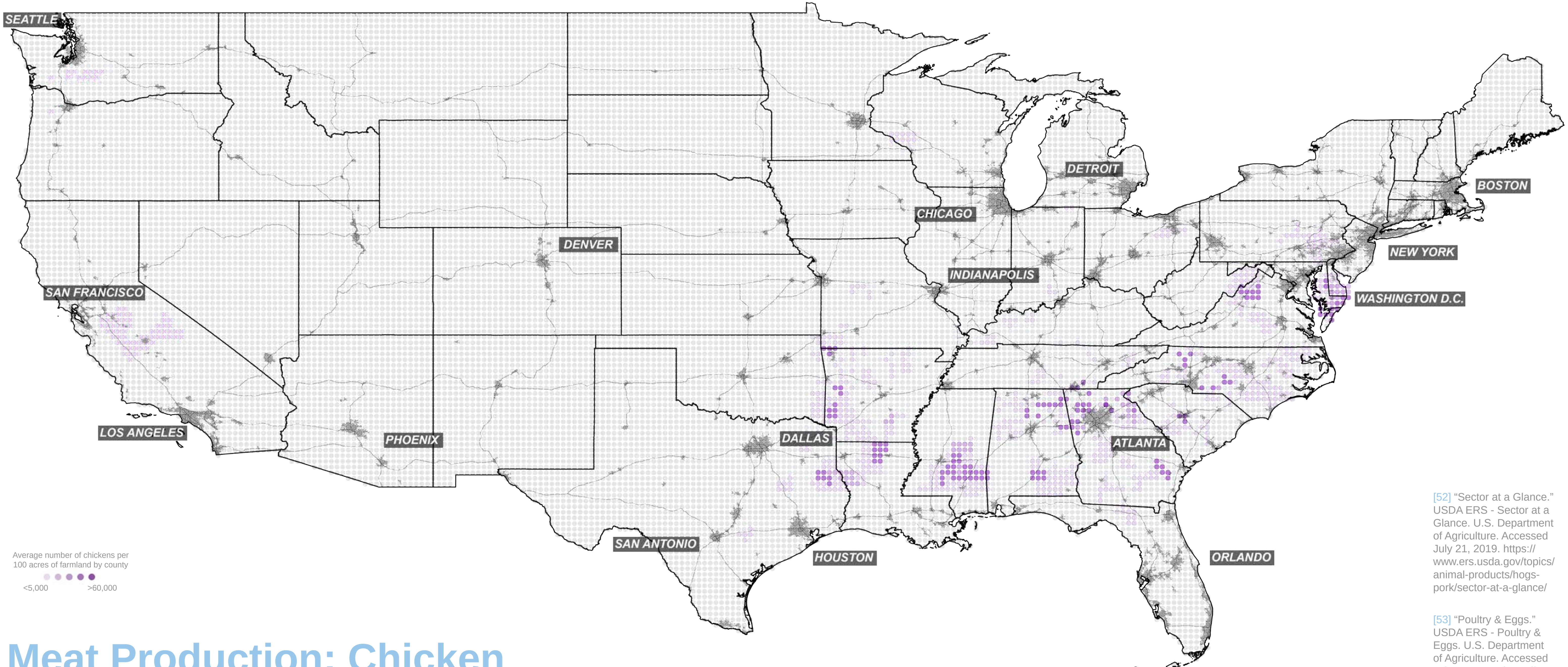
Meat Production: Pork

The US is the third-largest producer and consumer of pork, after China and the European Union.[50] The pork industry can be divided into three sectors, each incorporating some type of confinement: farrow-to-finish (pigs are born, raised, and grown to slaughter weight), feeder pig production (pigs are born and raised, then sold to be grown further), and feeder pig finishing (pigs are purchased at a certain weight, then grown further to slaughter weight).[51] Pork production is relatively minimal in most US counties; nearly 50% of counties have below 1 pig per 100 acres, and only 4% of counties have more than 50 pigs per 100 acres. However, the industry is highly concentrated, primarily in the Great Lakes megaregion and in North Carolina; in regions where production is prevalent, pig operations are at high densities. Duplin County, North Carolina, for example has 750 pigs per 100 acres on average.

[50] "Livestock and Poultry: World Markets and Trade." U.S. Department of Agriculture. 12 October 2016. Accessed 21 July 2019. https://downloads.usda.library.cornell.edu/usda-esmis/files/73666448x/

0r967405p/9s1616627/livestock-poultry-ma-10-12-2016.pdf

[51] "Sector at a Glance." USDA ERS - Sector at a Glance. U.S. Department of Agriculture. Accessed July 21, 2019. https://www.ers.usda.gov/topics/animal-products/hogs-pork/sector-at-a-glance/



Meat Production: Chicken

The US poultry industry is "the world's largest producer and second largest exporter of poultry meat and a major egg producer."[52] Production grew between 2008 and 2017 due to increasing domestic and foreign demand.[53] Domestic poultry demand has recently displaced a significant amount of beef and pork consumption—more poultry is consumed than either beef or pork, though less than both combined.[54] Since 1990, the US consumed 63.1 pounds of chicken and 52.9 pounds of beef per person.[55]

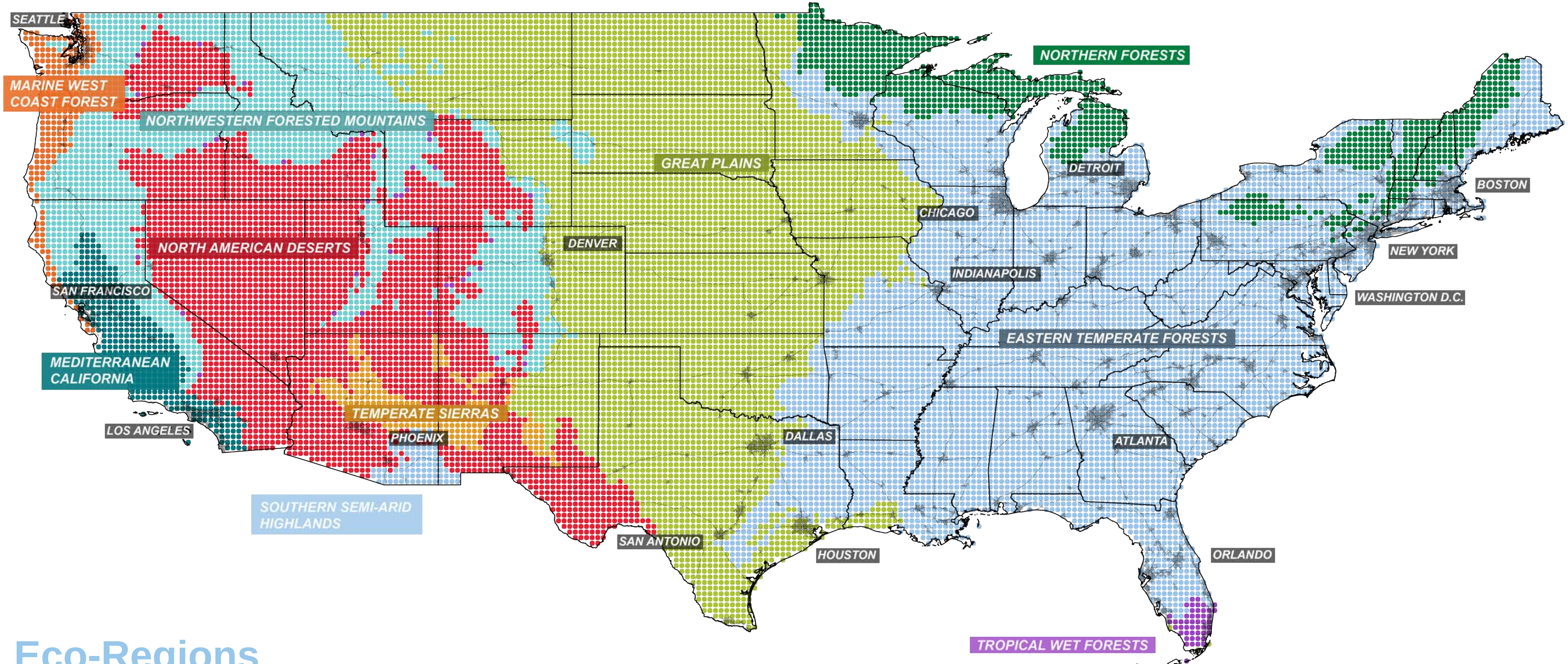
With a growing US human population and increasing consumer demand, more chickens are being bred, held in captivity, and killed than ever before. Chicken farming is highly concentrated, mostly running in a band across the South. Most US counties have little or no chicken farming, with 73.8% of counties reporting below 1 chicken per 100 acres or otherwise not reporting data. Only 10.2% of counties have over 5,000 chickens per 100 acres, and just 1.2% of counties have over 50,000 chickens per 100 acres. The highest density is in Gilmer County, Georgia, with over 275,000 chickens per 100 acres.

[52] "Sector at a Glance." USDA ERS - Sector at a Glance. U.S. Department of Agriculture. Accessed July 21, 2019. https://www.ers.usda.gov/topics/animal-products/hogs-pork/sector-at-a-glance/

[53] "Poultry & Eggs." USDA ERS - Poultry & Eggs. U.S. Department of Agriculture. Accessed July 21, 2019. https://www.ers.usda.gov/topics/animal-products/poultry-eggs/.

[54] "Poultry Sector at a Glance." USDA ERS - Sector at a Glance. U.S. Department of Agriculture. Accessed July 21, 2019.

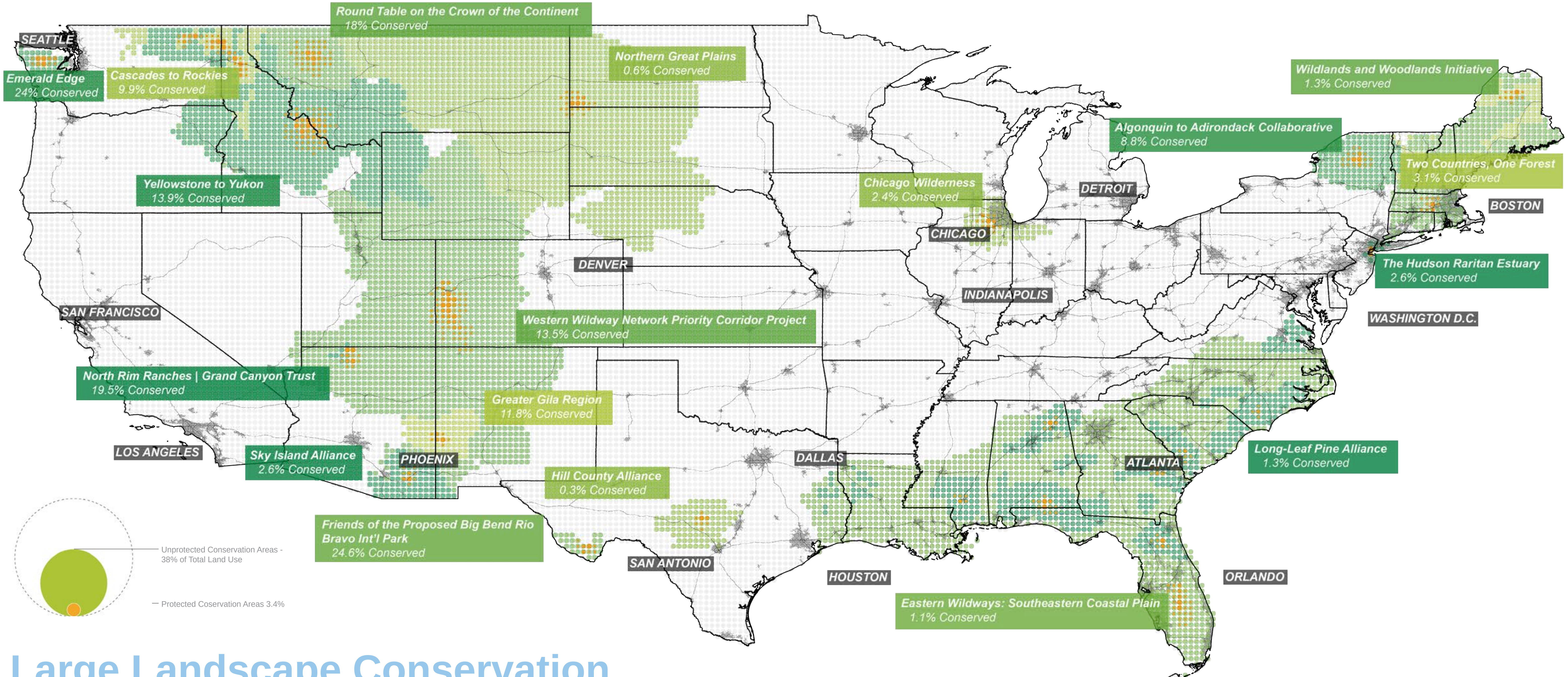
[55] "Poultry Sector at a Glance." USDA ERS - Sector at a Glance. U.S. Department of Agriculture. Accessed July 21, 2019. https://www.ers.usda.gov/topics/animal-products/poultry-eggs/sector-at-a-glance/



Eco-Regions

The EPA identifies fifteen North American ecoregions, areas where "ecosystems (and the type, quality, and quantity of environmental resources) are generally similar."[56] Of these, ten are present in the conterminous US. The largest ecoregion by land area "eastern temperate forests," comprising 25.6% of total US land area. The "great plains" ecosystem is the second largest, at 22.8%; "North American deserts," covering a large area of the interior West, comes in third at 14.4%. No other ecoregion exceeds 10% of total US land.

[56] "Food Availability and Consumption." USDA ERS - Food Availability and Consumption. U.S. Department of Agriculture. Accessed July 21, 2019. https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/food-availability-and-consumption/



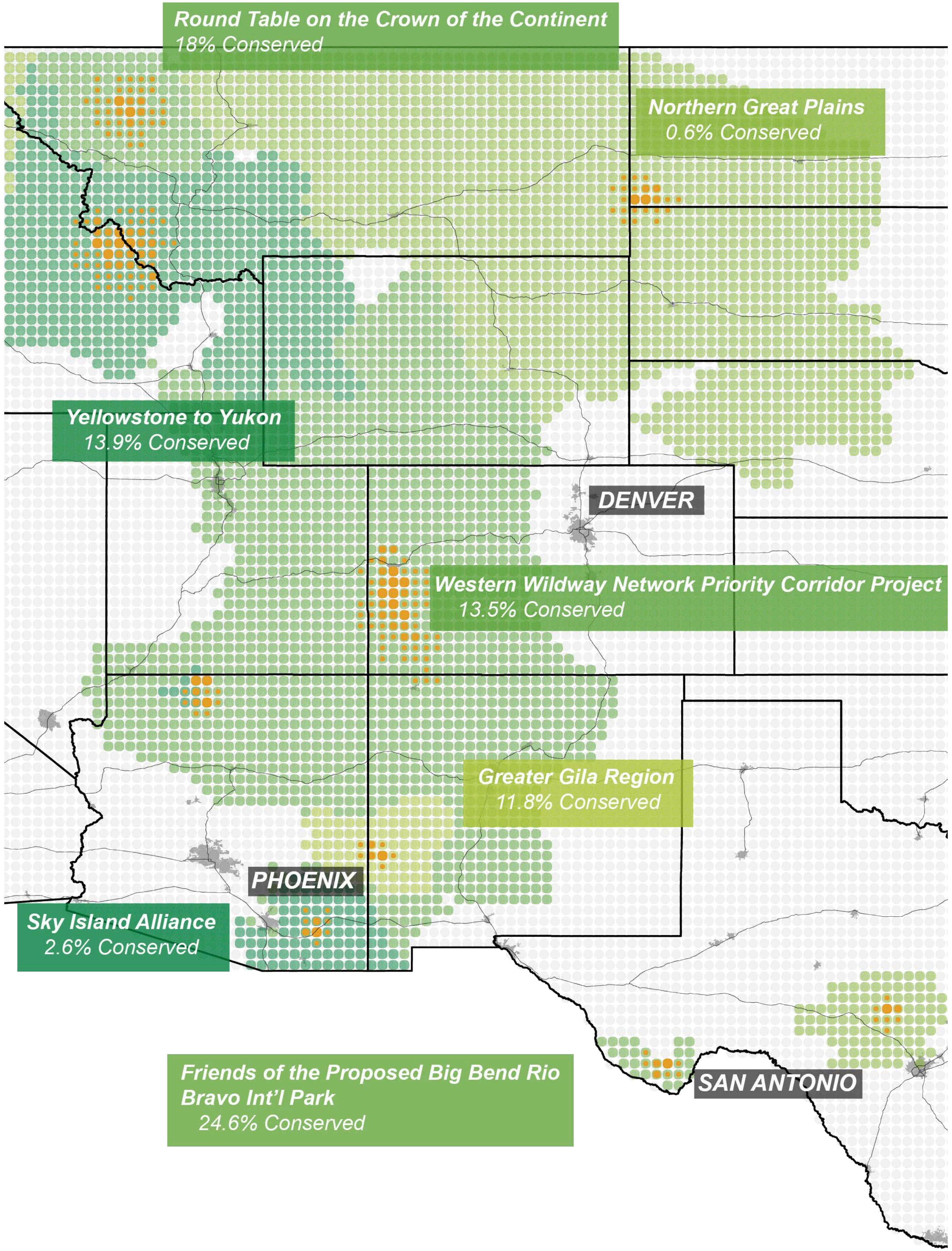
Large Landscape Conservation

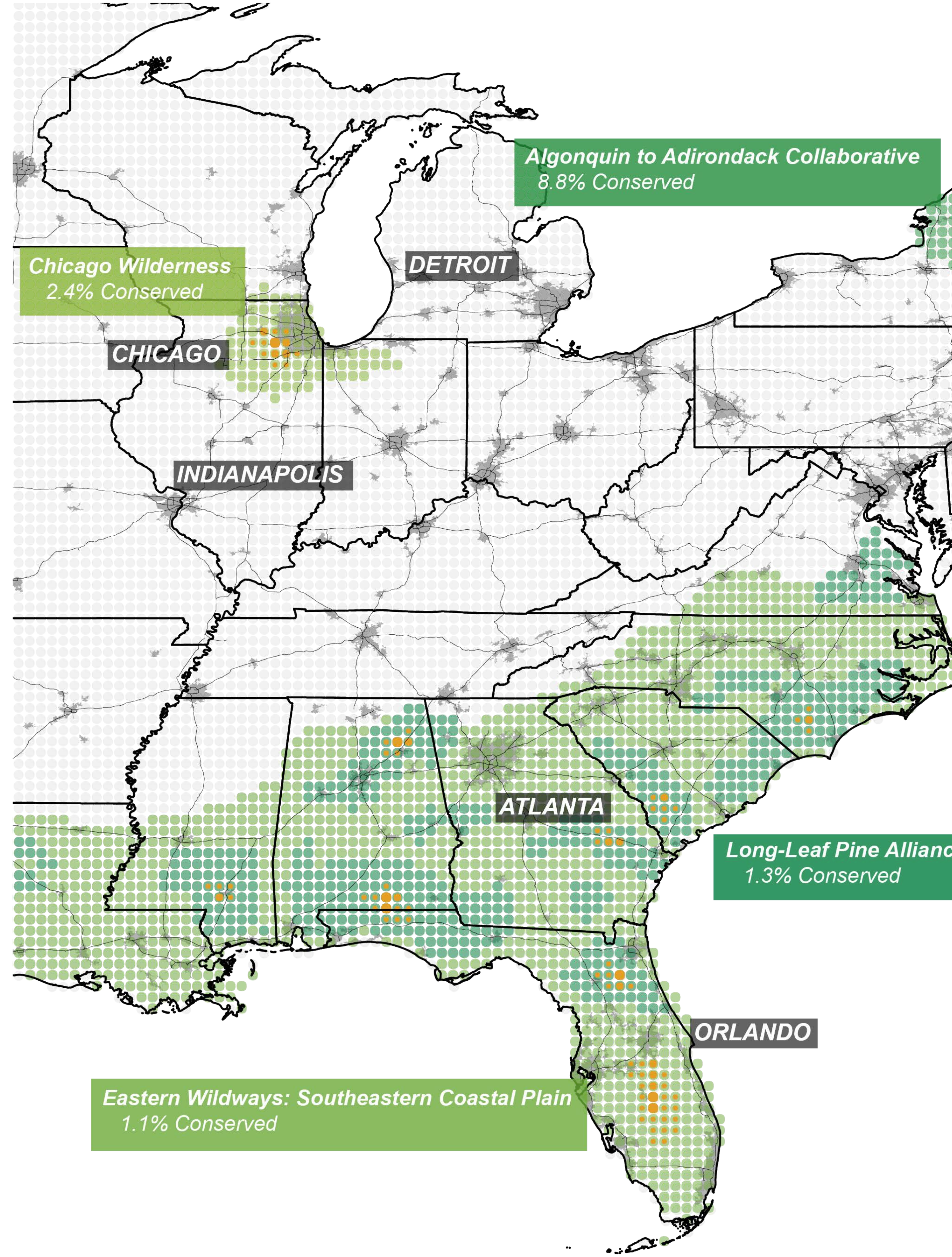
Conservation practices have shifted over the past few decades from a focus on fortresslike patches of "protected lands" toward interconnected corridors that improve resiliency and enable species migrations. In partnership with the International Union for Conservation of Nature (IUCN), the Connectivity Conservation Specialist Group is working on global connectivity efforts, calling for "connectivity conservation [to link] landscapes/seascapes, reducing fragmentation and enabling migratory flows essential to a functioning and resilient system."[57]

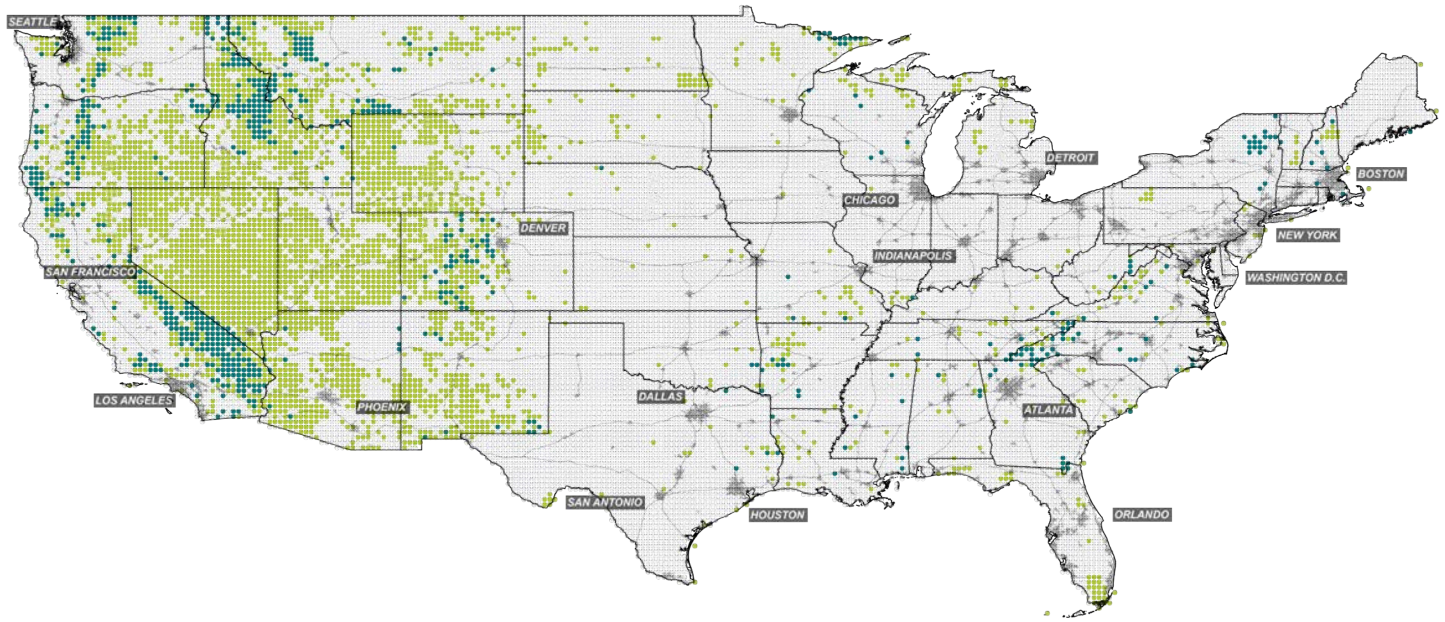
In the US, eighteen large-scale conservation efforts overlap across the country (and over national borders) to improve habitat connectivity throughout the half of the country they occupy. The projects vary in size from 826,612 to 685,470,328 acres; these boundaries include protected, semi-protected, and not protected lands. The project with the highest proportion of protected lands is the proposed Big Bend–Rio Bravo International Park, with 24.6% protected; lowest is the Northern Great Plains at 0.6%.[58] On average, only 8.8% of each project's land area is fully protected and 84.7% has no protection. Eight projects cross the US-Canada border and three cross the US-Mexico border; the Western Wildway Network Priority Corridor Project, the largest of the projects, spans the entirety of North America, from Alaska to Mexico.

[57] "Ecoregions." EPA. March 27, 2018. U.S. Environmental Protection Agency. Accessed July 21, 2019. https://www.epa.gov/eco-research/ecoregions.

[58] "Vision and Mission." Conservation Corridor. Accessed July 21, 2019. http://conservationcorridor.org/ccsg/vision-and-mission/.


Round Table on the Crown of the Continent
18% Conserved
Northern Great Plains
0.6% Conserved
Yellowstone to Yukon
13.9% Conserved
DENVER
Western Wildway Network Priority Corridor Project
13.5% Conserved
Greater Gila Region
11.8% Conserved
PHOENIX
Sky Island Alliance
2.6% Conserved
SAN ANTONIO
Friends of the Proposed Big Bend Rio Bravo Int'l Park
24.6% Conserved


Algonquin to Adirondack Collaborative
8.8% Conserved
Chicago Wilderness
2.4% Conserved
DETROIT
CHICAGO
INDIANAPOLIS
ATLANTA
Long-Leaf Pine Alliance
1.3% Conserved
ORLANDO
Eastern Wildways: Southeastern Coastal Plain
1.1% Conserved

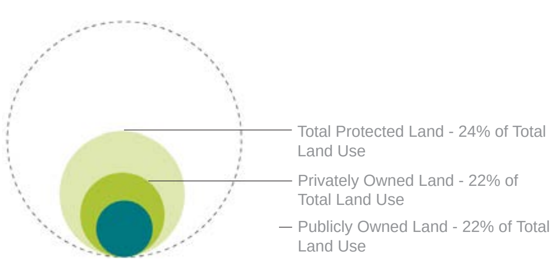


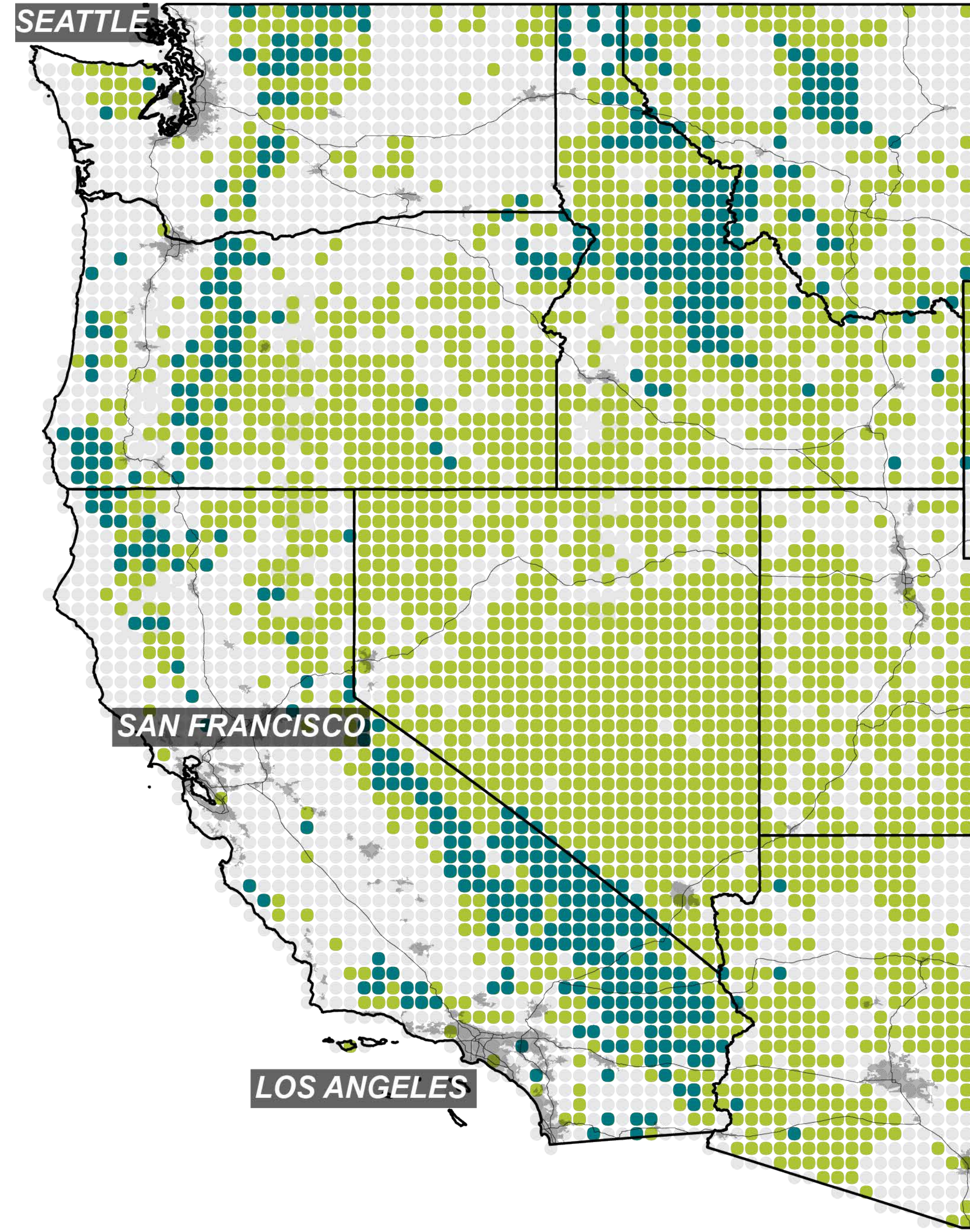
Protected Lands

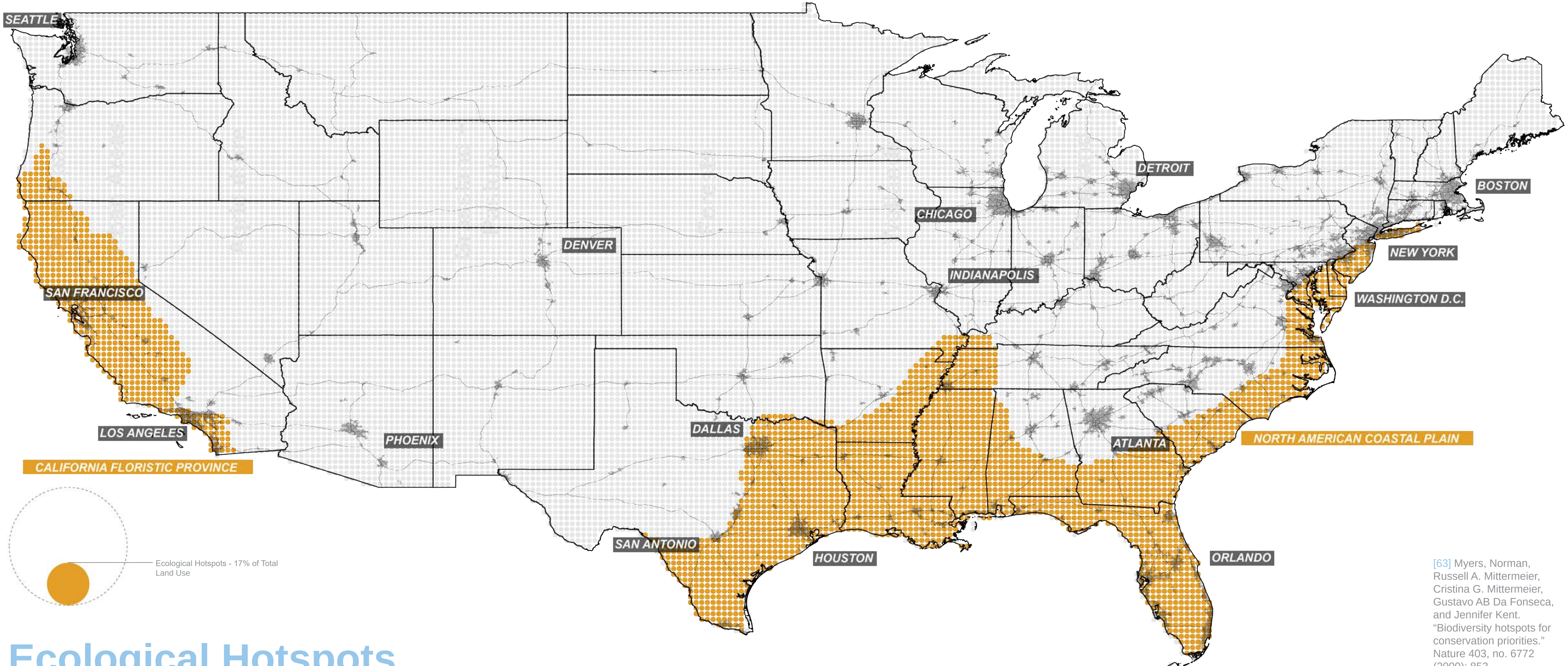
Protected areas are "dedicated to the preservation of biological diversity and to other natural, recreation and cultural uses, and managed for these purposes through legal or other effective means."[59] US protected areas are classified into two main categories based on management: publicly protected lands (including state and local government lands, American Indian lands, and regional agency special district management) and privately protected lands. Just under 25% of the US is considered protected. Most of these protected areas are concentrated in the West; this has roots in historical US settler colonialism and expansion. Settlement along the East Coast was largely driven by private individuals and entities, whereas land in the interior and West was generally acquired first by the federal government.[60]

[59] Globescapes. Accessed July 21, 2019. http://www.globescapes.org/map/.

[60] "Gap Analysis Project." Protected Areas | USGS.gov. U.S. Geological Survey. Accessed July 21, 2019. https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap/science/protected-areas







Ecological Hotspots

17% of US land is considered to be an ecological hotpot—one of "Earth's most biologically rich—yet threatened— terrestrial regions." There is little overlap between ecological hotspots and protected lands.[61] To qualify as a hotspot, an area must meet two criteria: it must contain 1,500 endemic vascular plant species; and it must have lost at least 70% of its primary vegetation—a common habitat category, especially for endemics, and thus a good marker for total biodiversity.[62]

US hotspots include the California floristic province and the North American coastal plain, both coastal regions. The California floristic province contains a wide variety of ecosystems, perhaps most famously the sequoia tree ecosystem, home to the endangered giant sequoia and coast redwood. Other threatened species inhabiting this hotspot include the endangered giant kangaroo rat, the desert slender salamander, and the critically endangered California condor.[63] This hotspot's main threats come from human activity and development, particularly agricultural expansion; only 25% of the hotspot's original vegetation remains.[64] The North American coastal plain, listed in 2016, is one of the newest hotspots. This hotspot is a fire-dependent region, and is threatened by fire suppression (which inhibits the cycle of the native vegetation), deforestation for agriculture, and infrastructure development. The climate crisis also now adds to the vulnerability of plants and animals in the hotspots.[65]

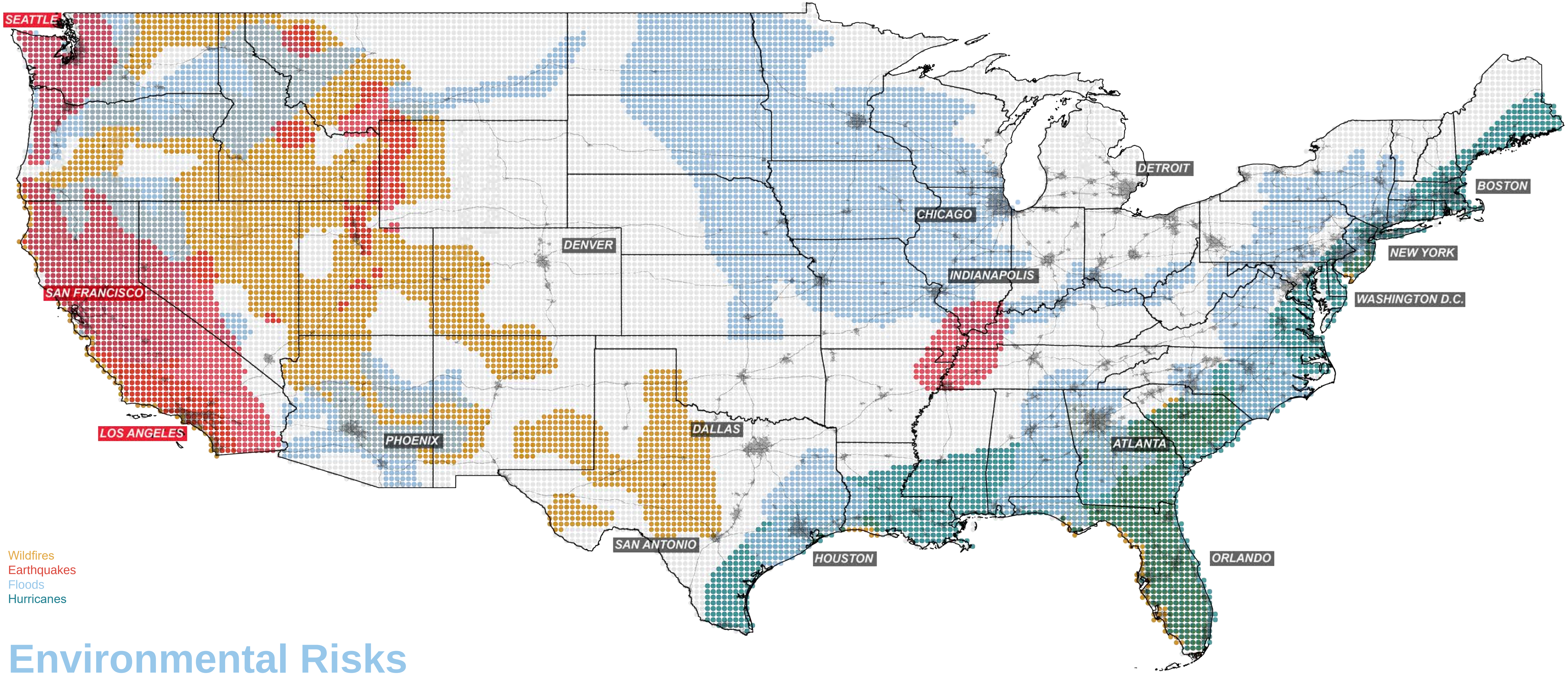
[61] Sowards, Adam M. "Public Lands and Their Administration." Oxford Research Encyclopedia of American History. October 19, 2017. Accessed July 21, 2019. https://oxfordre.com/americanhistory/view/10.1093/acrefore/9780199329175.001.0001/acrefore-9780199329175-e-396

[62] "Biodiversity Hotspots Defined." Critical Ecosystem Partnership Fund. Accessed July 21, 2019. https://www.cepf.net/our-work/biodiversity-hotspots/hotspots-defined.

[63] Myers, Norman, Russell A. Mittermeier, Cristina G. Mittermeier, Gustavo AB Da Fonseca, and Jennifer Kent. "Biodiversity hotspots for conservation priorities." Nature 403, no. 6772 (2000): 853.

[64] "California Floristic Province." Critical Ecosystem Partnership Fund. Accessed July 21, 2019. https://www.cepf.net/our-work/biodiversity-hotspots/california-floristic-province

[65] "California Floristic Province - Threats." Critical Ecosystem Partnership Fund. Accessed July 21, 2019. https://www.cepf.net/our-work/biodiversity-hotspots/california-floristic-province/threats

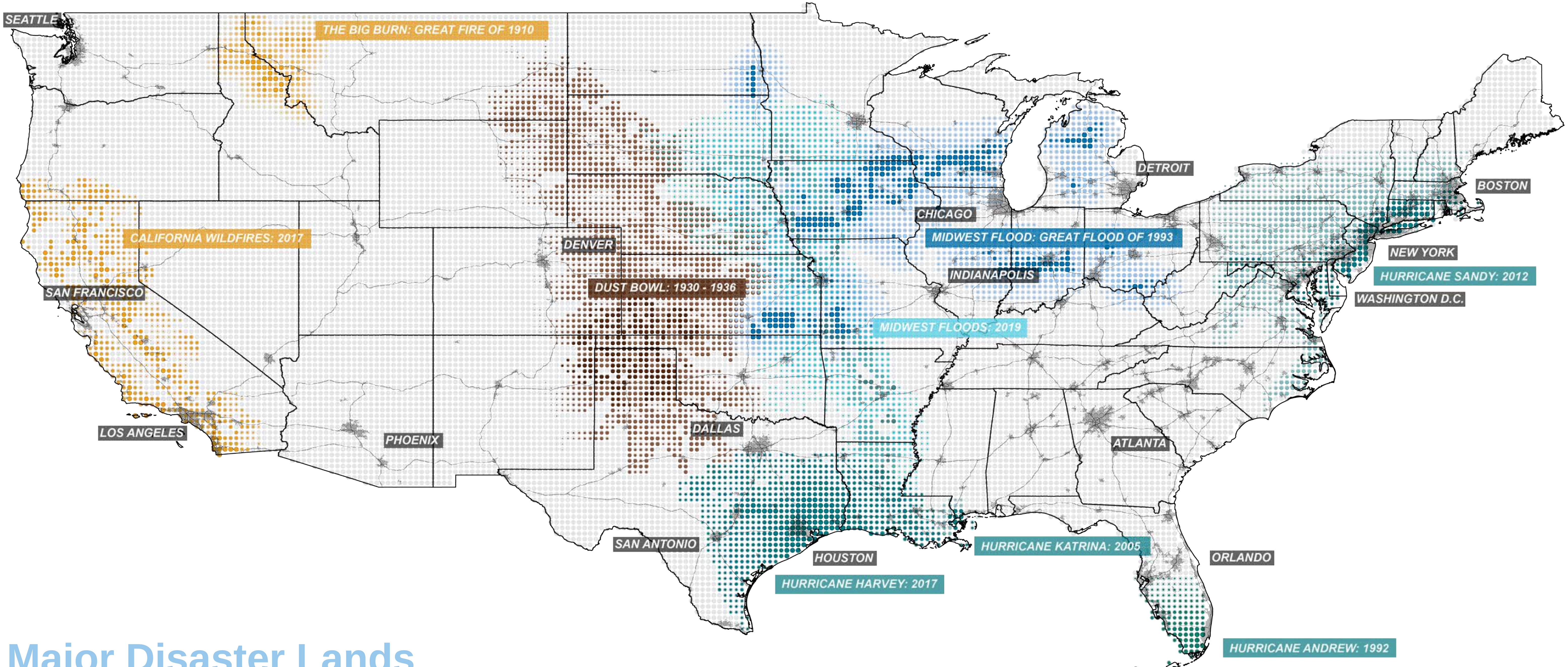


Environmental Risks

Environmental risks to humans vary significantly across the different regions and climates of the US. Some are products of oceanic and atmospheric forces, like flooding and tornadoes. Others, like earthquakes, are geological in origin—although mounting evidence suggests that hydraulic fracturing (fracking) and natural gas exploration may increase the risk of moderate earthquakes. The Atlantic coast is at high risk for hurricanes, flooding, and moderate earthquakes. The Great Lakes megaregion, with a significant portion of US surface water, is mainly at risk from flooding. The Midwest is primarily at risk from tornados; the regions west of the Rockies face significant risks from earthquakes, wildfires, and floods. The Pacific coast is at high risk from earthquakes due to the presence of the San Andreas fault, which is overdue for a significant earthquake.[66] Many of these environmental risks increase with the climate crisis, with predicted increasing intensity of storm events leading to more intense wildfires, floods, hurricanes, and tornados.[67]

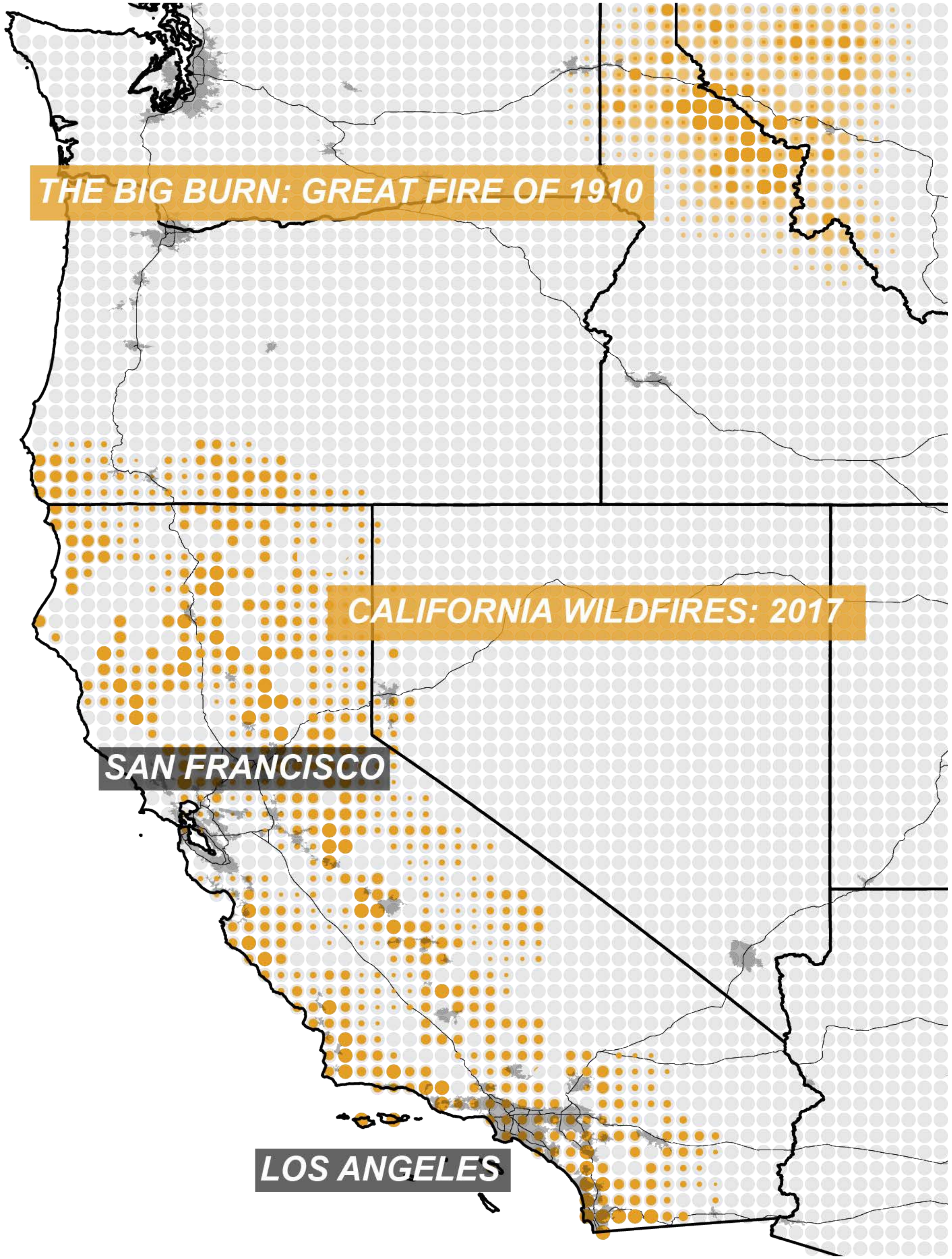
[66] "North American Coastal Plain - Threats." Critical Ecosystem Partnership Fund. Accessed July 21, 2019. https://www.cepf.net/our-work/biodiversity-hotspots/north-american-coastal-plain/threats

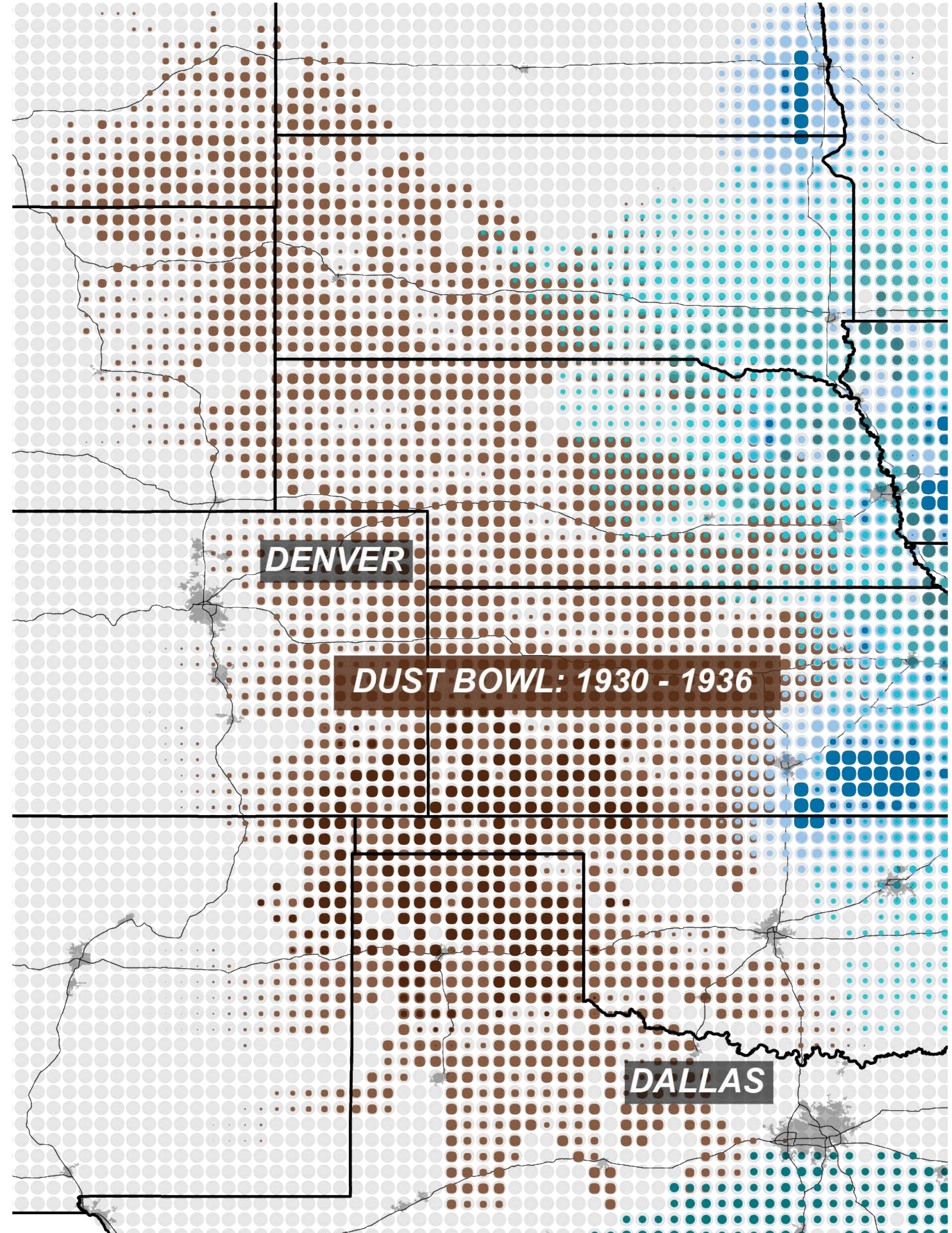
[67] "Back to the Future on the San Andreas Fault." U.S. Geological Survey. Accessed July 21, 2019. https://earthquake.usgs.gov/learn/topics/safz-paleo/.

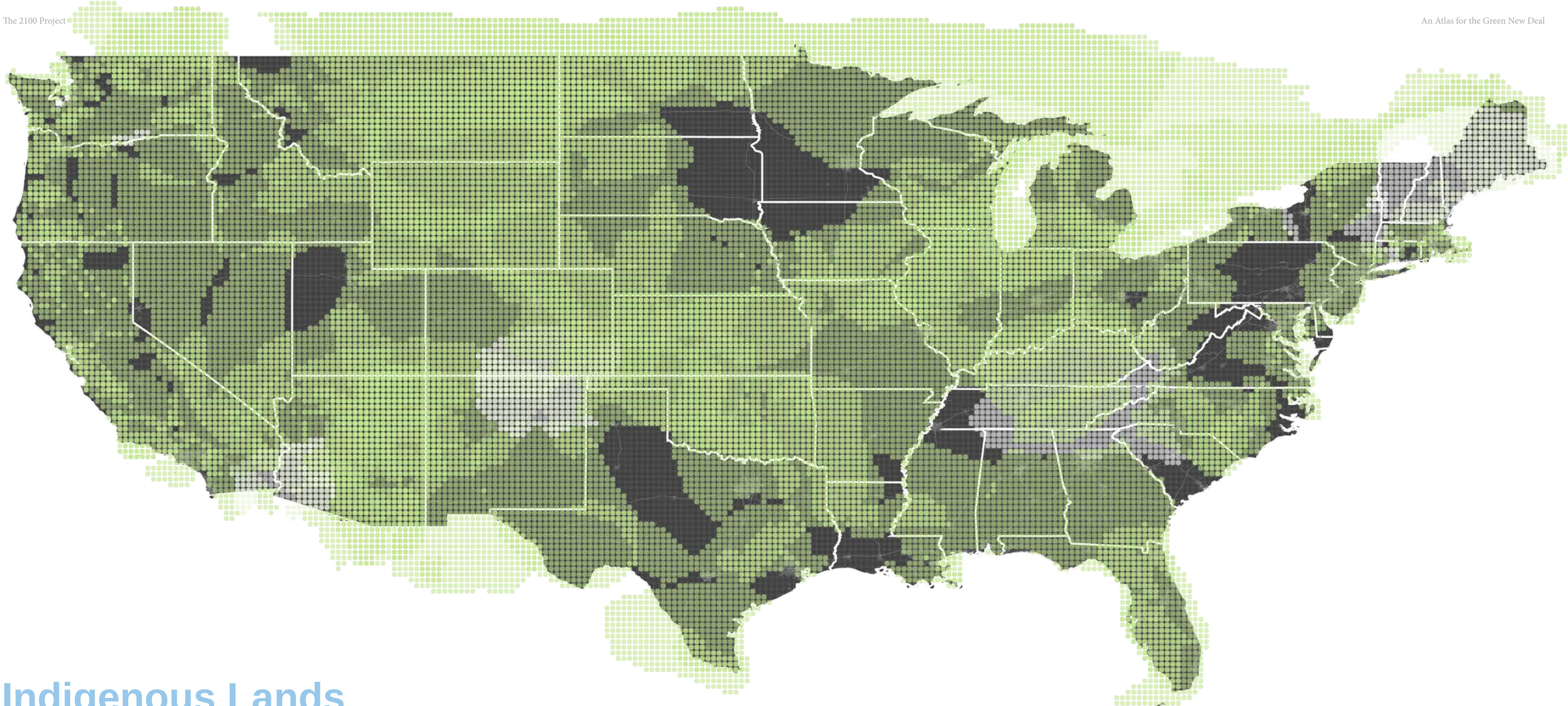


Major Disaster Lands

The US has seen several major disasters in the past century. As the climate crisis progresses, the number, frequency, and intensity of these events is likely to increase. This map is an illustrative (and incomplete) accounting of their impacts.


THE BIG BURN: GREAT FIRE OF 1910
CALIFORNIA WILDFIRES: 2017
SAN FRANCISCO
LOS ANGELES

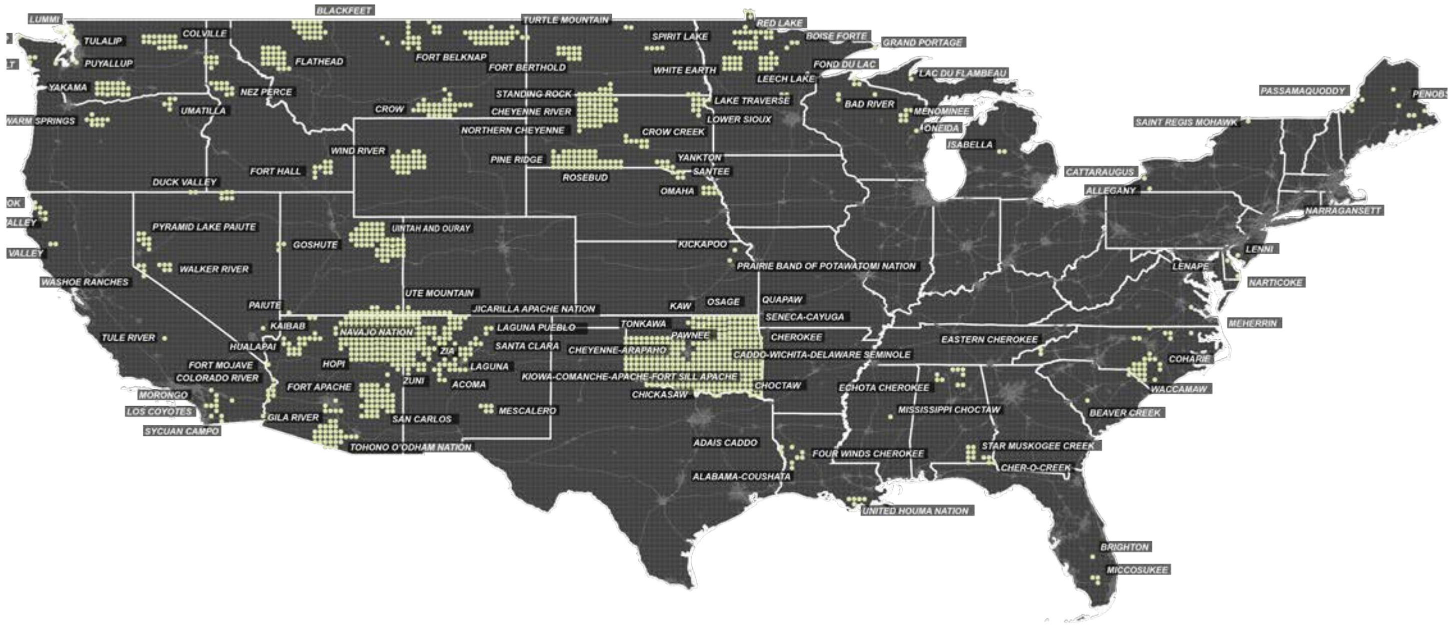

DENVER
DUST BOWL: 1930 - 1936
DALLAS



Indigenous Lands

The entirety of the US was inhabited by Indigenous peoples before their displacement by European settler colonial regimes and the disease, violence, and coercion that they brought with them.[68]

[68] "How Can Climate Change Affect Natural Disasters?" U.S. Geological Survey. Accessed July 21, 2019. https://www.usgs.gov/faqs/how-can-climate-change-affect-natural-disasters-1?qt-news_science_products=0#qt-news_science_products



Americanized Tribal Lands

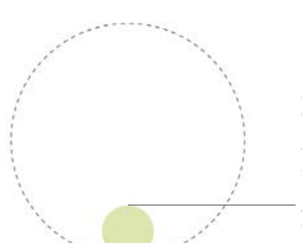
The relationship between the United States and America's Indigenous tribes has been characterized by displacement, genocide, and violence, much of it borne out in the conflict over sovereignty and land ownership. Once occupying the entirety of the continent, tribal members now are sovereign over just 6.2% of the conterminous US, in the form of federally recognized tribal lands (also called reservations, rancherias, pueblos, and Indian colonies); the largest area of tribal land is the Navajo Nation, at over 15 million acres.[69] There is a clear pattern to the size and number of reservations that reflects the progression of settler colonialism. Intense tribal displacement and land theft left eastern tribal lands fragmented and small, whereas in the western US larger areas were set aside by the US government as tribal lands. Treaty rights have historically governed this partitioning, but the rights have always been only selectively applied.[70]

There are 326 reservations in the US, holdings of single and shared tribal oversight. Legal frameworks of tribal sovereignty recognize the right of Indigenous tribes to govern themselves, acting as domestic dependent nations within the area of the US.[71] The relationships between the US and tribal governments have been established through 375 treaties, laws, and policies shaping where and how tribal members could live in exchange for resettlement and self-government.[72]

There are currently 573 recognized tribes at the federal level, 63 tribes unrecognized at the federal level but recognized by a state (a situation allowed in 11 states), and 359 tribes (as of 2013) unrecognized by the government but which have petitioned for recognition.[73] A further unknown number have never petitioned, or have never been able to. As of the 2010 census, 5.2 million people in the US identified as American Indian and Alaska Native either alone or in combination.[74] Of this population, 22% live on reservations.[75]

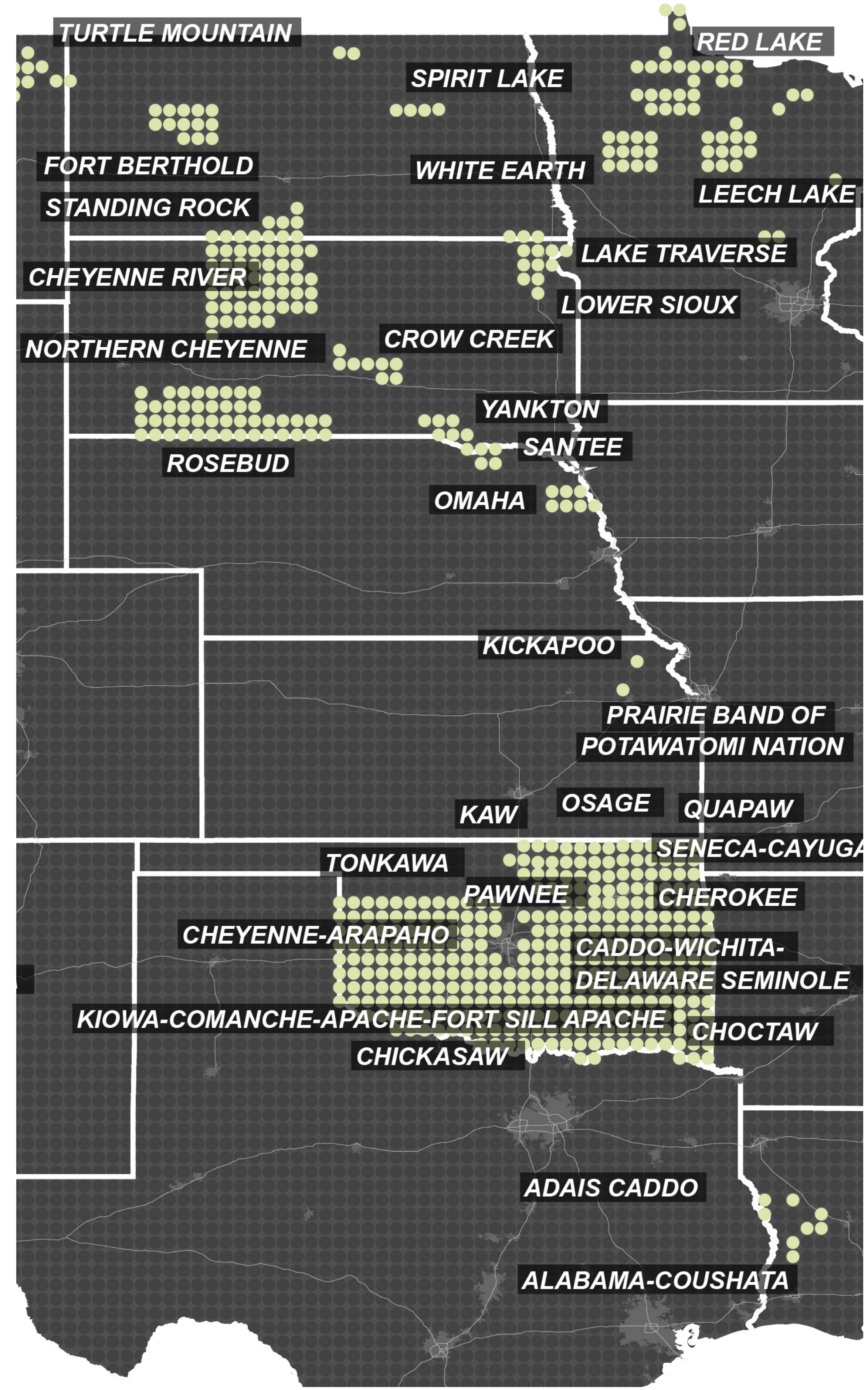
[69] "NativeLand.ca." Native. Accessed August 20, 2019. https://native-land.ca/.

[70] "TIGER/Line Shapefile, 2017, Nation, U.S., Current American Indian Tribal Subdivision (AITS) National." Data.gov. June 20, 2019. Accessed July 21, 2019. https://catalog.data.gov/harvest/object/72b2b12b-055b-498e-8939-0b76c091....



[Americanized tribal subdivisions are administrative subdivisions of federally recognized American Indian reservations/off-reservation trust lands or Oklahoma tribal statistical areas (OTSAs)]

Americanized Tribal Subdivisions 6.2% of Total Land USE



[71] "BROKEN PROMISES: Continuing Federal Funding Shortfall for Native Americans." United States Commission on Civil Rights. December 20, 2018. Accessed August 19, 2019. https://www.usccr.gov/pubs/2018/12-20-Broken-Promises.pdf

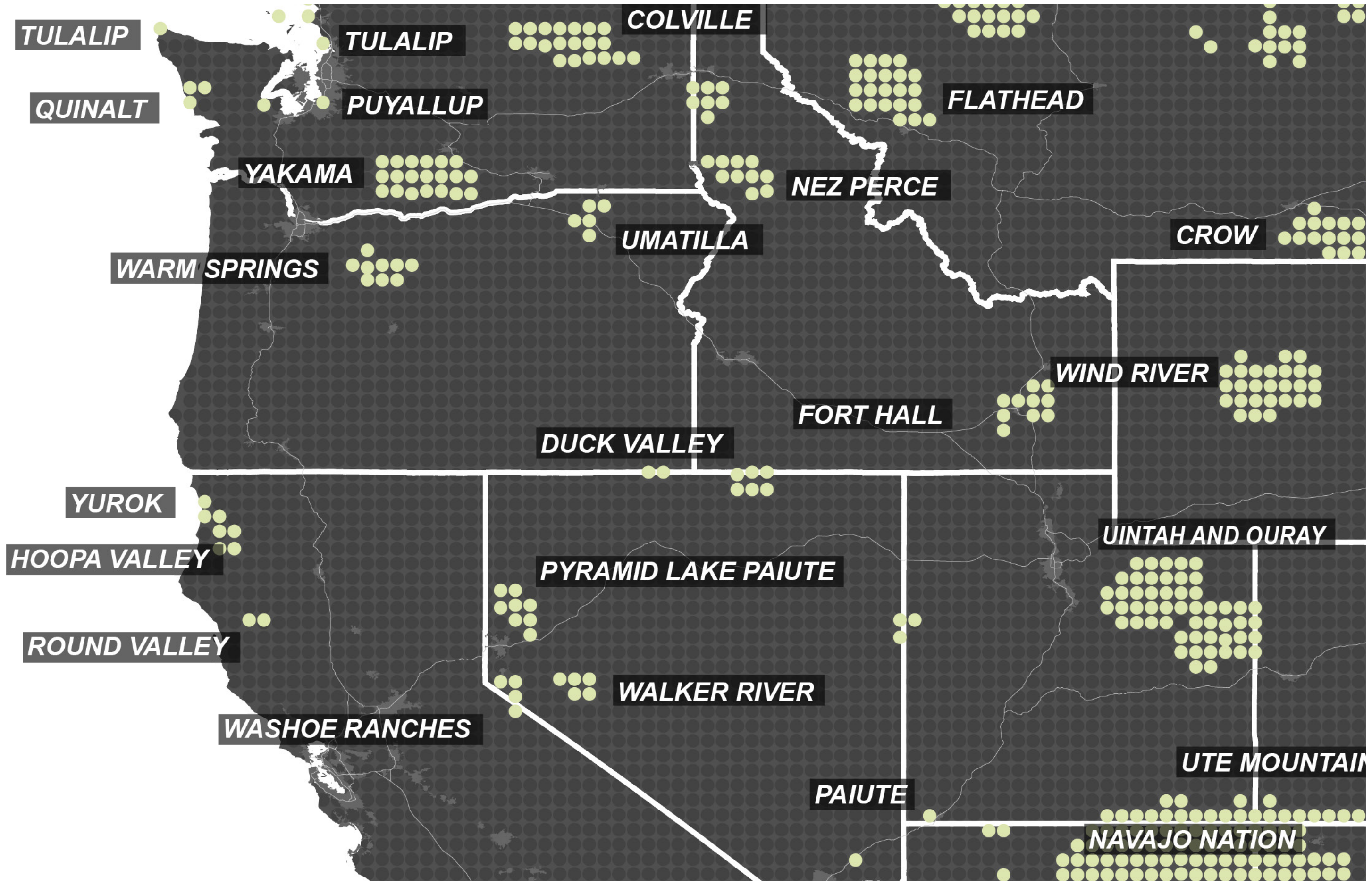
[72] "Native American Policies." U.S. Department of Justice. October 18, 2018. Accessed July 21, 2019. https://www.justice.gov/otj/native-american-policies.

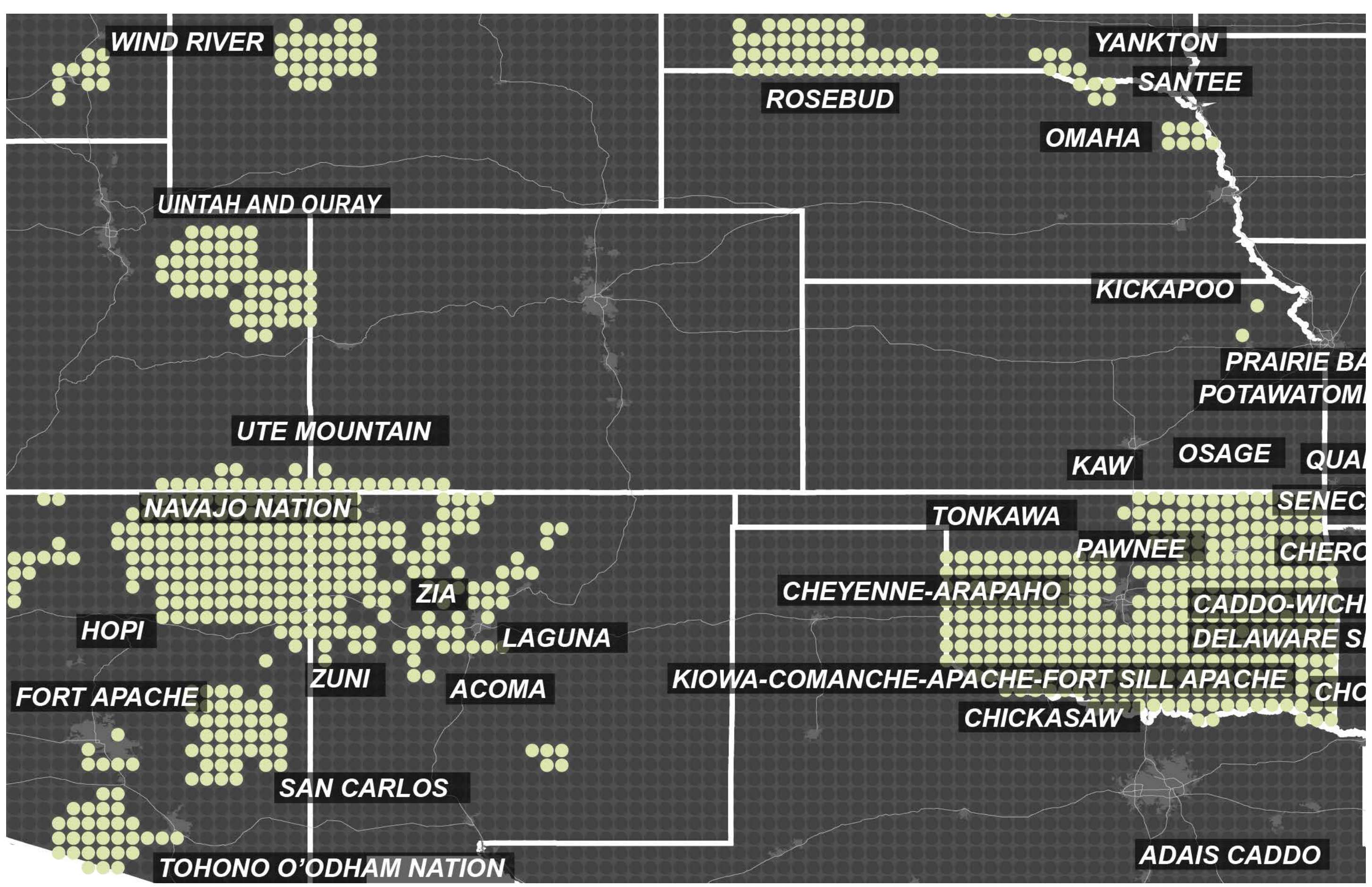
[73] "BROKEN PROMISES: Continuing Federal Funding Shortfall for Native Americans." United States Commission on Civil Rights. December 20, 2018. Accessed August 19, 2019. https://www.usccr.gov/pubs/2018/12-20-Broken-Promises.pdf

[74] "Federal and State Recognized Tribes." List of Federal and State Recognized Tribes. The National Conference of State Legislatures. November 2018. Accessed July 22, 2019. http://www.ncsl.org/research/state-tribal-institute/list-of-federal-and-state-recognized-tribes.aspx; "List of Petitioners by State (as of November 2013." The Bureau of Indian Affairs. November 2013. Accessed July 22, 2019. https://www.bia.gov/sites/bia.gov/files/assets/as-ia/ofa/admindocs/ListPetByState_2013

-11-12.pdf

[75] Norris, Tina, Paula L. Vines, and Elizabeth M. Hoeffel. The American Indian and Alaska Native Population: 2010. Washington, DC: US Department of Commerce, Economics and Statistics Administration, US Census Bureau, 2012.


TULALIP
TULALIP
COLVILLE
QUINALT
PUYALLUP
FLATHEAD
YAKAMA
NEZ PERCE
UMATILLA
CROW
WARM SPRINGS
WIND RIVER
FORT HALL
DUCK VALLEY
YUROK
HOOPA VALLEY
UINTAH AND OURAY
PYRAMID LAKE PAIUTE
ROUND VALLEY
WALKER RIVER
WASHOE RANCHES
UTE MOUNTAI
PAIUTE
NAVAJO NATION


WIND RIVER
YANKTON
SANTEE
ROSEBUD
OMAHA
UINTAH AND OURAY
KICKAPOO
PRAIRIE BA
POTAWATOMI
UTE MOUNTAIN
KAW
OSAGE
QUA
SENEC
NAVAJO NATION
TONKAWA
PAWNEE
CHERO
ZIA
CHEYENNE-ARAPAHO
CADDO-WICH
HOPI
LAGUNA
DELAWARE S
ZUNI
ACOMA
KIOWA-COMANCHE-APACHE-FORT SILL APACHE
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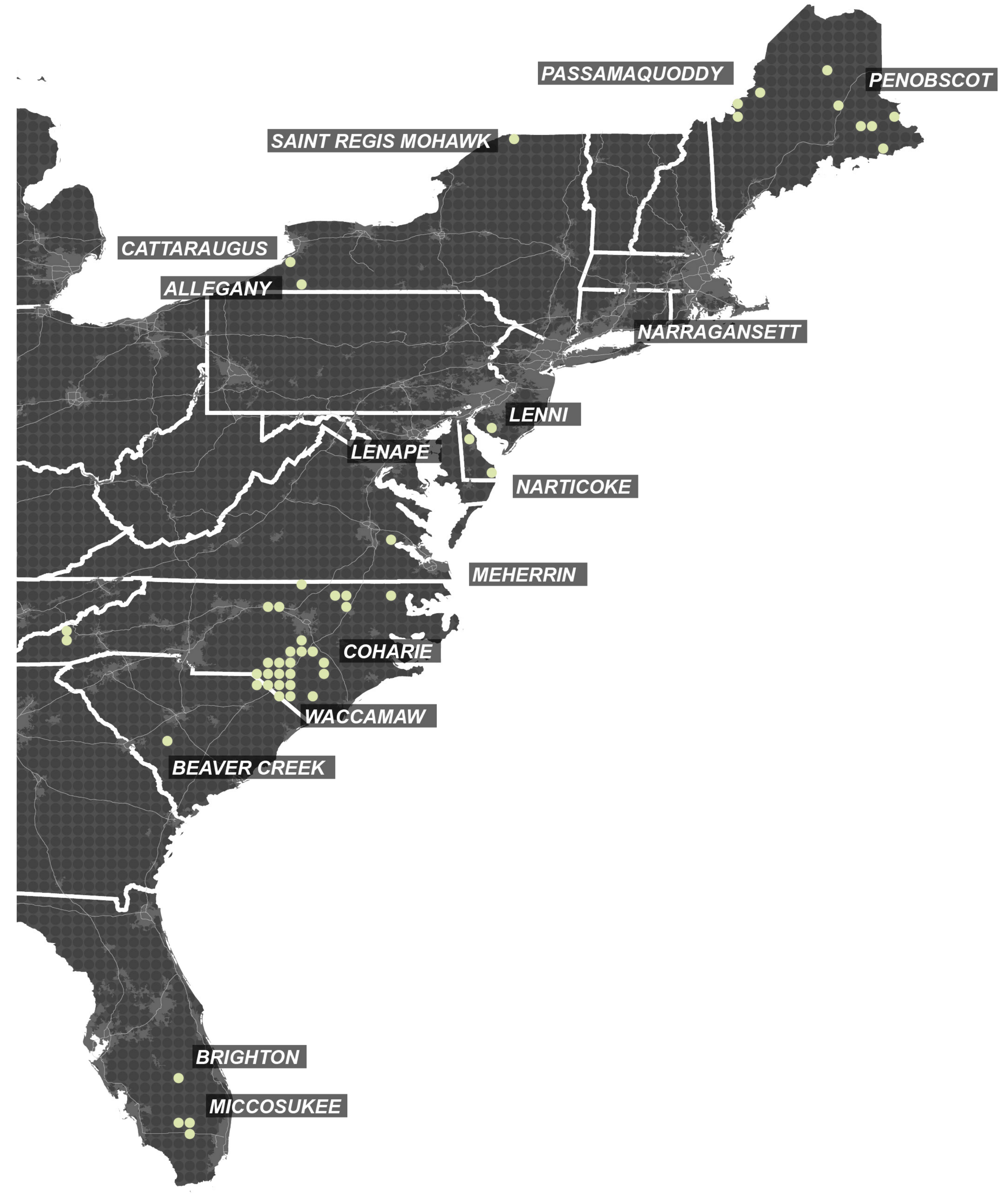
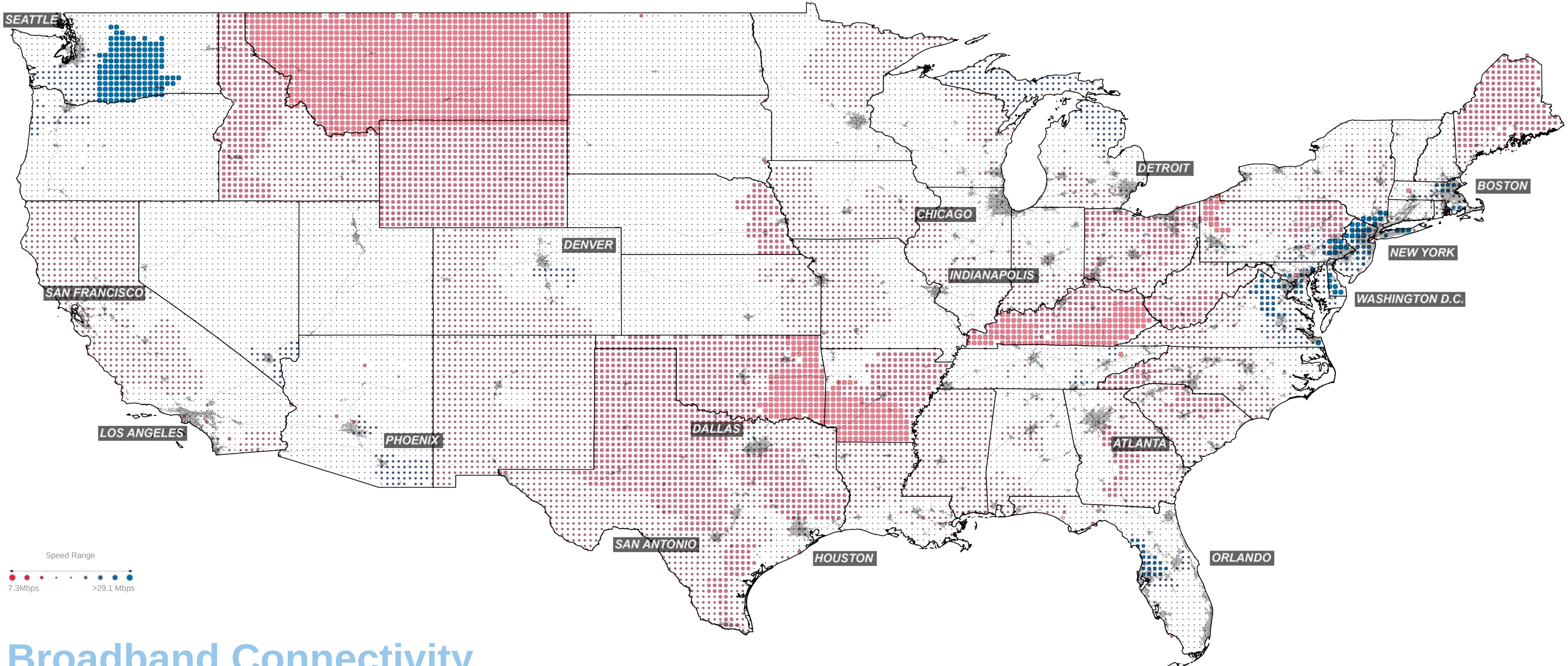
SAN CARLOS
ADAIS CADDO
TOHONO O’ODHAM NATION

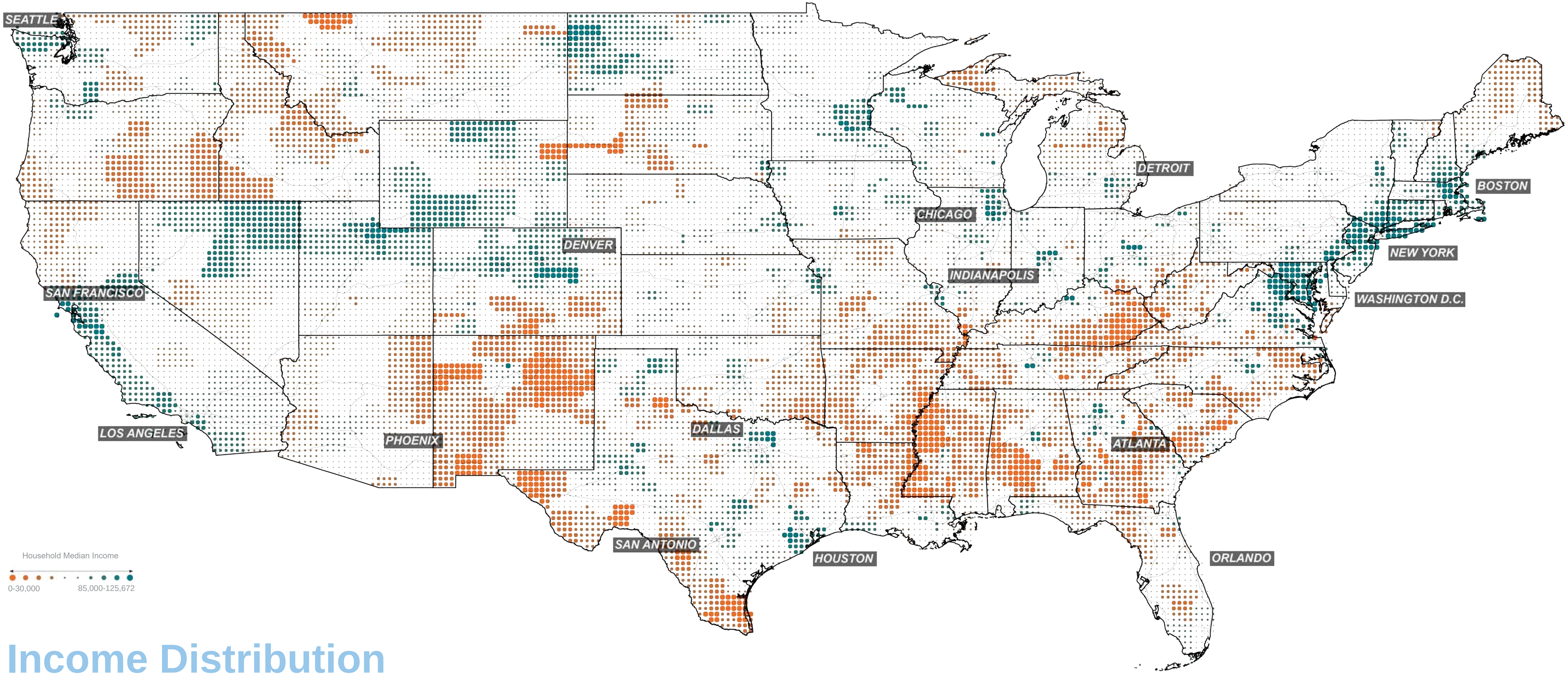

PASSAMAQUODDY
PENOBSCOT
SAINT REGIS MOHAWK
CATTARAUGUS
ALLEGANY
NARRAGANSETT
LENNI
LENAPE
NARTICOKE
MEHERRIN
COHARIE
WACCAMAW
BEAVER CREEK
BRIGHTON
MICCOSUKEE



Broadband Connectivity

The US average download speed in 2013 was 18.2 Mbps.[76] While the majority of the country had rates near the average, spatial variation is notable: for instance, average download speeds outside of Seattle were 85.5 Mbps, while northeastern Arizona saw average speeds closer to 1.5 Mbps. There is an obvious privileging of urban and high-income areas, offering higher speeds to more concentrated and wealthier populations. This is due in part to the monopolistic and loosely regulated telecommunications industry in the US. By 2019, some rural areas were still completely disconnected from the broadband network.

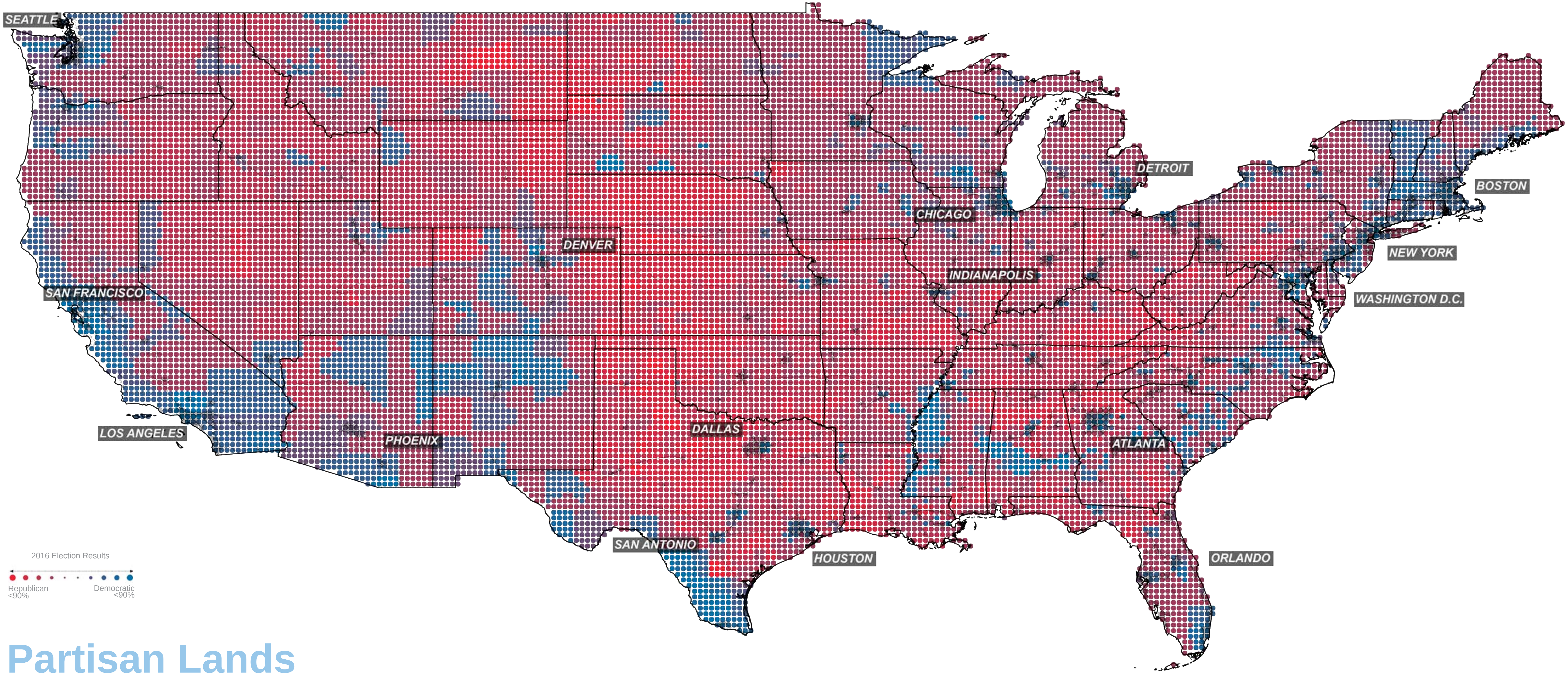
[76] Fischer-Baum, Reuben. "A Map of Who's Got the Best (And Worst) Internet Connections in America." Gizmodo. September 09, 2013. Accessed July 22, 2019. https://gizmodo.com/americas-internet-inequality-a-map-of-whos-got-the-b-1057686215



Income Distribution

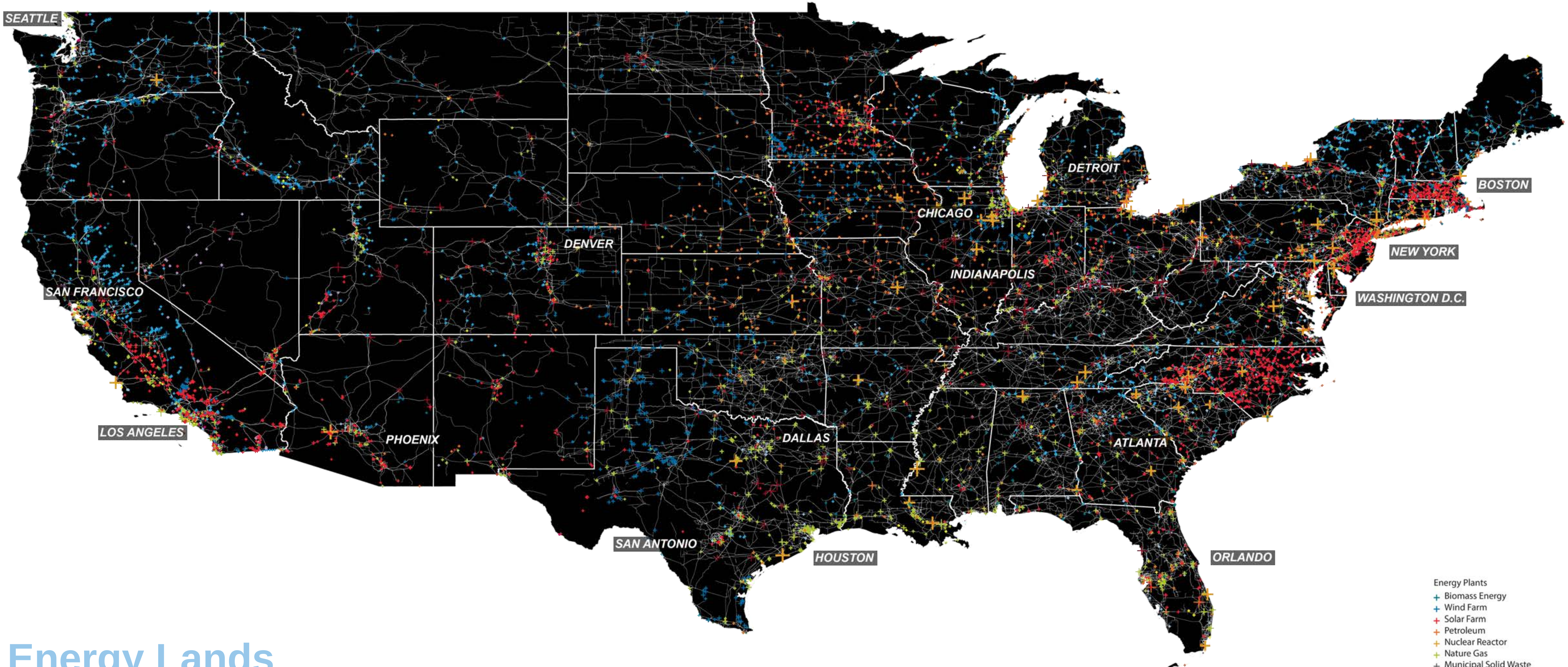
In 2016, the highest-income areas, in which median household income was over $85,000, were clustered along the Northeast corridor, in California and Pacific Northwest tech hubs, and around interior cities. Low-income areas, in which median household income was less than $30,000, were most clustered in the Southeast, the Southwest, and the interior Northwest. The median annual income of a US household was $57,617, with the official poverty rate at 12.7%.[77]

[77] "Median Household Income in the United States." U.S. Census Bureau. September 14, 2017. Accessed April 2019. https://www.census.gov/library/visualizations/2017/comm/income-map.html; "Income and Poverty in the United States: 2016." U.S. Census Bureau. September 12, 2017. Accessed July 23, 2019. https://www.census.gov/library/publications/2017/demo/p60-259.html



Partisan Lands

There is a clear divide in partisan support between the coasts and interior urban areas (Democratic) and rural areas (Republican).



Energy Plants
+ Biomass Energy
+ Wind Farm
+ Solar Farm
+ Petroleum
+ Nuclear Reactor
+ Nature Gas
+ Municipal Solid Waste
+ Landfill Gas
+ Hydroelectric Pumped Storage
+ Geothermal
+ Flywheel
+ Steam Coal
+ Conventional Hydroelectic
+ Coal Integrate
+ Batteries
+ Others

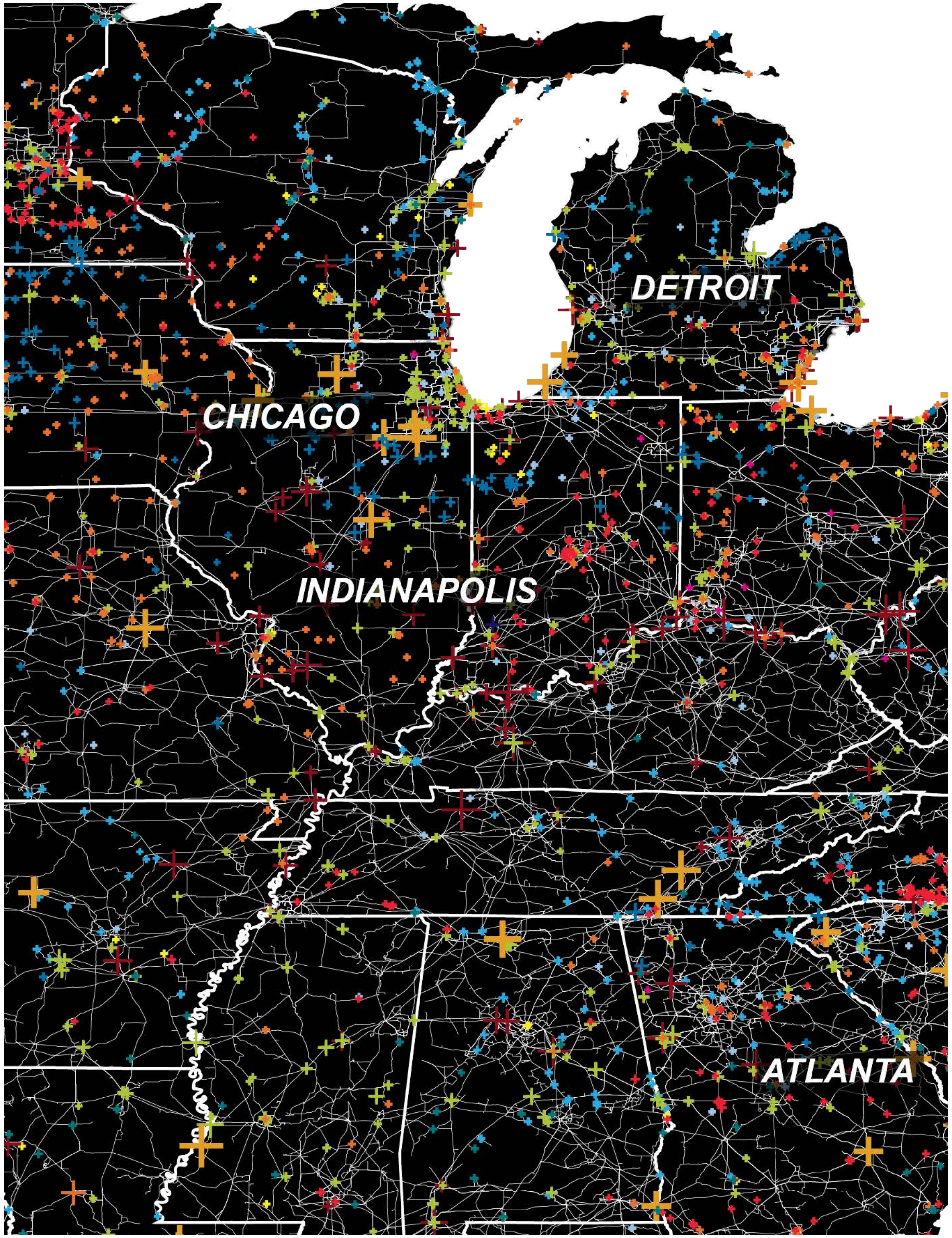
Electric Power Transmission Line

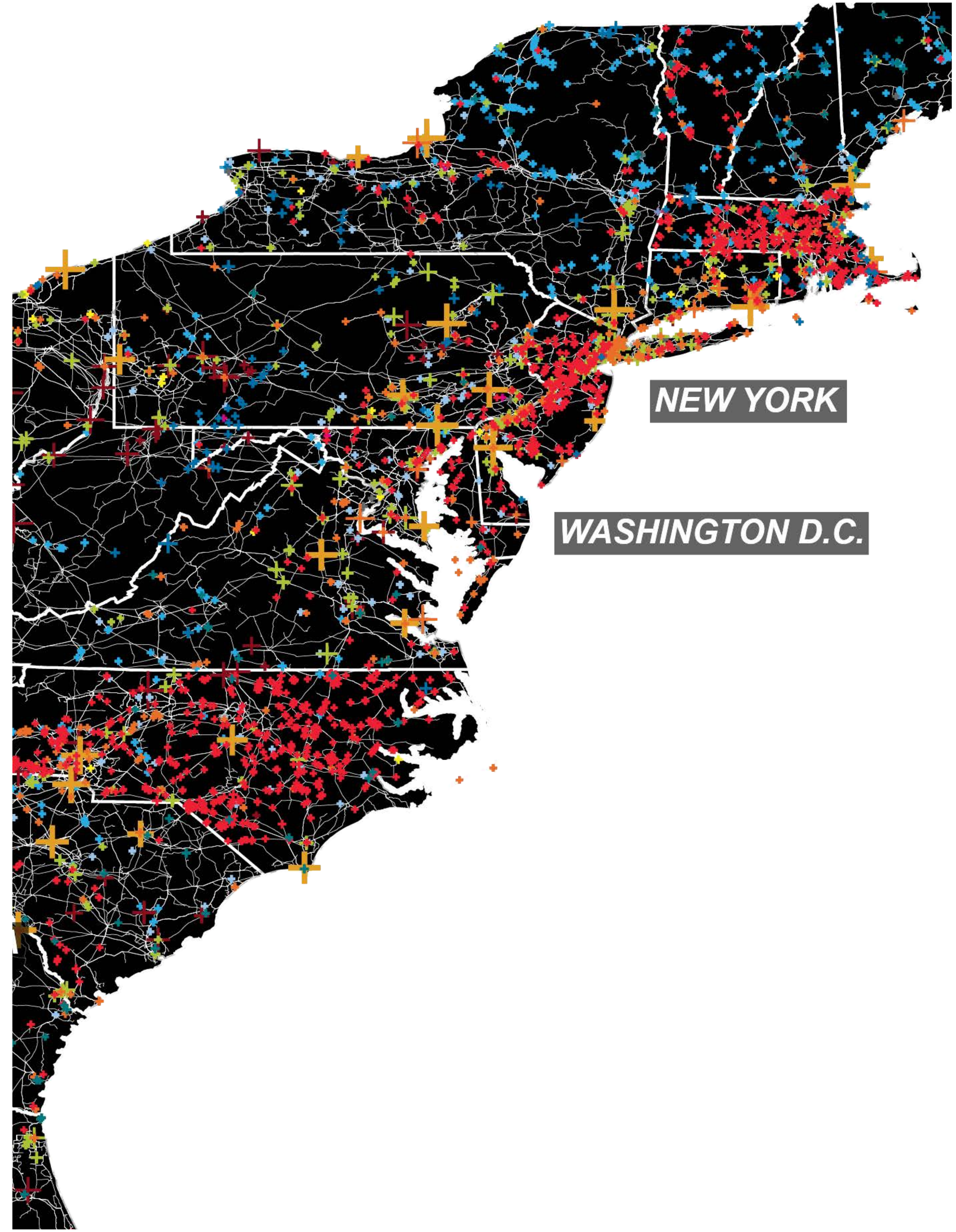
Energy Lands

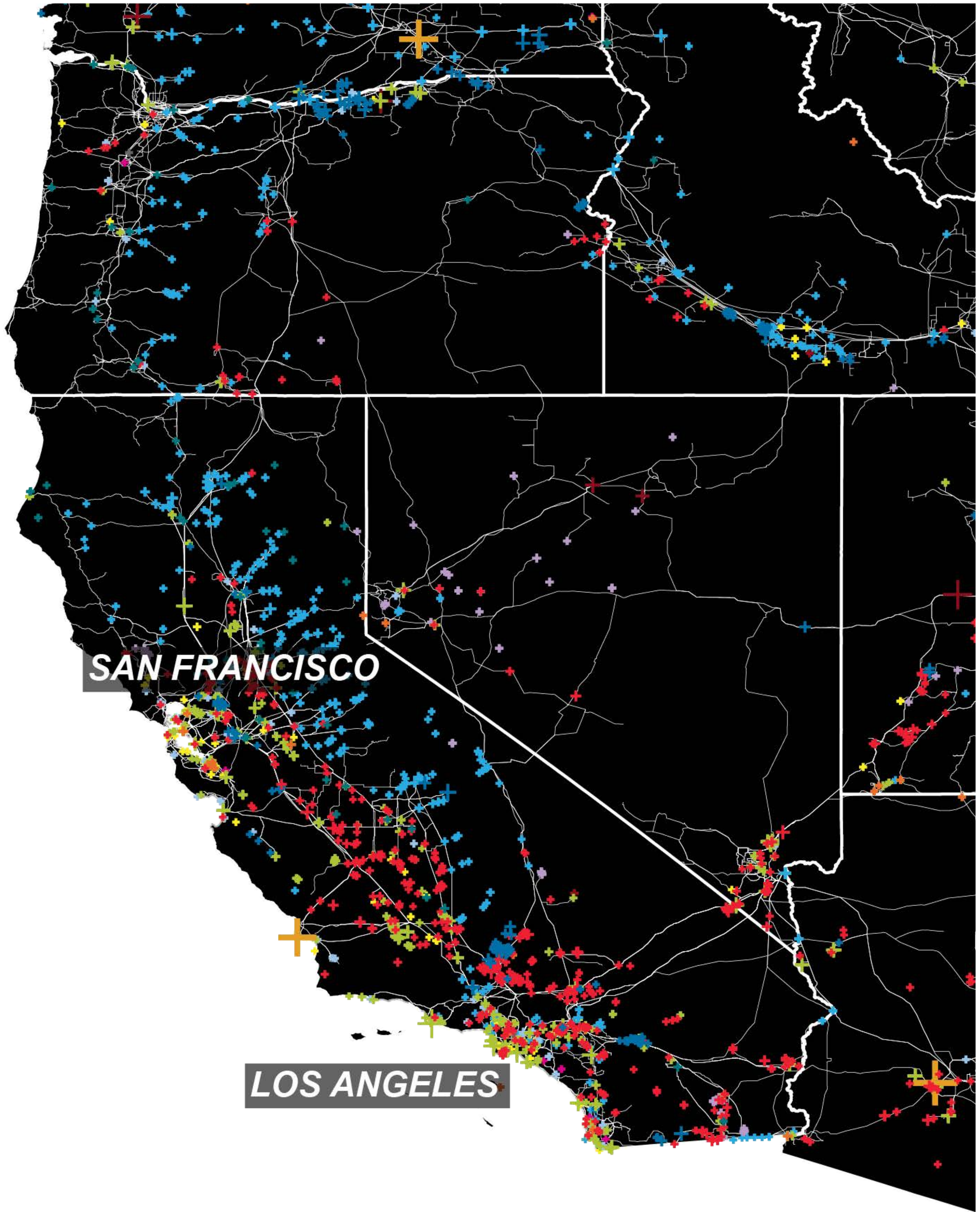
Transmission lines connect the US, forming corridors that pulse in every direction across the continent. Energy plants are present across the US, with a heavy concentration on the East Coast; this concentration diffuses toward the Great Lakes and Texas Triangle megaregions. Further west, infrastructure is minimal, with the exception of the energy-dense West Coast.

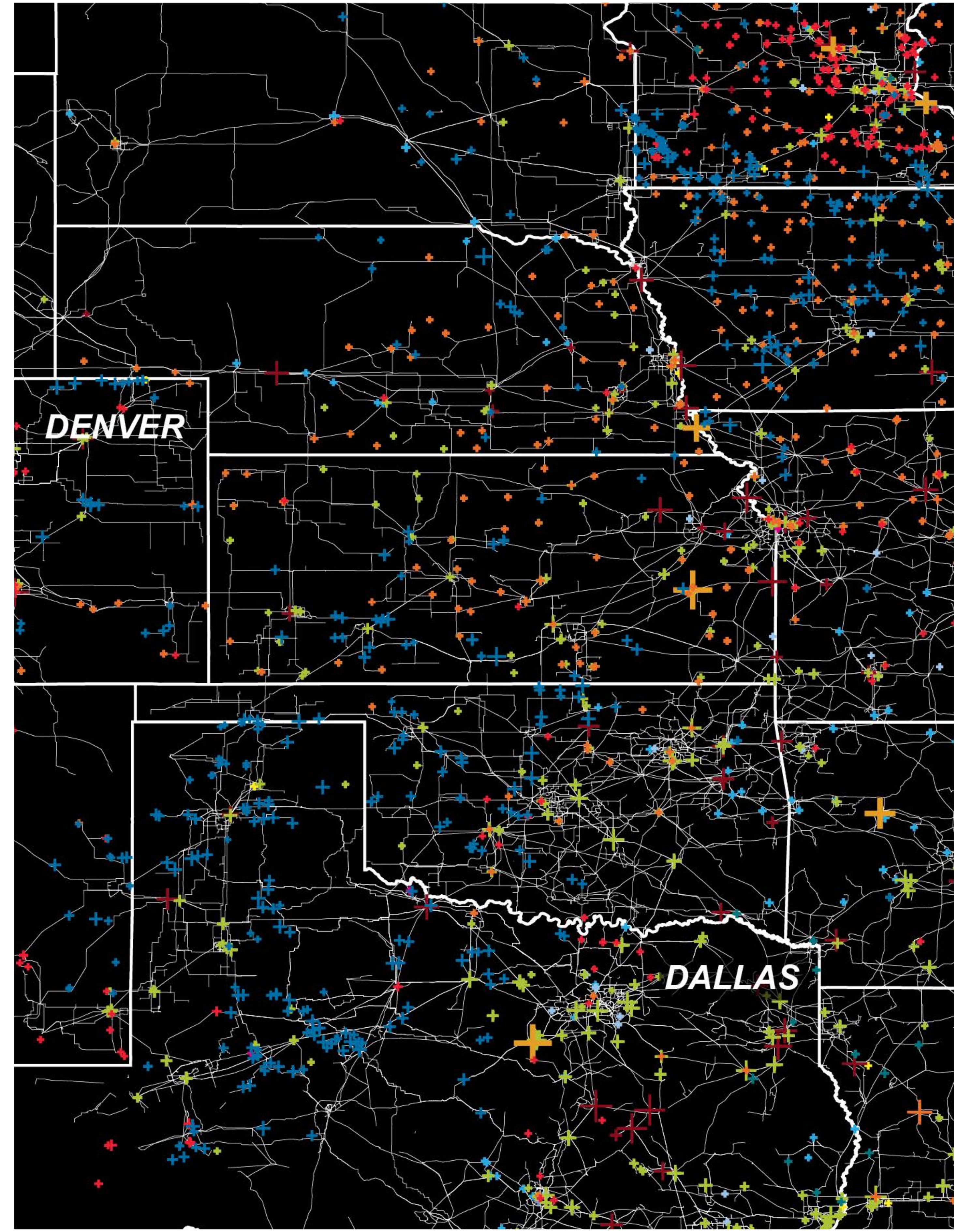
The construction of the modern energy grid began in 1882 with the inauguration of the Pearl Street station in Manhattan. Over the next 130 years, the generation, transmission, and storage facilities comprising the nation's grid developed in two major thrusts: the late nineteenth-century "war of the currents," in which Thomas Edison (direct current) and Nikola Tesla (alternating current) competed for government contracts and private equity; and the private electricity company boom of the early twentieth century, which saw the proliferation of small, private, and unregulated electric utilities across the US. These generation and transmission systems and utilities came under stronger federal regulation in 1978 and have remained largely unchanged since then.[78]

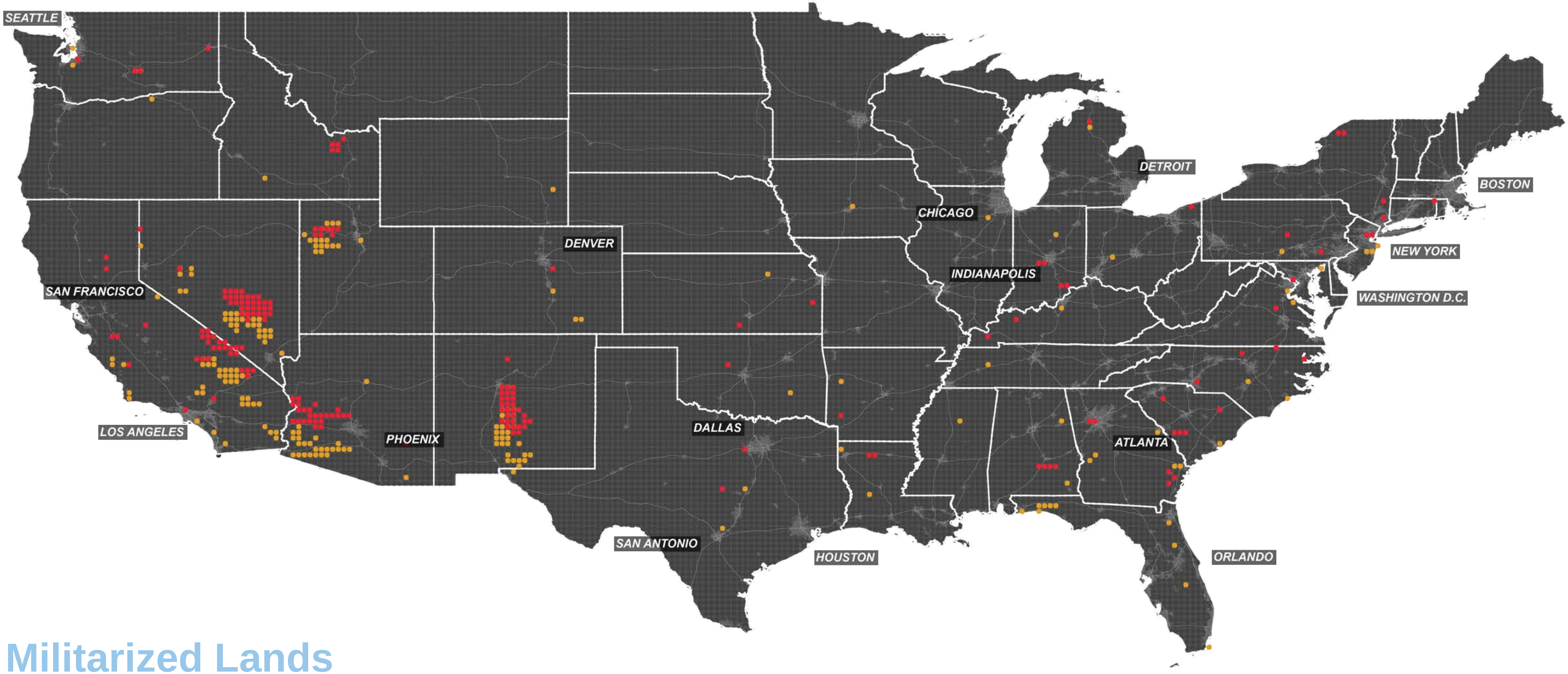
[78] Department of Energy. "The War of the Currents: AC vs. DC Power." Accessed September 8, 2019. Available at: https://www.energy.gov/articles/war-currents-ac-vs-dc-power.


DETROIT
CHICAGO
INDIANAPOLIS
ATLANTA


NEW YORK
WASHINGTON D.C.

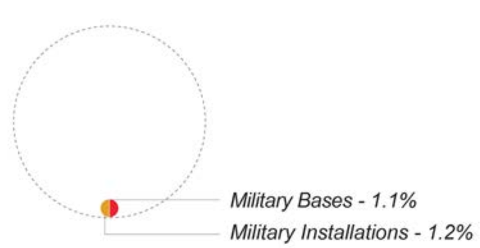

SAN FRANCISCO
LOS ANGELES


DENVER
DALLAS

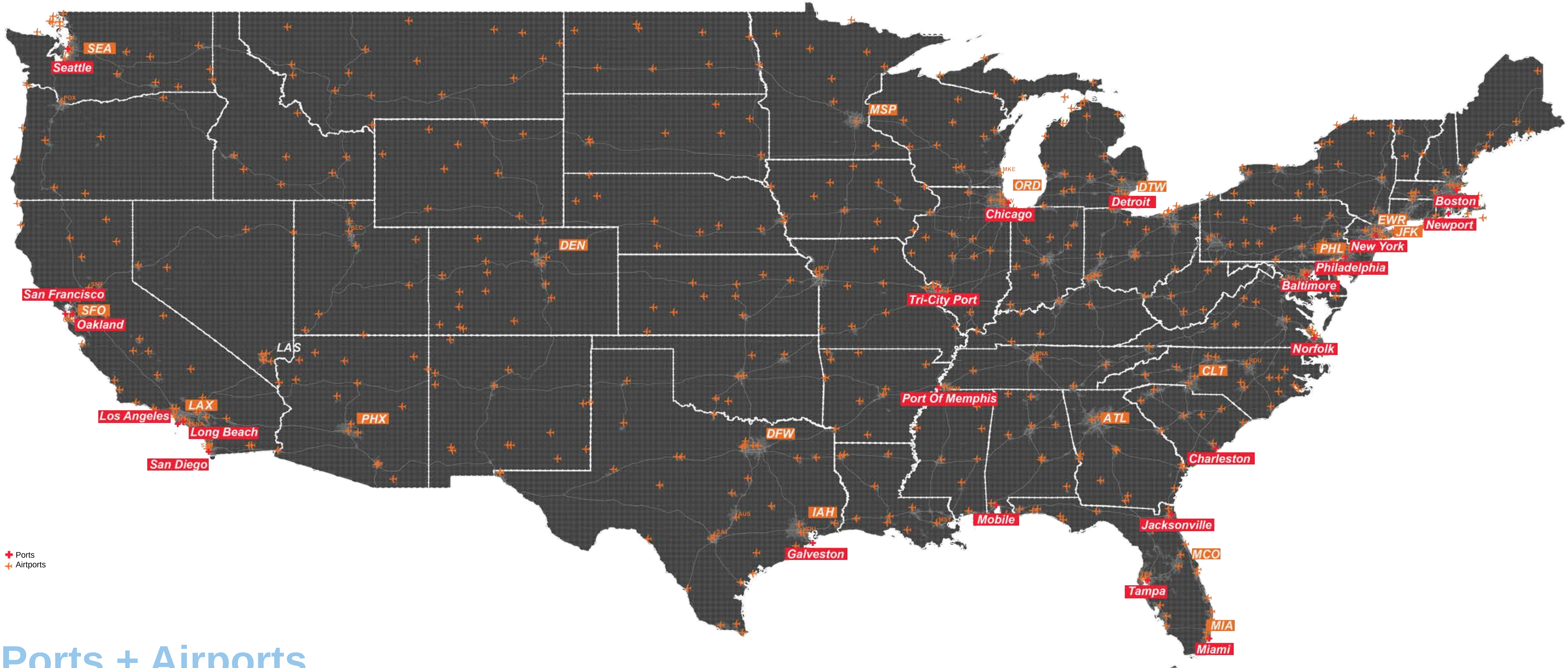


Militarized Lands

As of 2015, the US government had 71 air force bases inside the conterminous US and 36 outside; 66 army bases inside and 59 outside; 38 Coast Guard bases on US territory; 10 joint operations bases outside the US; 19 Marine Corps bases inside and 18 outside; and 75 navy bases inside and 21 outside.[79] These installations occupy 2.3% of US land—a larger percentage than total urban areas, at only 2%. Understandably, these military bases line the coasts and sit along major roads. There are few bases near the land borders with Canada and Mexico.



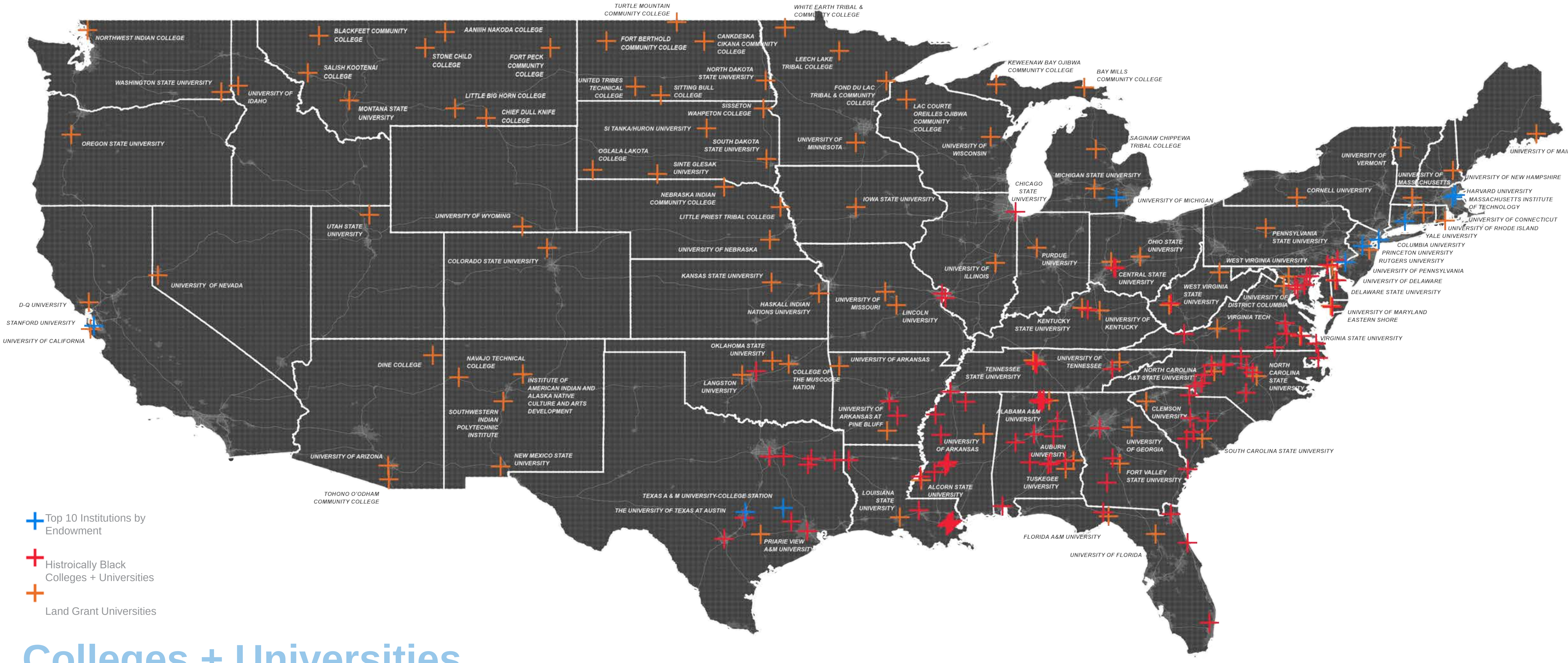
[79] "US Military Bases - Air Force Bases, Army Bases, Navy Bases, Marine." Military Bases. Accessed July 23, 2019. https://militarybases.com/.



Ports + Airports

Due to historical settlement patterns and water transportation, most major cities in the US have a port. These port cities sit on the Atlantic and Pacific coasts, as well as along the Great Lakes, the Gulf Coast, and the Mississippi and other inland rivers. The growth of air travel in the twentieth century resulted in a current total of 3,321 airports, of which 380 are considered "primary"[80]

[80] "Report to Congress: National Plan of Integrated Airport Systems (NPIAS) 2019-2023." U.S. Department of Transportation – Federal Aviation Administration. September 26, 2018. https://www.faa.gov/airports/planning_capacity/npias/reports/media/NPIAS-Report-2019-2023-Narrative.pdf



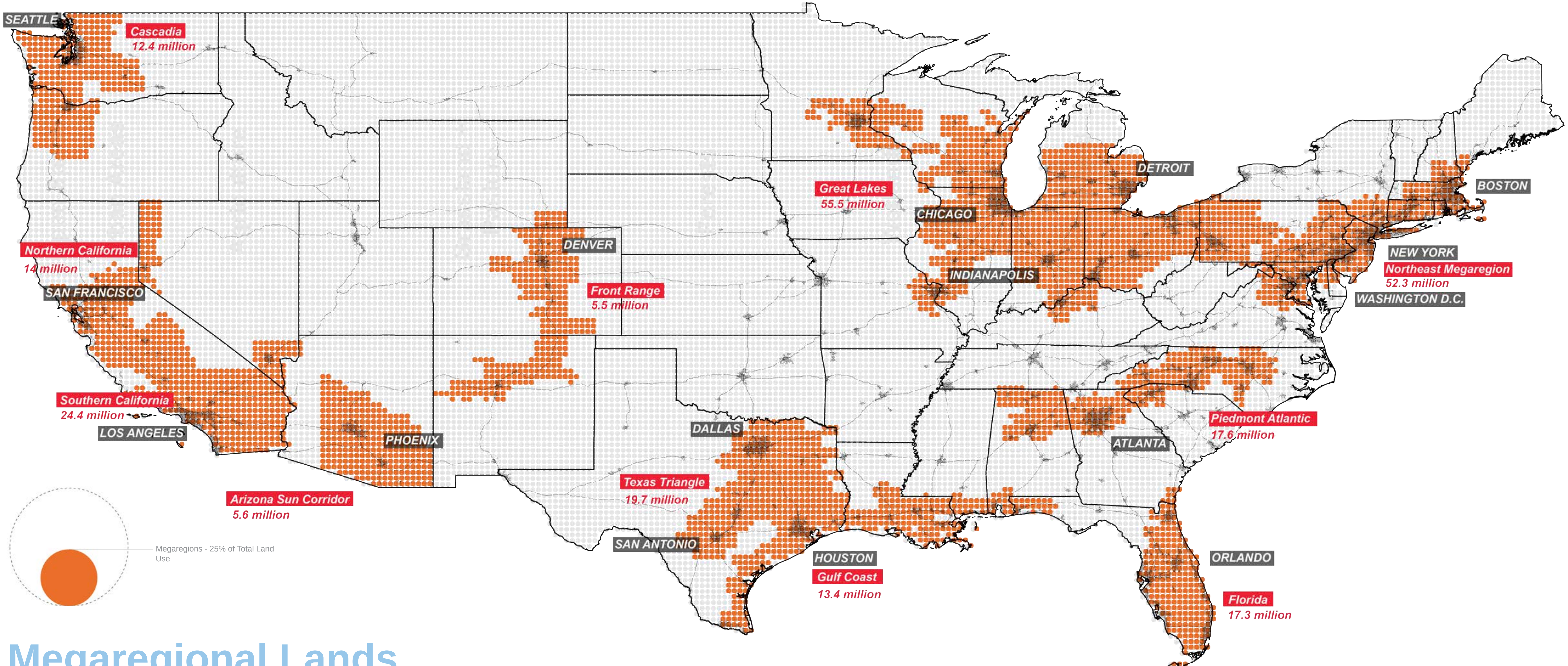
Colleges + Universities

There are more than four thousand universities in the US. These can be grouped into three broad categories: private colleges and universities; public and land grant institutions; and historically black colleges and universities (HBCUs) and minority-serving institutions (MSIs).

The land grant institutions were a response to industrialization pressures in the late nineteenth century. The Morrill Acts of 1862 and 1890 granted federally controlled land to the states to establish and endow land grant colleges, which would "without excluding other scientific and classical studies, and including military tactics, [teach] such branches of learning as are related to agriculture and the mechanic arts."[81] Now mostly public universities, these schools have broadened their curriculums over time but tend to maintain strong connections to either agriculture or mechanics. One subset of land grant institutions are the tribal colleges and universities, authorized by the 1994 Elementary and Secondary Education Reauthorization Act, which focus on teaching, community outreach, and research in Indigenous communities.

HBCUs are institutions established before the Civil Rights Act of 1964 to serve the black community in response to the segregation of higher education. There are currently 101 HBCUs offering undergraduate and graduate education, largely concentrated in the Southeast, where segregation was historically most prevalent.

[81] 7 U.S.C. § 304



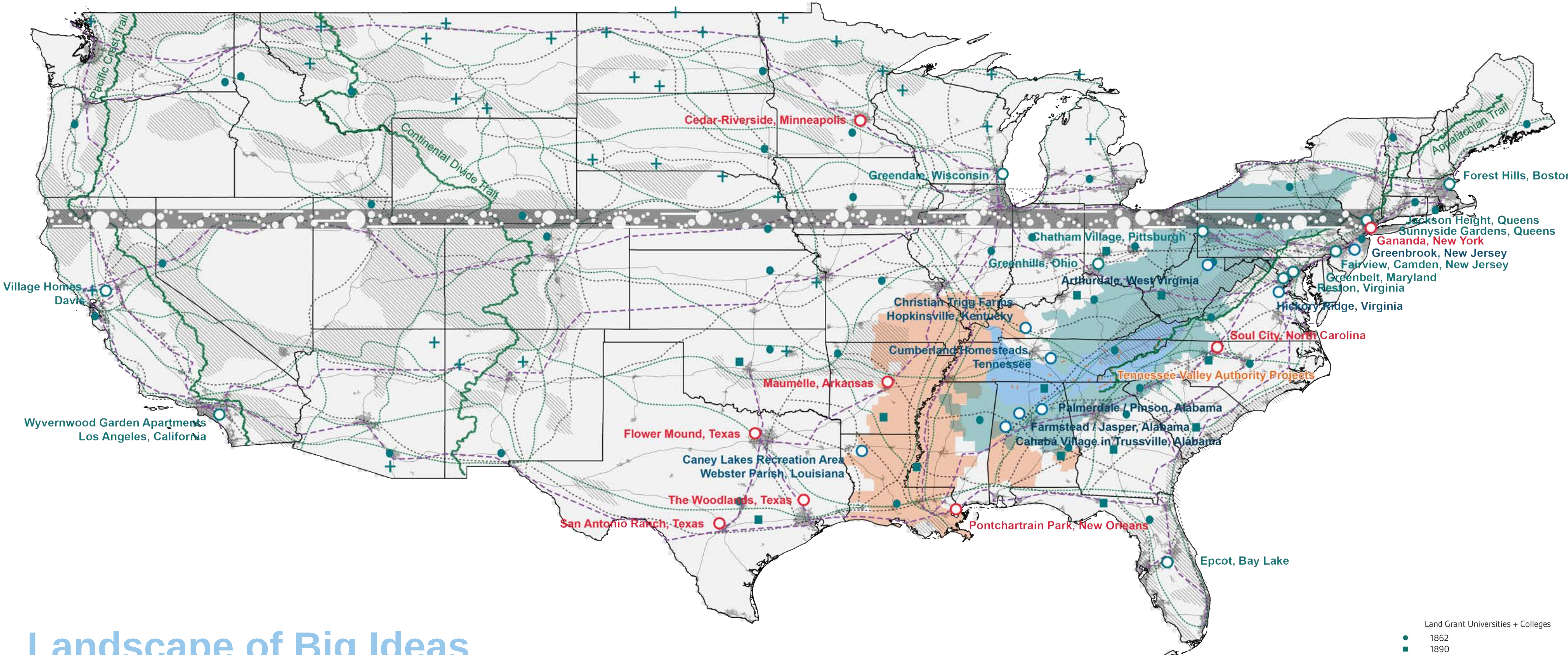
Megaregional Lands

Settlement patterns in the second half of the twentieth century reached such a spatial extent to warrant a new unit of urbanization. Categorized as "megaregions," these enlarged, polycentric zones of urbanization are defined by complex interrelations in the following categories: environmental systems and topography; infrastructure systems; economic linkages; settlement patterns and land use; and shared culture and history.[82] Richard Florida has also proposed that megaregions can be defined by mapping continuous bands of electric light viewed from space at night.

There are eleven such recognized megaregions in the US: Cascadia, Northern California, Southern California, Arizona Sun Corridor, Front Range, Texas Triangle, Gulf Coast, Florida, Piedmont Atlantic, Great Lakes, and Northeast.

*2010 Populations of the 11 megaregions are estimated by RPA

[82] Megaregions - America 2050. Regional Plan Association. Accessed July 23, 2019. http://www.america2050.org/content/megaregions.html#more.



Landscape of Big Ideas

This map shows a range of visionary large-scale planning initiatives, some realized, some not. Variously inspiring and cautionary, these big ideas serve as speculative precedents for current debates about national-scale planning and investment in relation to the climate crisis and a Green New Deal.

Land Grant Universities + Colleges
- 1862
- 1890
- 1994

Manning's National Plan
- Recreation Ways
- Recreational Areas
- Commercial Ways

Comprehensive City

HUD Title VII Urban Growth and New Community Development Act

Garden Cities

Resettlement Authority Projects

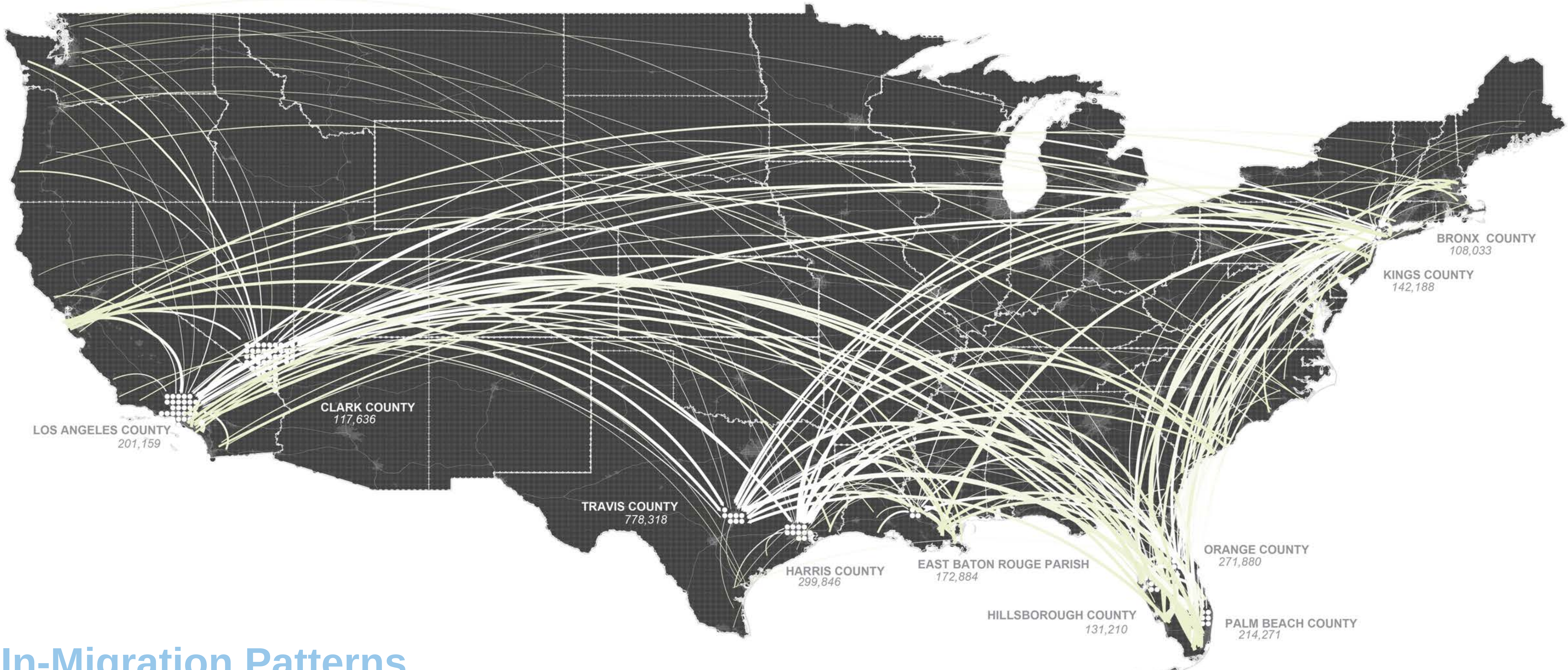
Tennessee Valley Authority Projects Area

Tennessee Valley Authority Projects

Delta Regional Authority Area

Appalachian Regional Authority Area

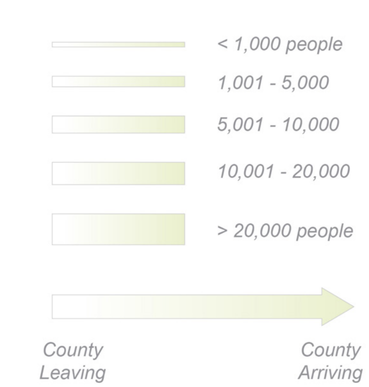
Obama Era High Speed Rail Plan



In-Migration Patterns

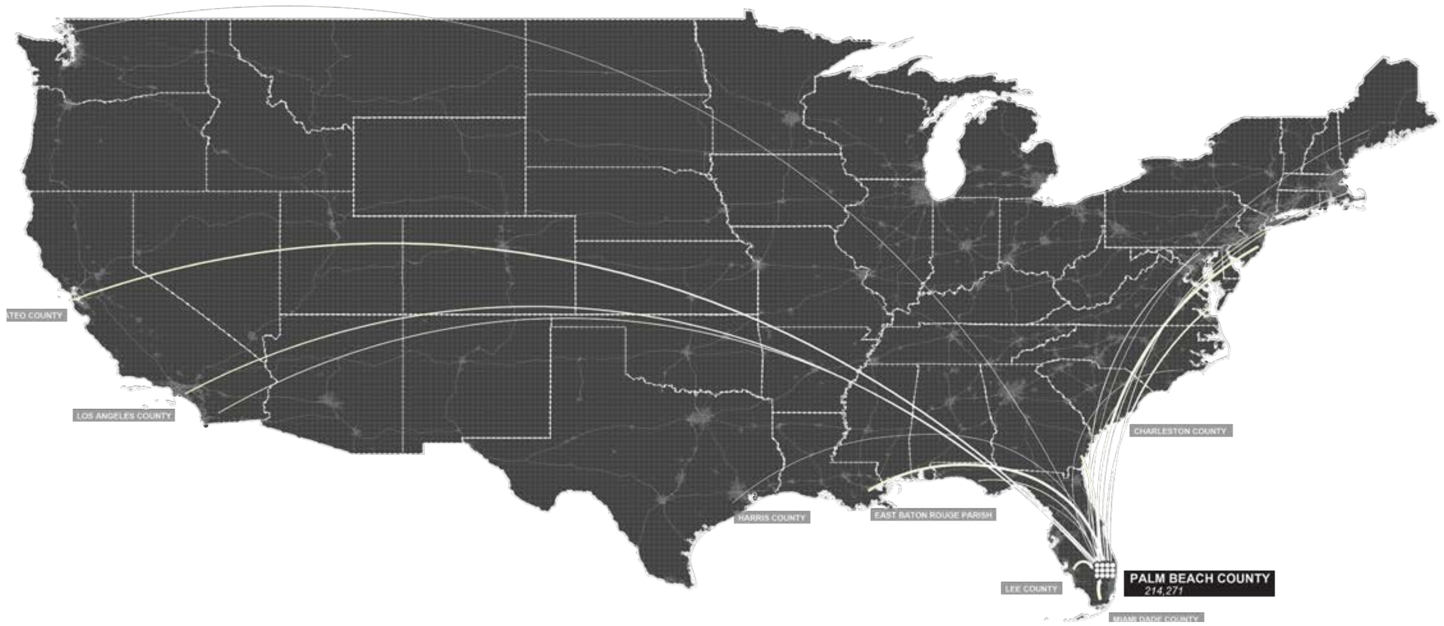
Sea level rise is expected to radically reshape the physical and social geography of the coastal US. These maps draw on models developed by the sociologist and demographer Mathew Hauer, the first scholar to assess the number of structures—and therefore people—that can be expected to be inundated by sea level rise over the course of the twenty-first century.[83]

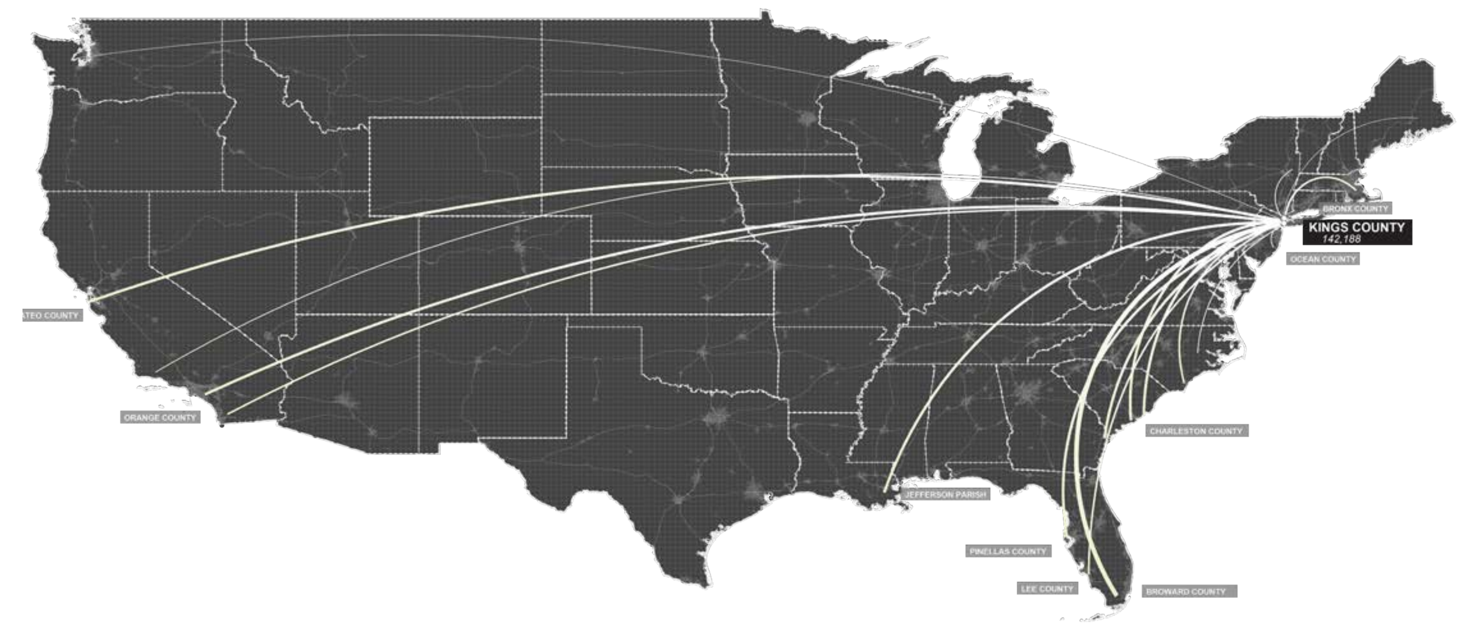
These maps are visualizations of this work, showing major trends in in-migration toward coastal cities and the gulf coast. East coast in-migration is concentrated in the following counties: Bronx and Kings in New York; Orange, Palm Beach, and Hillsborough in Florida; East Baton Rouge Parish in Louisiana; Harris and Travis in Texas; Los Angeles, Santa Cruz, and San Francisco in California; and Clark in Nevada.These regions will be the primary receiving zones for climate refugees moving within the US. They do not incorporate the expected influx of foreign climate refugees.[84]

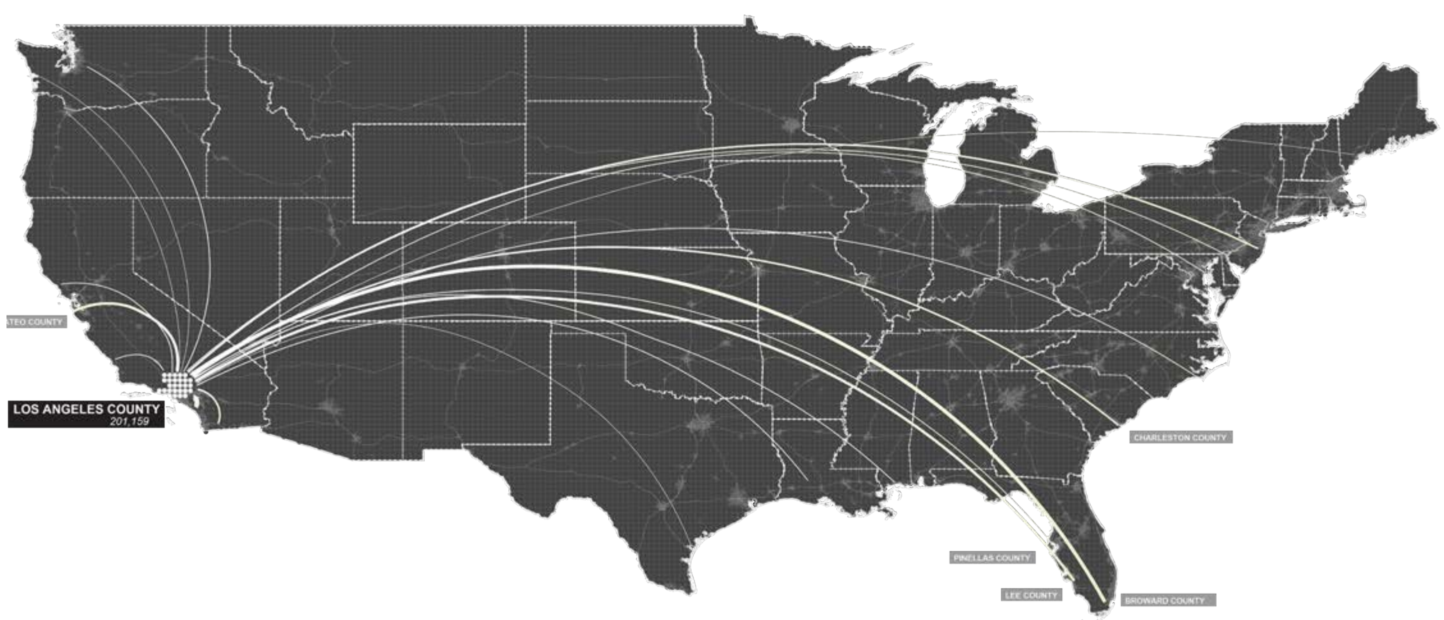


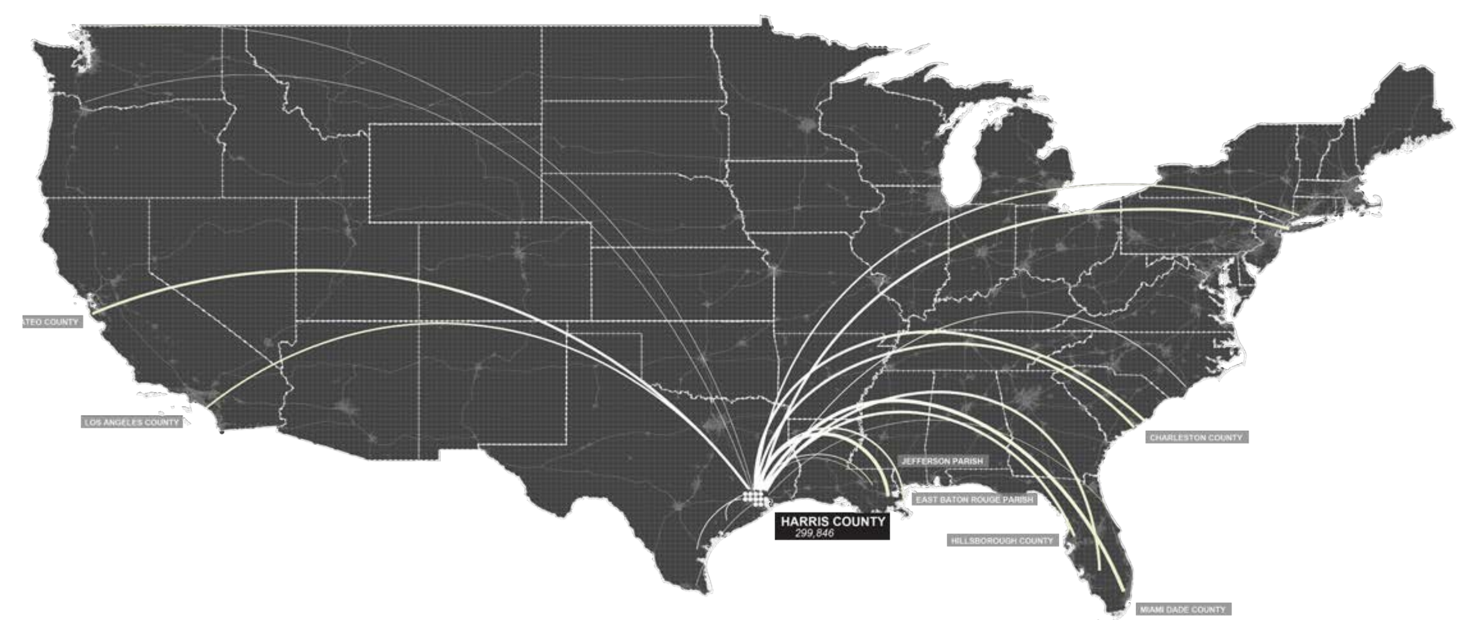
[85] Hauer, Mathew, Evans, Jason, and Mishra, Deepak. 2016. "Millions projected to be at risk from sea-level rise in the continental United States." Nature Climate Change, 6, 691-695. Accessed September 8, 2019.

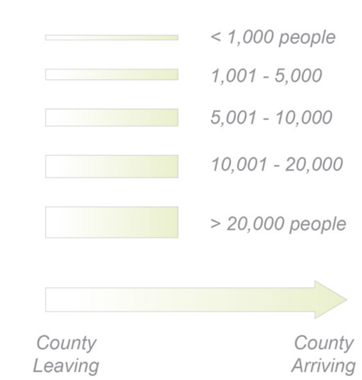
[86] Hauer, Mathew. 2017. "Migration induced by sea level rise could reshape the US population landscape." Nature Climate Change, 7, pp. 321-325. Accessed September 8, 2019.





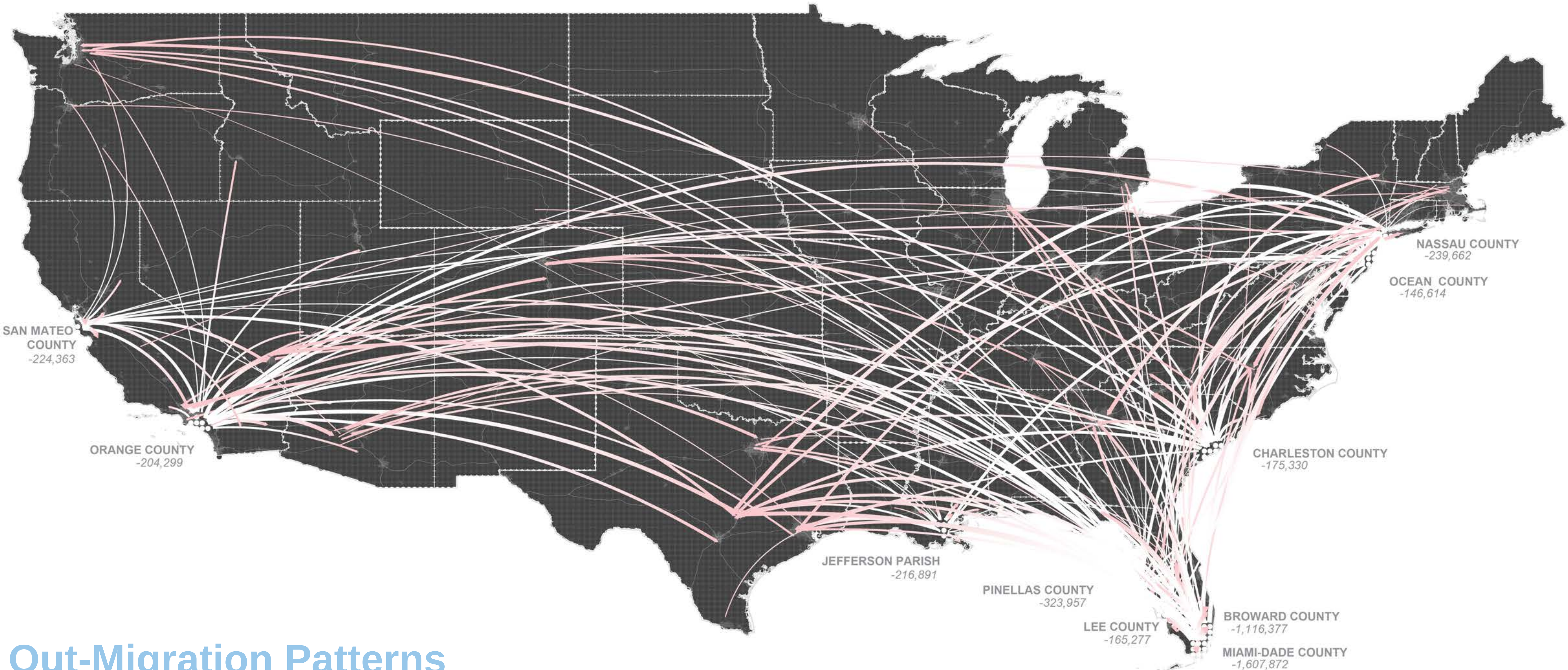






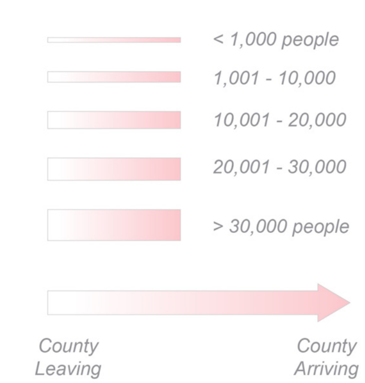
[85] Hauer, Mathew, Evans, Jason, and Mishra, Deepak. 2016. "Millions projected to be at risk from sea-level rise in the continental United States." Nature Climate Change, 6, 691-695. Accessed September 8, 2019.

[86] Hauer, Mathew. 2017. "Migration induced by sea level rise could reshape the US population landscape." Nature Climate Change, 7, pp. 321-325. Accessed September 8, 2019.

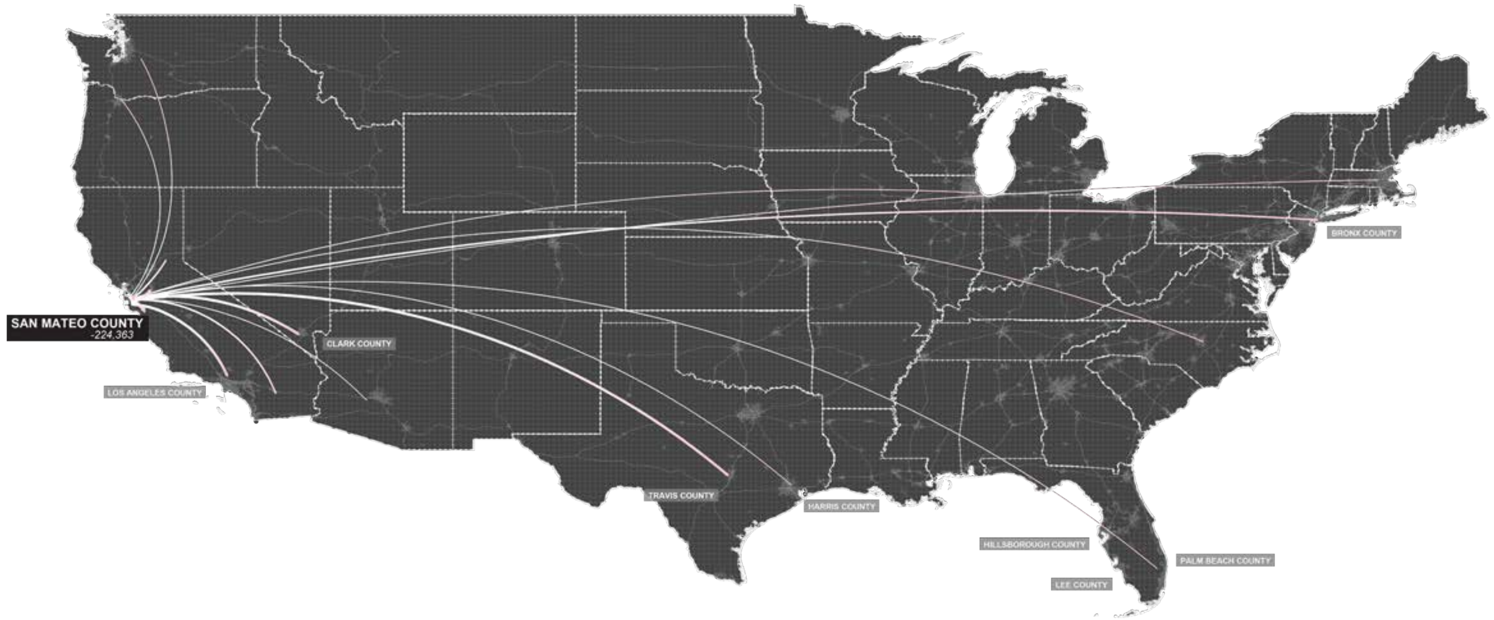


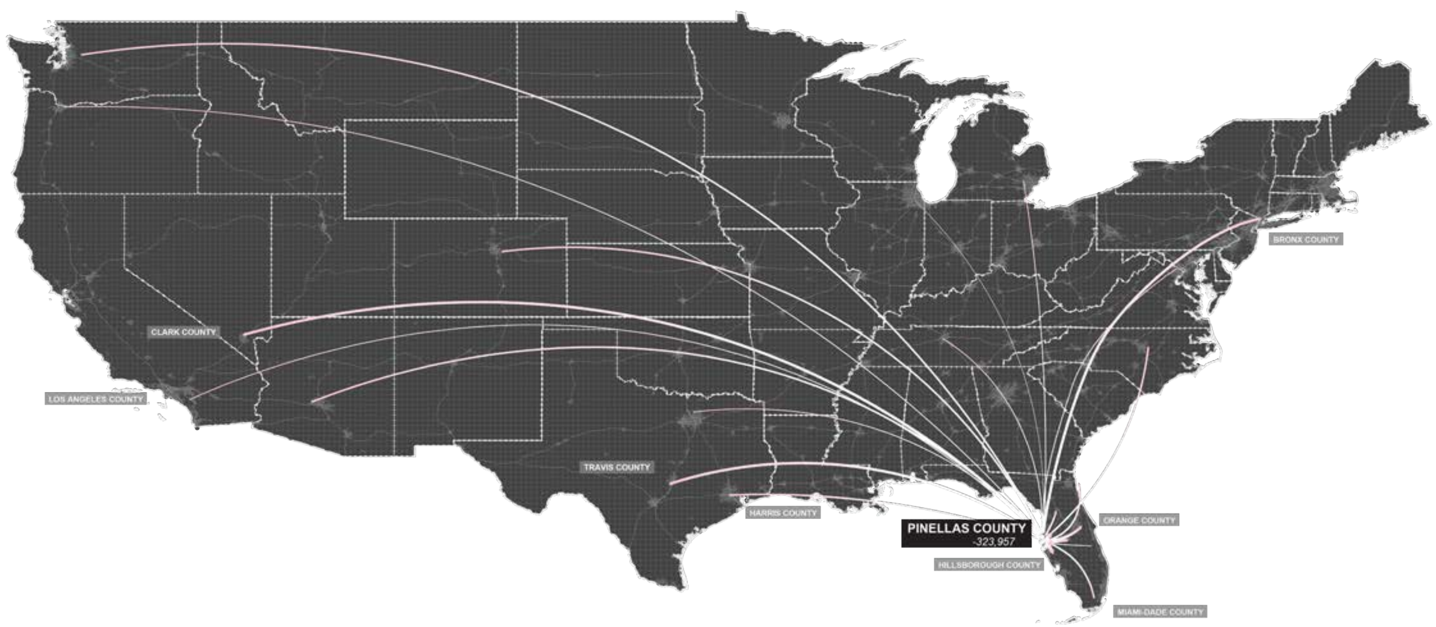
Out-Migration Patterns

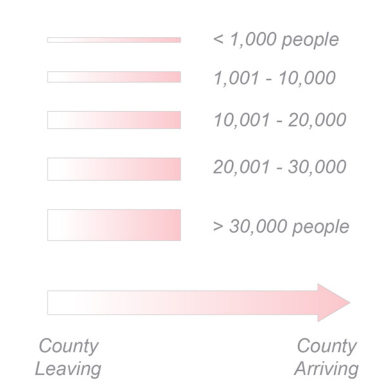
In-migration and out-migration patterns suggest that the US population is moving from cities to cities, crisscrossing the nation. Drawing on Mathew Hauer's work, these maps show that most people in the US who moved within the last decade moved from coastal counties, with the Seattle area a particularly major source of out-migration. The major East Coast out-migration counties are Nassau in New York; Ocean in New Jersey; Charleston in South Carolina; Broward, Miami-Dade, Lee, and Pinellas in Florida; and Jefferson Parish in Louisiana. West Coast counties include King in Washington and San Mateo and Orange in California. Many of the states with large out-migration populations also have large in-migration populations, but the populations are not moving within the state. See San Mateo, Orange, and Los Angeles in California; Pinellas, Lee, Miami-Dade, Broward, Orange, Palm Beach, and Hillsborough in Florida; Nassau, Bronx, and Kings in New York; and Jefferson and East Baton Rouge in Louisiana. Many of the out-migration counties are coastal counties already facing challenges from sea level rise.[85]



[85] Hauer, Mathew, Evans, Jason, and Mishra, Deepak. 2016. "Millions projected to be at risk from sea-level rise in the continental United States." Nature Climate Change, 6, 691-695. Accessed September 8, 2019.



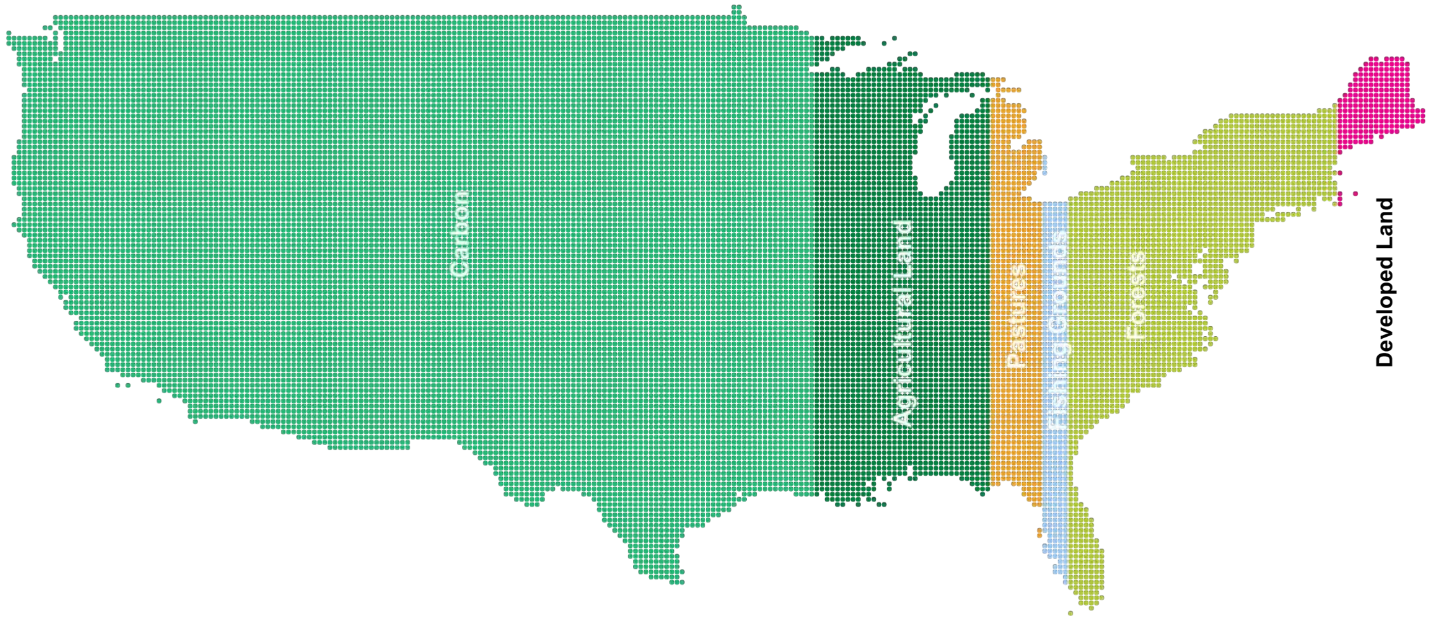




[85] Hauer, Mathew, Evans, Jason, and Mishra, Deepak. 2016. "Millions projected to be at risk from sea-level rise in the continental United States." Nature Climate Change, 6, 691-695. Accessed September 8, 2019.

[86] Hauer, Mathew. 2017. "Migration induced by sea level rise could reshape the US population landscape." Nature Climate Change, 7, pp. 321-325. Accessed September 8, 2019.


Consumption



[Figure D]Eco-footprint By Land

Amercian Eco-footprints

Individual Ecologcial Footprints [Figure A]

An ecological footprint "measures the demand on and supply of nature"—that is, how fast we consume resources and generate waste, and how fast nature can absorb our waste and generate new resources.[86] All things considered, an individual in the US would require 21.2 acres to support their lifestyle at today's average standards. This includes 14.9 acres for carbon sequestration; 2.9 acres of cropland; 2.0 acres of forest; 0.7 acres of pasture; 0.3 acres of fishing grounds; and 0.2 acres of built-up or developed land. The total land area of the US divided by its total population, however, is below ten acres, meaning that US individuals must draw on land elsewhere in the world to satisfy their current lifestyles.

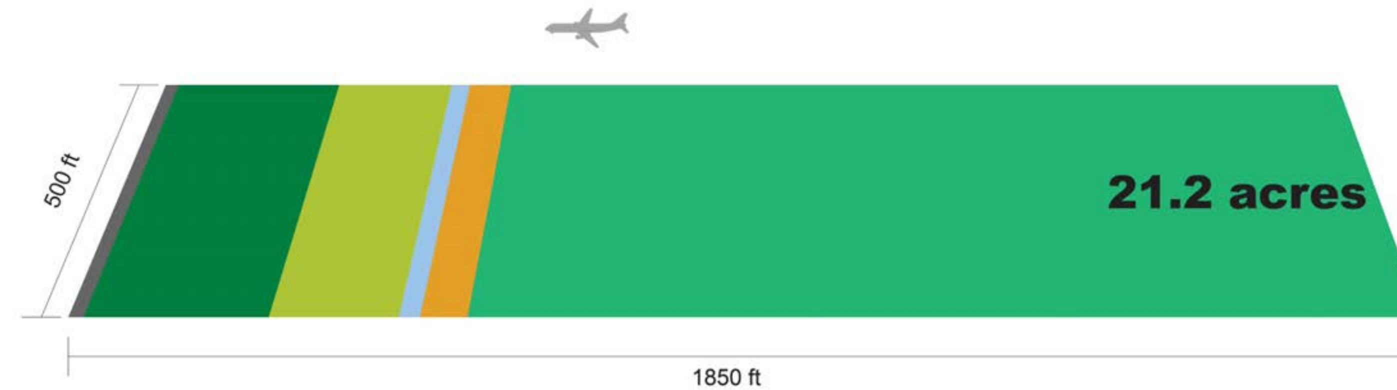
Global Ecological Footprints [Figures B, C]

The average ecological footprint globally is 6.9 acres required to sustain one person. Since average global bioavailability is only 4.2 acres, it can be concluded that humanity is living well beyond the Earth's capacity to supply the resources and absorb the waste required for contemporary demand.

Ecological Footprint by Land [Figure D]

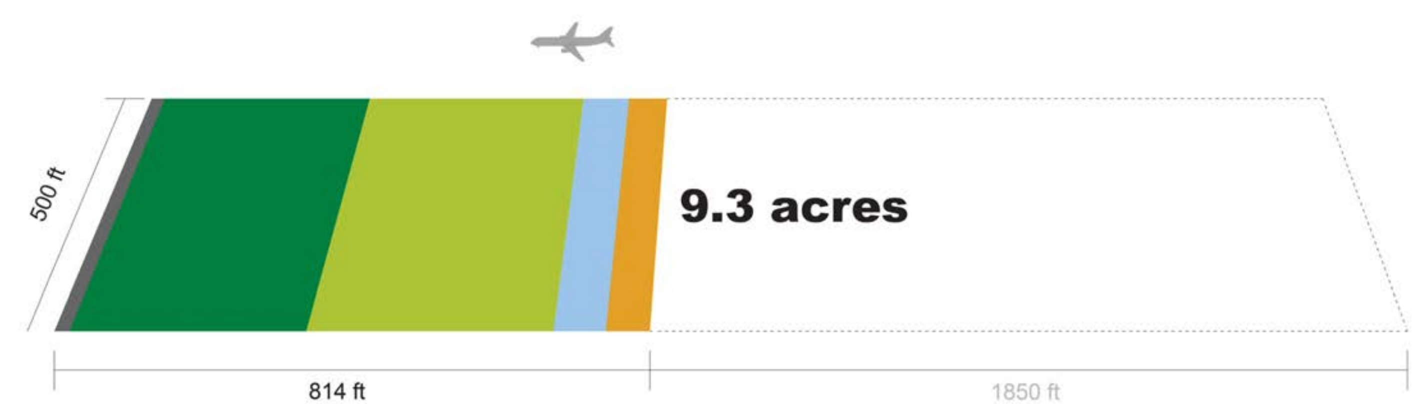
The US land mass would need to be 2.3 times its current size to provide the resources required by its current population, and 3 times its current size to support the projected 2060 population of 417 million, if today's standards of living continue unchanged.

[86] "Ecological Footprint." Global Footprint Network. Accessed July 24, 2019. https://www.footprintnetwork.org/our-work/ecological-footprint/.

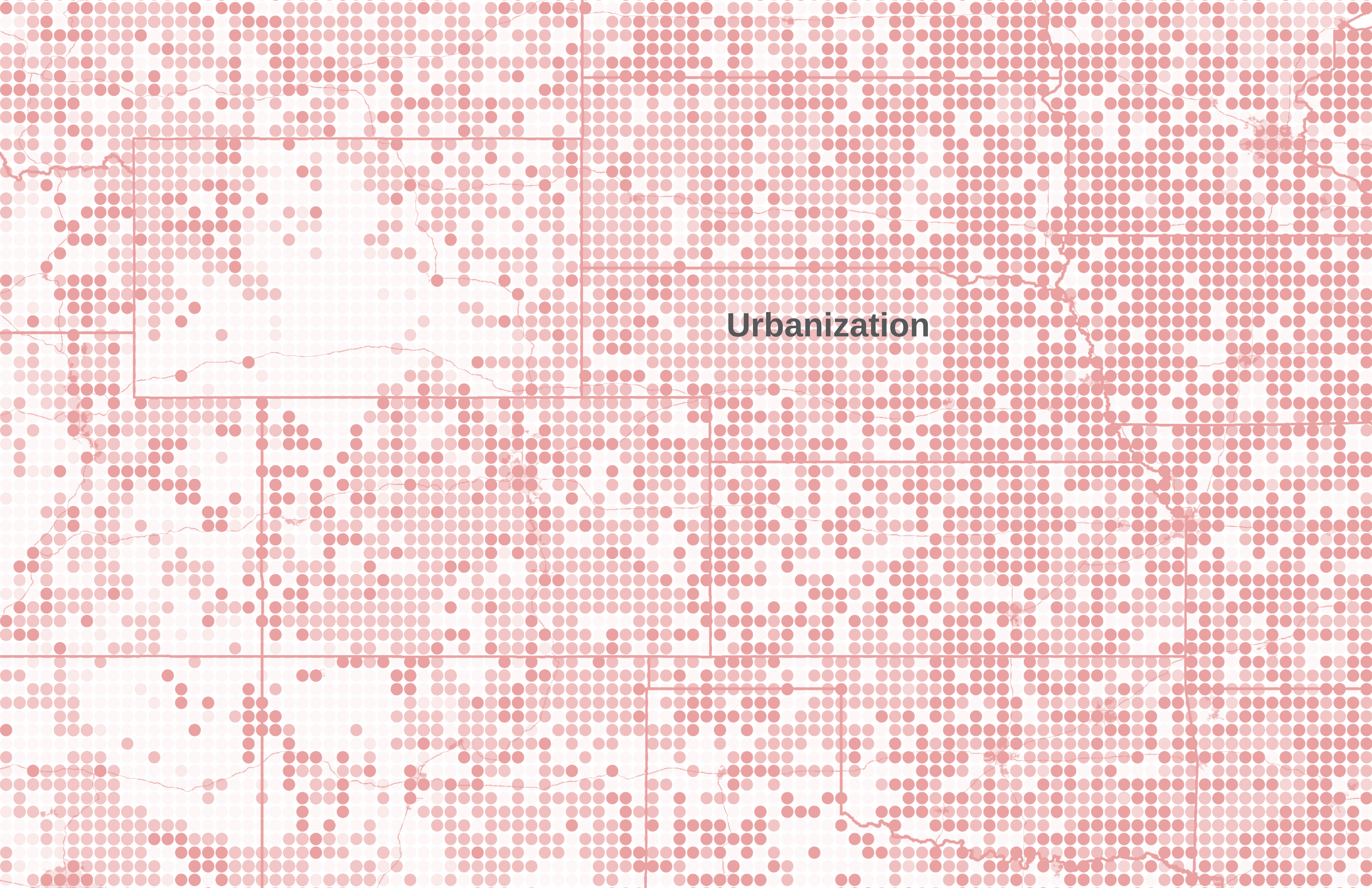


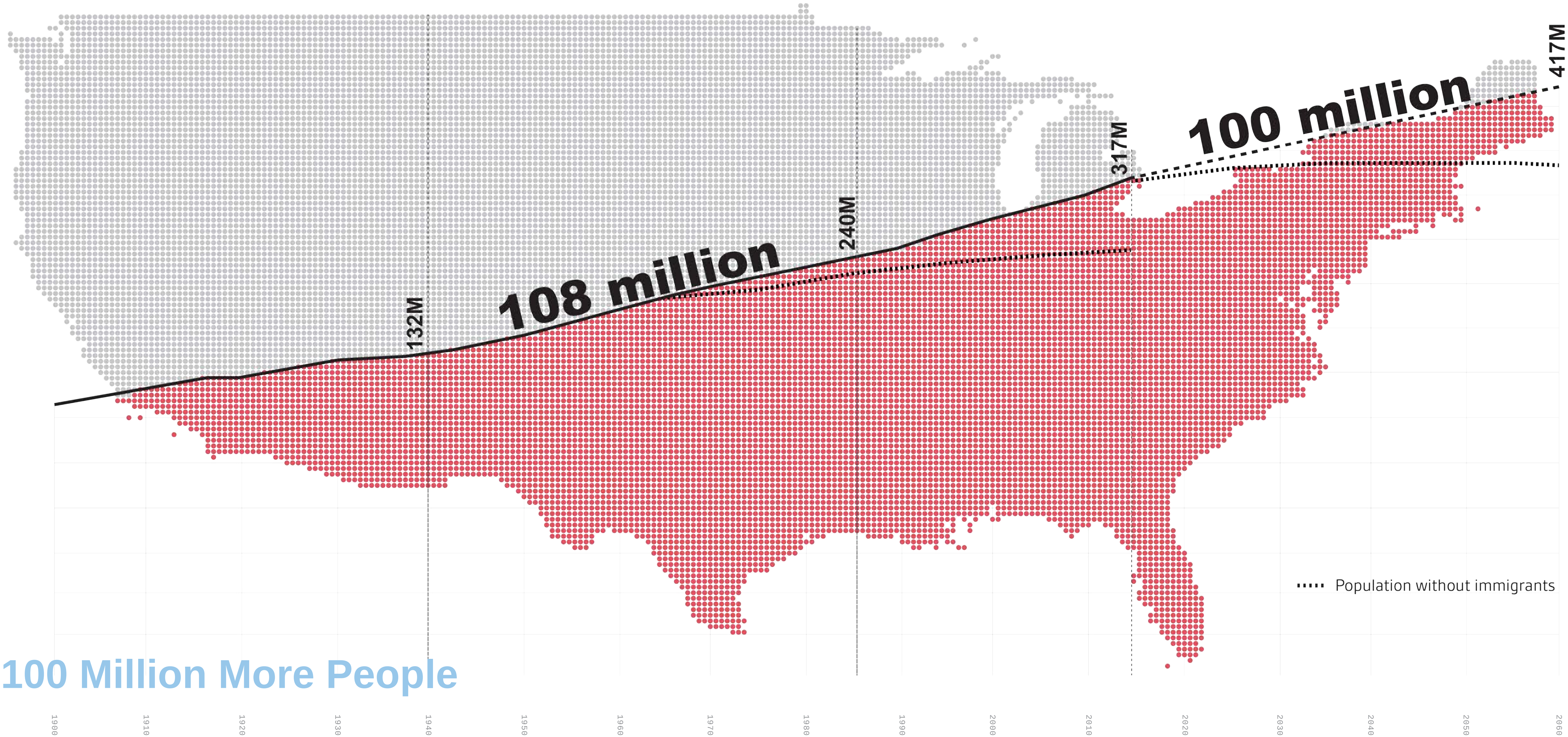
[Figure A]One American's Eco-Footprint

[Figure A]Eco-footprint to World Average



[Figure C]Eco-capacity of the Planet


Urbanization



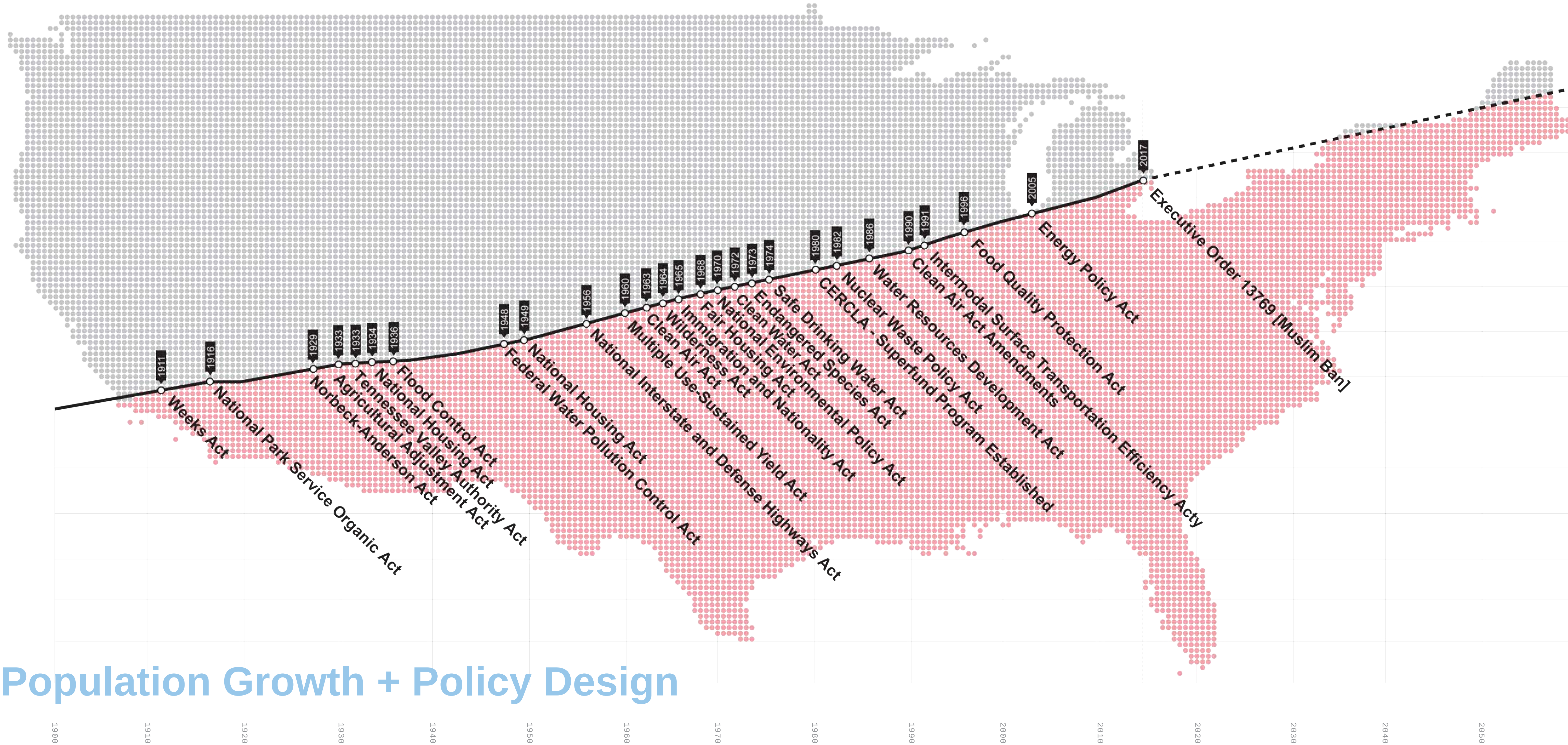
100 Million More People

The US population is projected to grow from 319 million in 2014 to 417 million in 2060—an increase of 98 million people in less than 50 years. The US has gone through similar periods of population growth in the past: the post–World War II baby boom nearly doubled the population, from 132 million in 1940 to 240 million in 1990.[88] The population grew another 77 million between 1990 and 2015, to 319 million. Foreign-born persons made up 13% of the population in 2014 (43 million) and are expected to comprise 19% (78.2 million) by 2060.

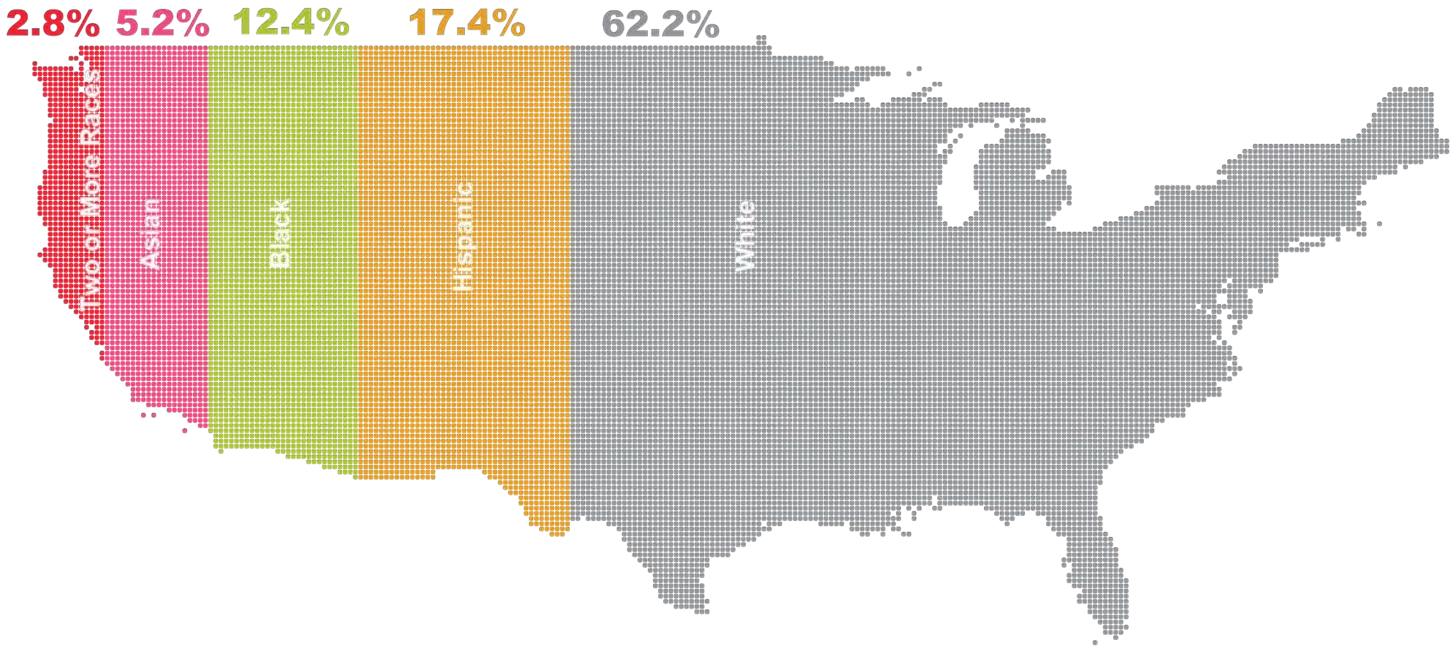
[87] Colby, Sandra L., and Jennifer M. Ortman. “Projections of the Size and Composition of the US Population: 2014 to 2060. Population Estimates and Projections. Current Population Reports. P25-1143.” US Census Bureau (2015).

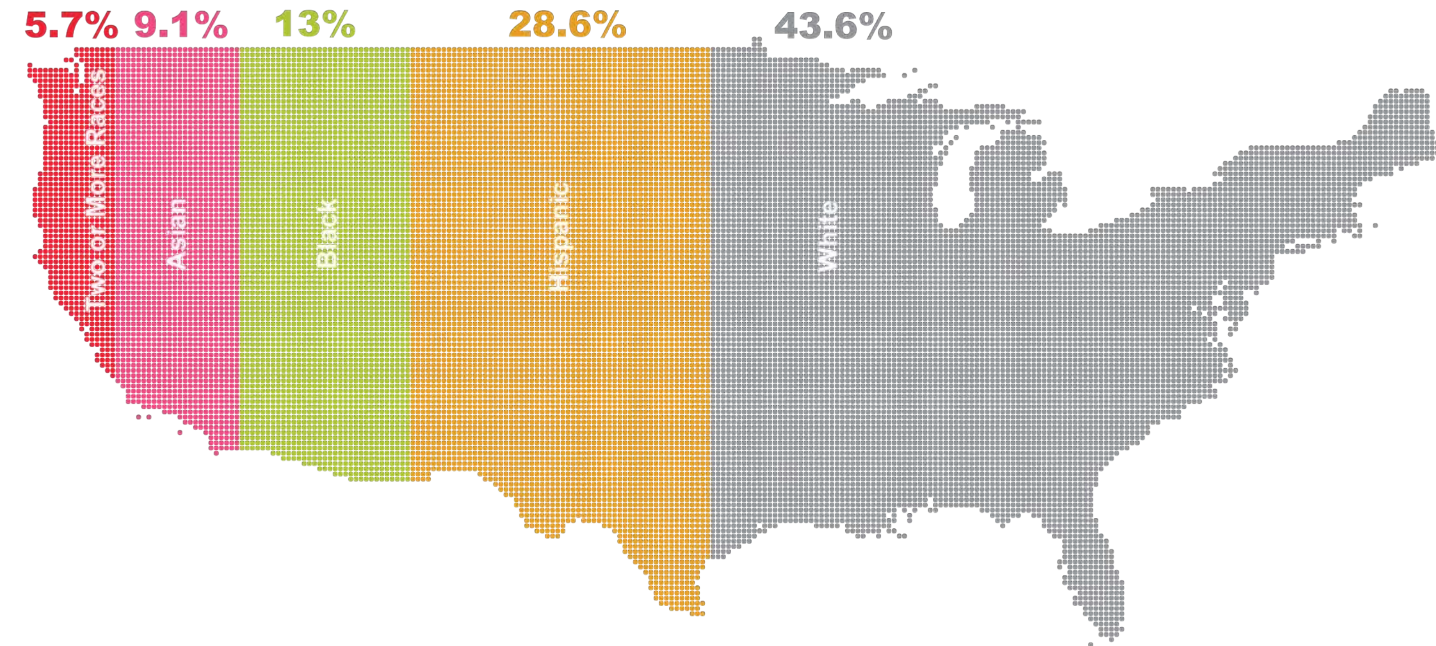
[88] “A Look at the 1940 Census.” US Population - 1940 to 2010. U.S. Census Bureau. Accessed April 09, 2018. https://www.census.gov/newsroom/cspan/1940census/CSPAN_1940slides.pdf.

Population Growth + Policy Design



During the post–World War II era, the US passed various pieces of legislation to address the nation's rapid growth. These included significant ecological, infrastructural, and social reforms. A similar series of policy decisions will be needed to address the twenty-first century's increasing population, changing demographics, economic restructuring, and climate crisis. After at least half a century, many of these legislative achievements will lapse in the 2020s, if they have not already.





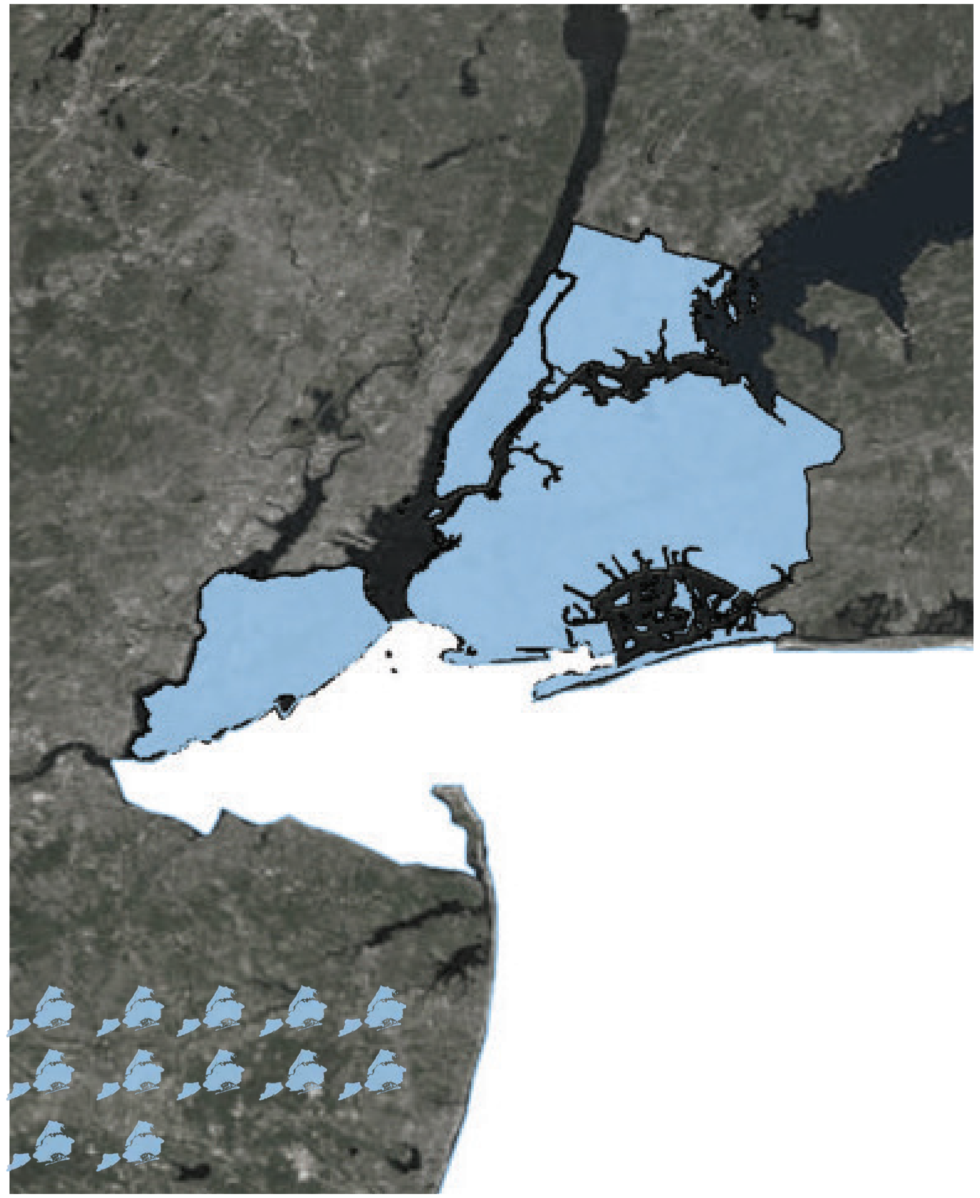
Changing Demographics

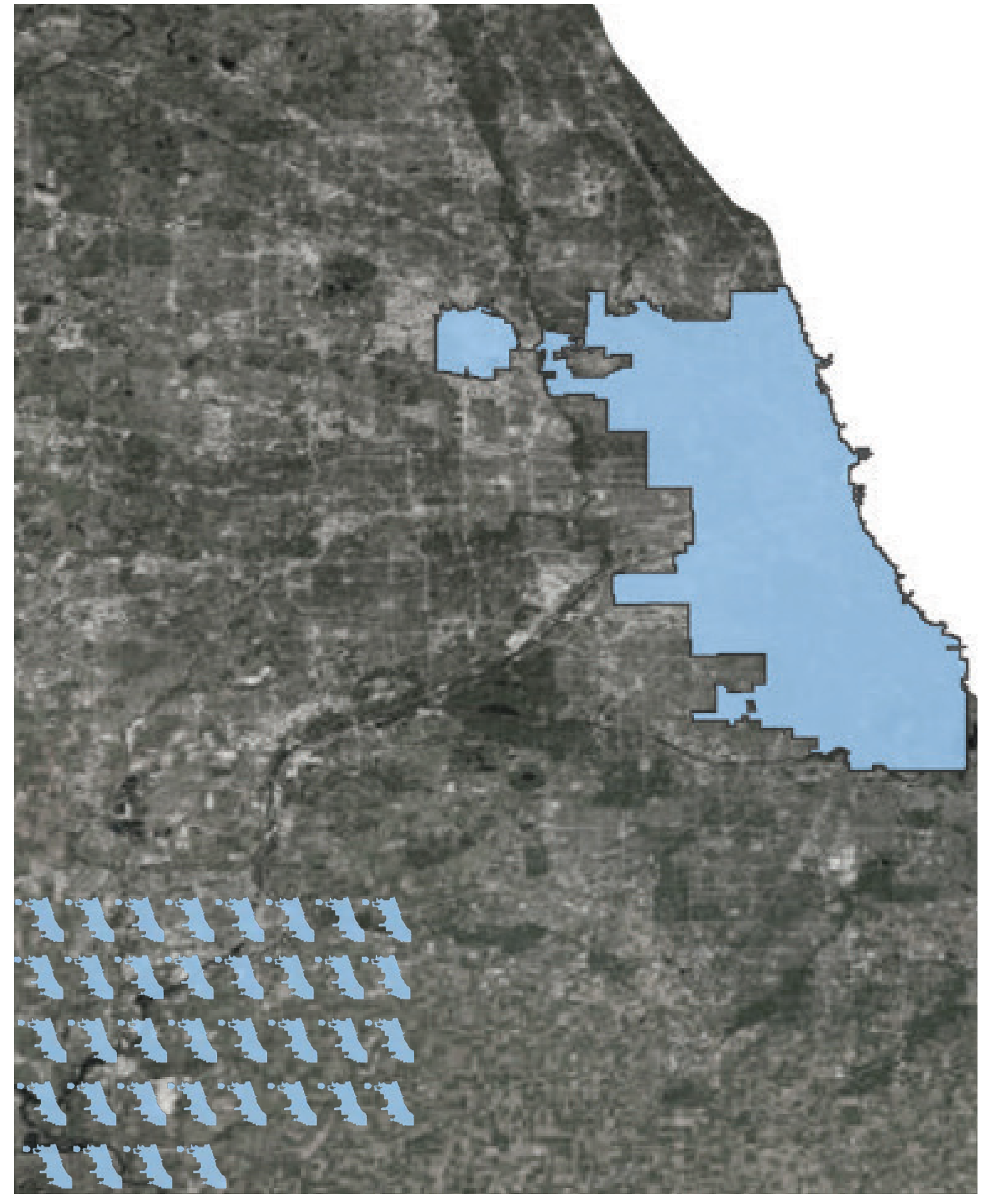
US fertility rates are predicted to decline between 2014 and 2060. This is projected to result in a rising share of foreign-born people in the US.[89] The population will also be older than ever before, as baby boomers and their children age. The percentage of the population aged 65 or older will increase from 15% in 2014 to 24% in 2060, for both native-born and foreign-born. The "working age" (age 18–64) proportion of the population will decrease for both native-born and foreign-born, with the overall percentage decreasing from 62% to 57%.[90] Overall, the population is projected to be more diverse, with non-Hispanic whites projected to decrease from 62.2% of the US population in 2014 to 43.6% in 2060.[91] The Hispanic population will increase from 17.4% to 28.6%; the black population will increase from 12.4 to 13%; and the Asian population will increase from 5.2 to 9.1%. Those who identify as two or more races will more than double, from 2.8% to 5.7%.

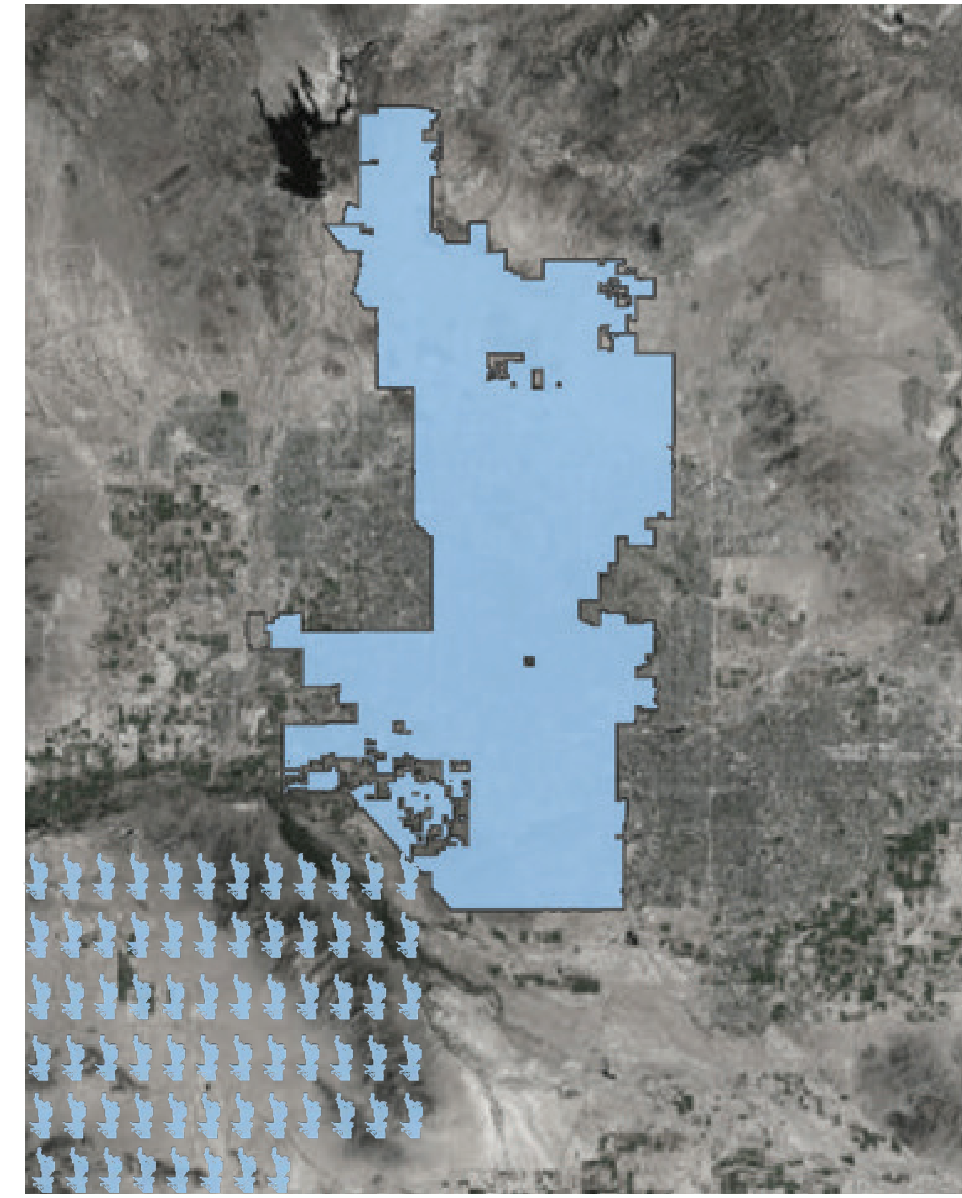
[89] Colby, Sandra L., and Jennifer M. Ortman. "Projections of the Size and Composition of the US Population: 2014 to 2060. Population Estimates and Projections. Current Population Reports. P25-1143." US Census Bureau (2015).

[90] Colby, Sandra L., and Jennifer M. Ortman. "Projections of the Size and Composition of the US Population: 2014 to 2060. Population Estimates and Projections. Current Population Reports. P25-1143." US Census Bureau (2015).

[91] Colby, Sandra L., and Jennifer M. Ortman. "Projections of the Size and Composition of the US Population: 2014 to 2060. Population Estimates and Projections. Current Population Reports. P25-1143." US Census Bureau (2015).







Building for 100 Million More People

Adding 100 million new people to the US by 2060 will require massive expansions of, and investments in, communities; it will also require densifying our cities. Most demographers expect an increasing share of these people will live in large cities like New York, Chicago, and Phoenix. If the next 100 million live in high-density cities, equivalent to New York, then they will require 12 new New Yorks (based on the 2010 population of 8,175,133)—with approximately one new New York constructed every 3.5 years. If they live in medium-density cities, equivalent to Chicago, then they will require 36 new Chicagos (based on the 2010 population of 2,695,598)—with about one constructed every 14 months. Finally, if the next 100 million choose to live in a low-density suburban configuration, equivalent to Phoenix, then they will require 68 new Phoenixes (based on the 2010 population of 1,445,632)—approximately one new Phoenix every 7 months.[92]

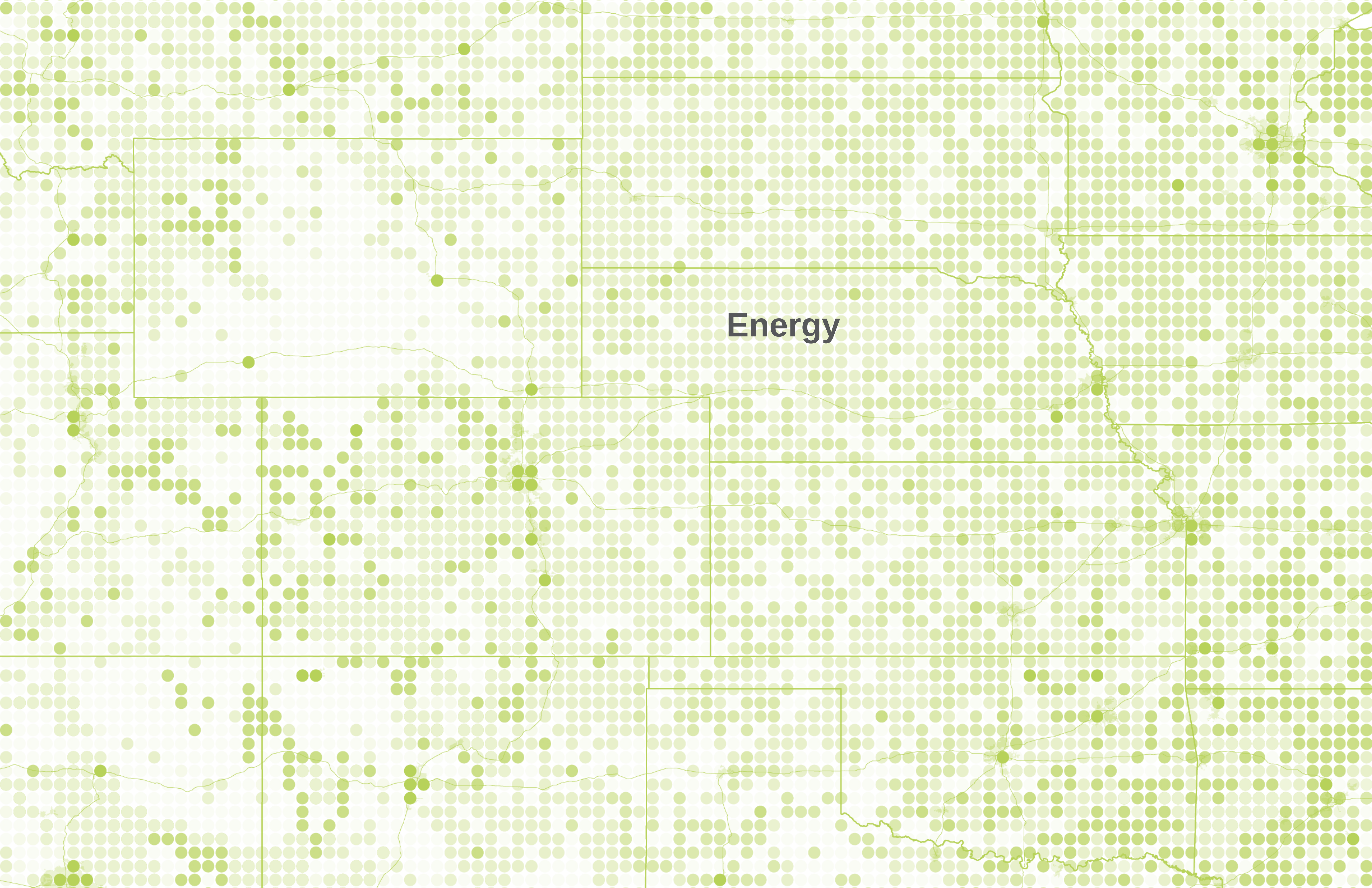
[92] U.S. Census Bureau. "Phoenix, AZ." American FactFinder - Results. October 05, 2010. Accessed April 09, 2018. https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml?src=bkmk

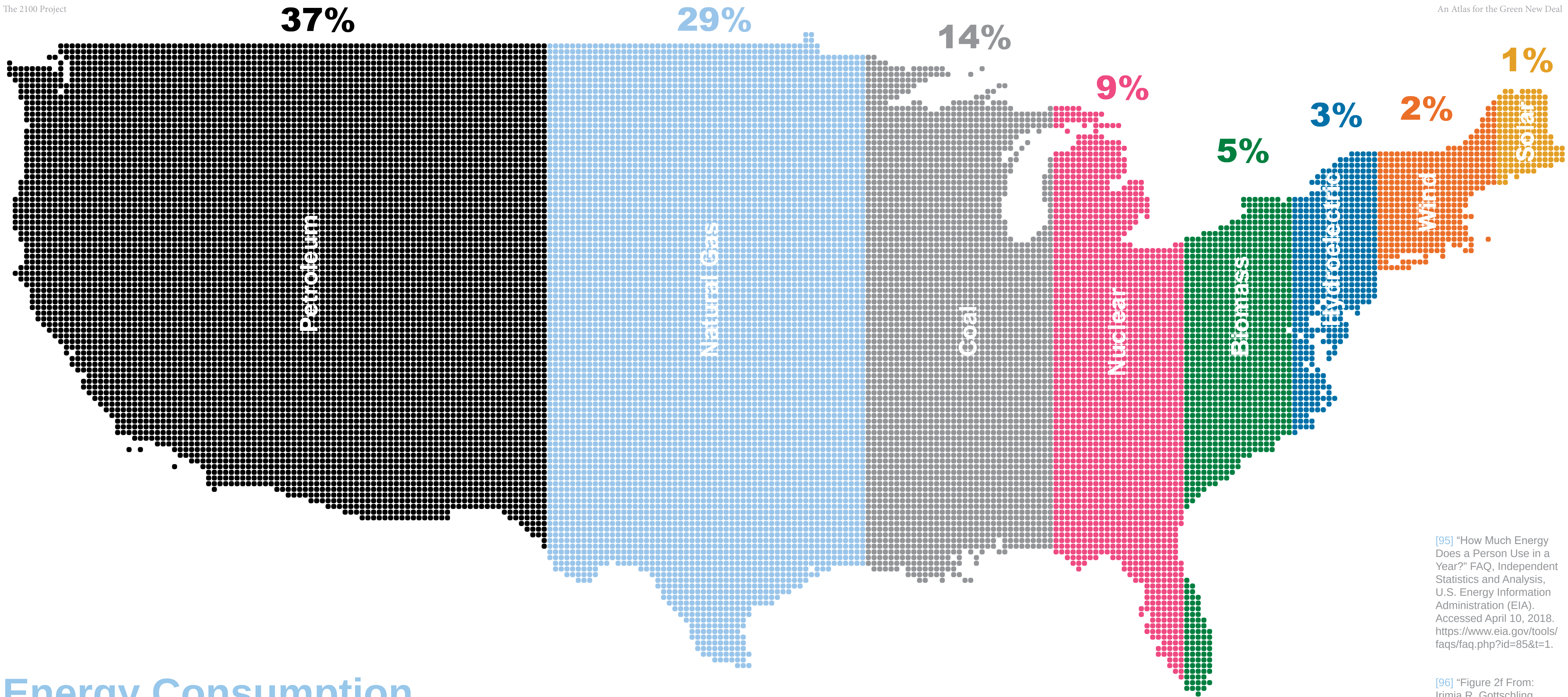
Roadways for 100 Million More People

The US averages around 27 lane miles of road for every 1,000 people.[93] If that average is maintained over the next 100 million people, 2,668,080 miles of new road will be required, costing at least $120 billion.[94] This would be the equivalent road length of 476 round trips between New York and Los Angeles.

[93] "Highway Statistics Series." U.S. Department of Transportation/Federal Highway Administration. March 26, 2018. Accessed April 10, 2018. https://www.fhwa.dot.gov/policyinformation/statistics/abstracts/2015/.

[94] "Paving Cost/mile." Ohio Department of Transportation. Accessed April 10, 2018. http://www.dot.state.oh.us/Divisions/Finance/GASB%2034%20Documents/PavingCostpermile.pdf


Energy



Energy Consumption

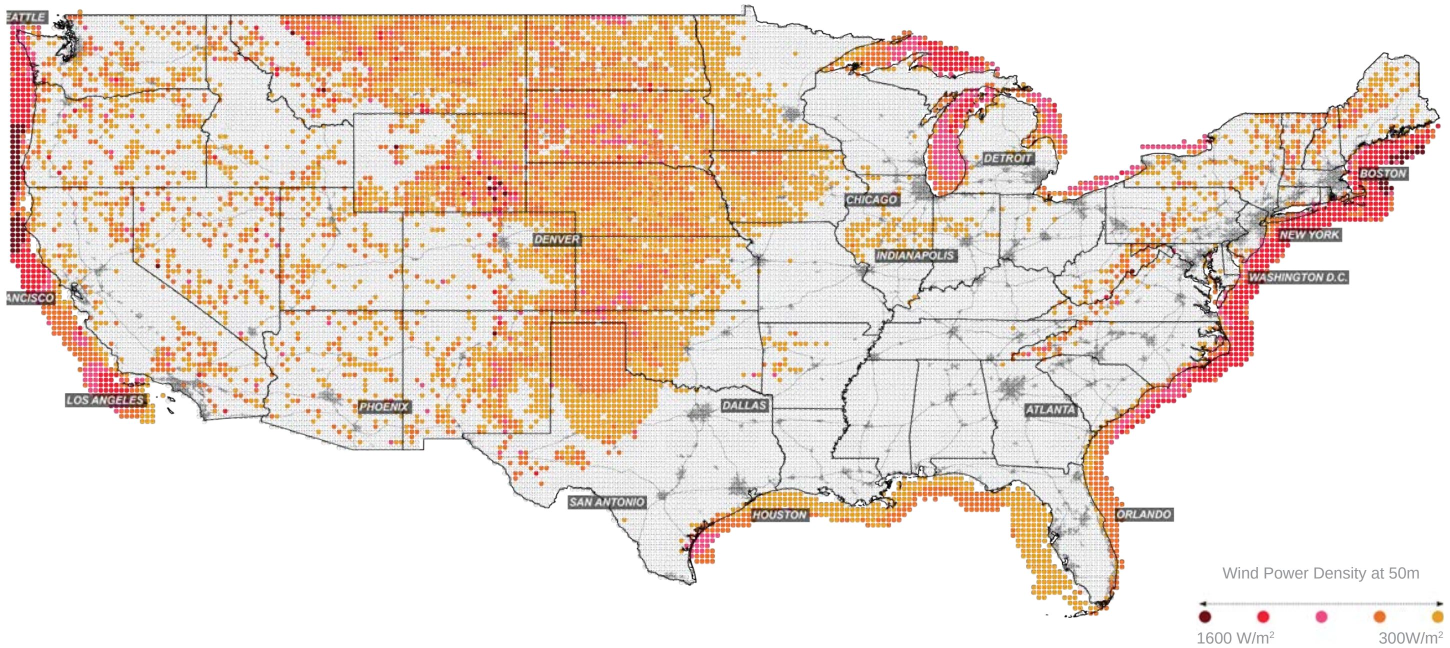
Individuals in the US use approximately four times the global average annual energy consumption. In 2017, the average American used 88.21 MWh of energy, against a global average of only 21.69 MWh.[95] Of this consumption, 80% came from fossil fuels, 9% from nuclear power, and 11% from renewable energy sources.[96] Of the renewable energy, only 3% is considered viable for future expansion: wind and solar. Much of the rest comes from hydroelectricity.

The next 100 million will need 8,645,008 GWh of energy per year if today's consumption patterns are maintained. Since US energy consumption per capita has been increasing (nearly tripling since the nineteen-fifties), then it seems likely that current patterns of consumption will continue, if not increase.[97] Few, if any, proposals for creating a clean energy grid for the US incorporate these population projections into their various buildout scenarios.

[95] "How Much Energy Does a Person Use in a Year?" FAQ, Independent Statistics and Analysis, U.S. Energy Information Administration (EIA). Accessed April 10, 2018. https://www.eia.gov/tools/faqs/faq.php?id=85&t=1.

[96] "Figure 2f From: Irimia R, Gottschling M (2016) Taxonomic Revision of Rochefortia Sw. (Ehretiaceae, Boraginales). Biodiversity Data Journal 4: E7720. Https://doi.org/10.3897/BDJ.4.e7720." doi:10.3897/bdj.4.e7720.figure2f.

[97] "Table 1.3 Primary Energy Consumption by Source." U.S. Energy Information Administration, Monthly Energy Review. June 2019. Accessed July 25, 2019. https://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf.

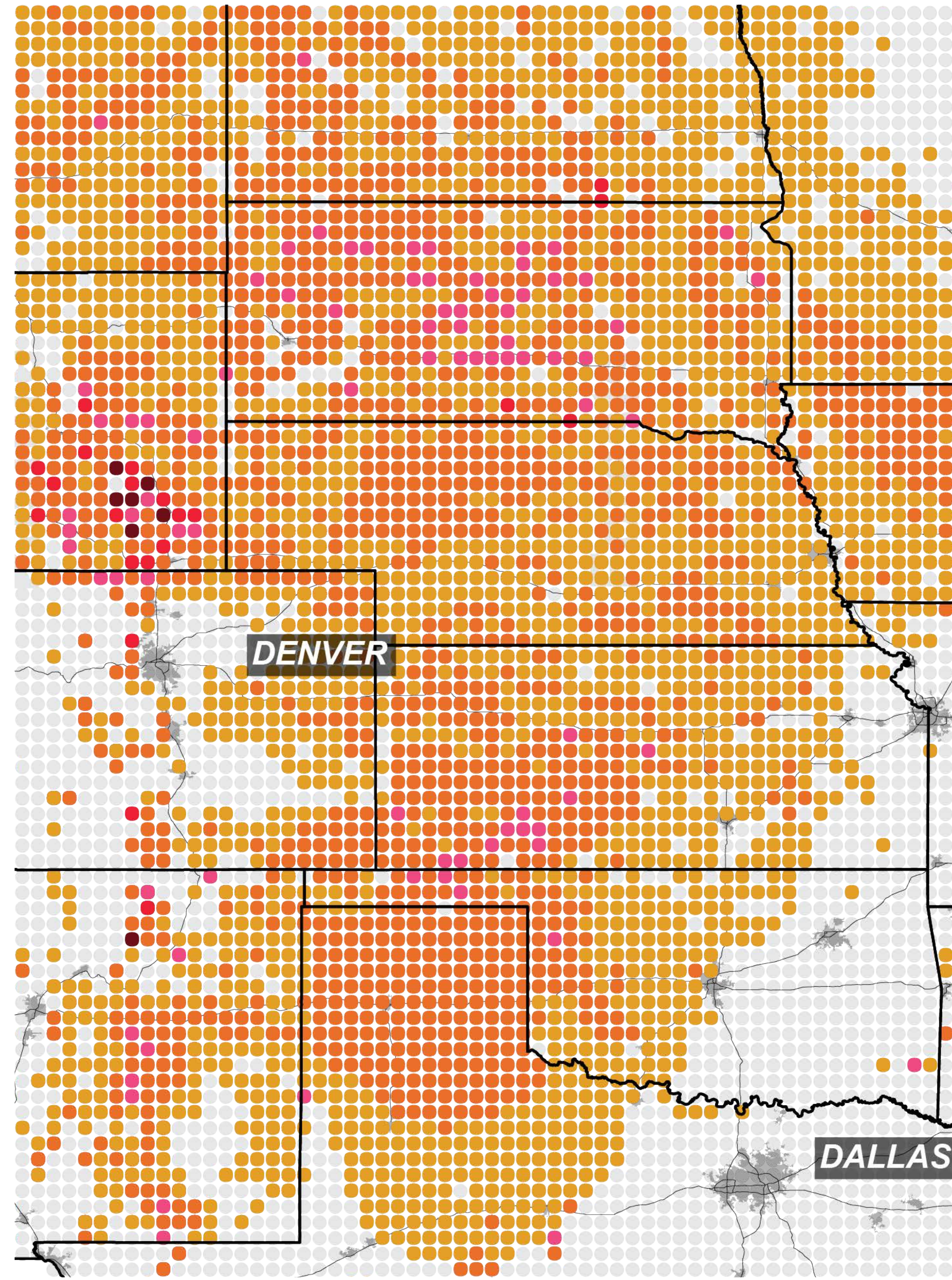


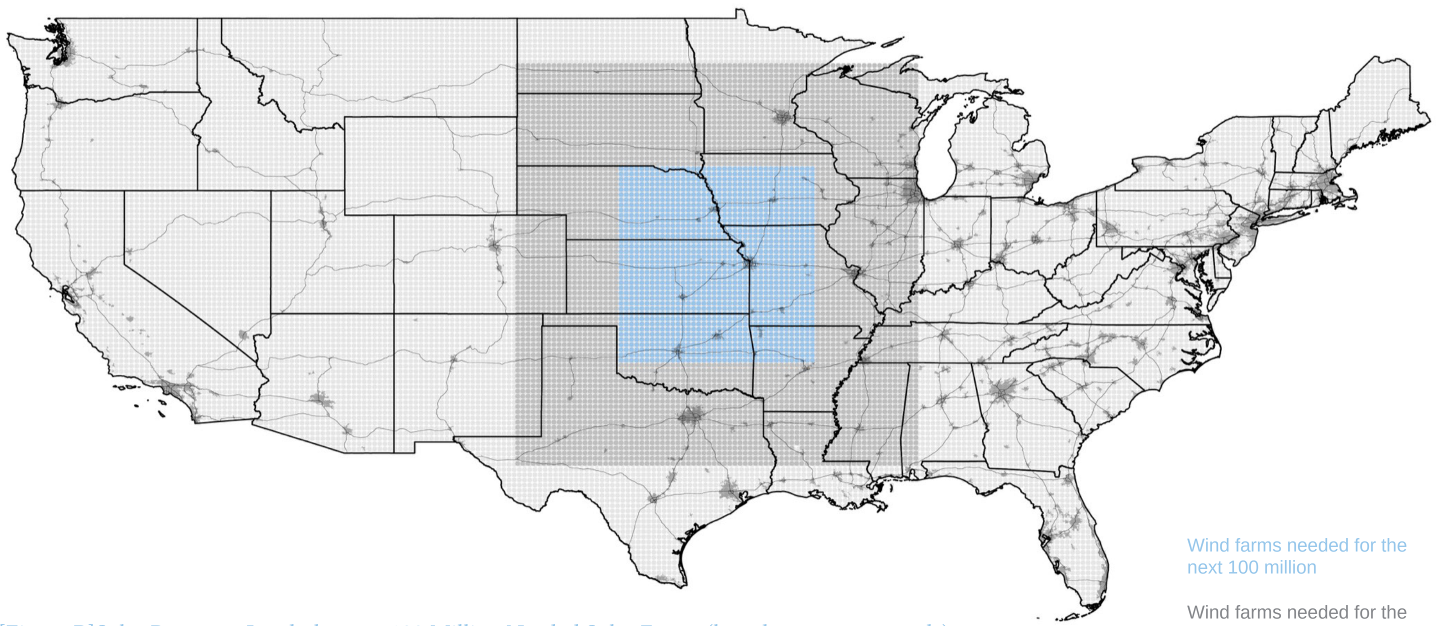
Wind Power Potential

Wind production is most viable offshore (near the Atlantic Coast, Pacific Coast, and Great Lakes megaregions) with some potential viability in the inland US.[98] Pockets of good potential wind energy also occur along the Appalachian Mountains and west of the Rockies.[99]

[98] "United States – Wind Resource Map." National Renewable Energy Laboratory, U.S. Department of Energy. May 6, 2009. Accessed August 19, 2019. https://www.nrel.gov/gis/assets/pdfs/windsmodel4pub1-1-9base200904enh.pdf

[99] "2016 Offshore Wind Energy Resource Assessment for the United States." Walt Musial, Donna Heimiller, Philipp Beiter, George Scott, and Caroline Draxl, National Renewable Energy Laboratory, U.S. Department of Energy. September 20016. Accessed August 19, 2019. https://www.energy.gov/sites/prod/files/2019/02/f59/66599.pdf





[Figure B]Solar Power on Land: the next 100 Million Needed Solar Farms (based on current trends)

Wind Power Demands

Wind Arrays [Figure A]

A typical 2 MW wind turbine will produce around 4,700 MWh per year.[100] To produce the energy needed for the next 100 million, the US would need 1,834,337 such wind turbines.

Wind Power on Land [Figure B]

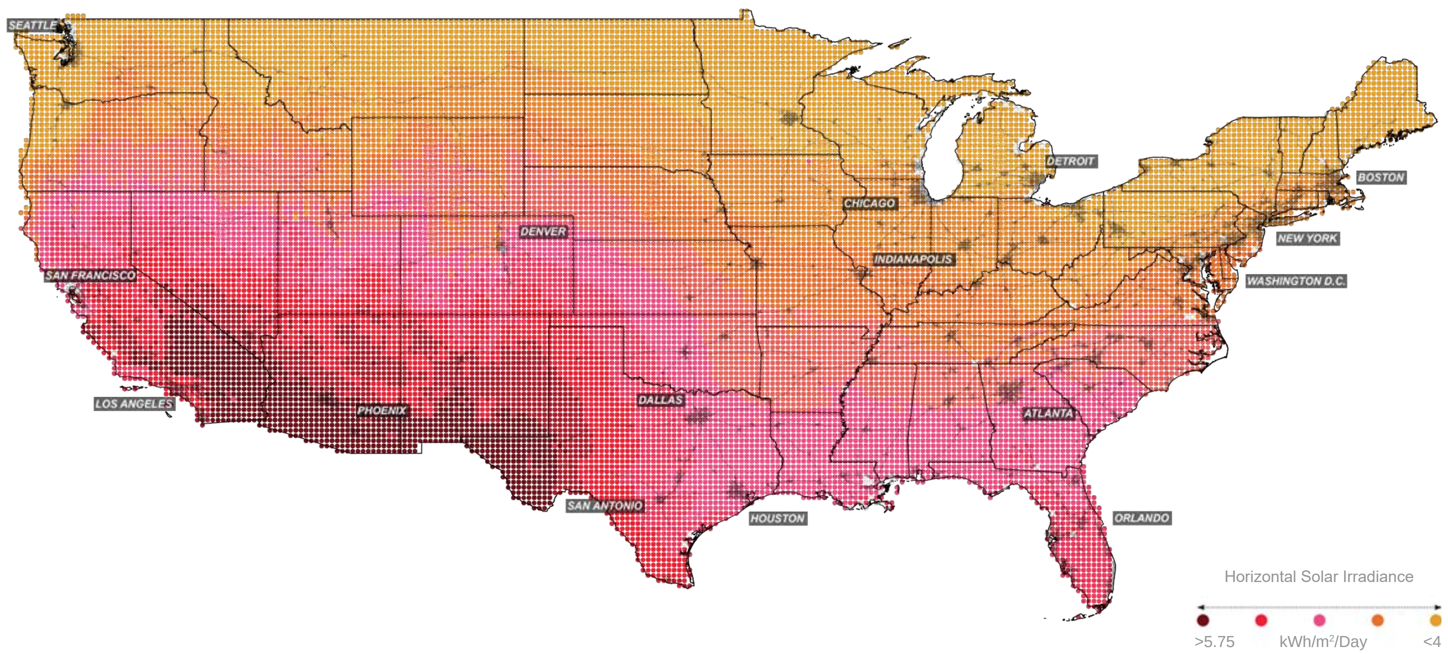
Turbines that can take advantage of wind from any direction require 82 acres of land on average per turbine.[101] Meeting the energy consumption needs of the next 100 million would therefore require 150,415,603 acres of wind farms, nearly the total land area of Texas.[102] By the same logic, the total US population in 2060 would need 627,233,065 acres of wind turbines, 31% of the total land area of the conterminous US. This does not include the massive unbuilt storage capacity required to provide power when wind energy is not available.

[100] "State Area Measurements and Internal Point Coordinates." U.S. Census Bureau Geography. December 01, 2012. April 10,. 2018. https://www.census.gov/geo/reference/state-area.html.

[101] "State Area Measurements and Internal Point Coordinates." U.S. Census Bureau Geography. December 01, 2012. April 10,. 2018. https://www.census.gov/geo/reference/state-area.html.

[102] "State Area Measurements and Internal Point Coordinates." U.S. Census Bureau Geography. December 01, 2012. April 10,. 2018. https://www.census.gov/geo/reference/state-area.html.

[Figure A]Needed Energy Storage Capacity: The next 100 Million Americans needs 150,415,603 acres of wind farms

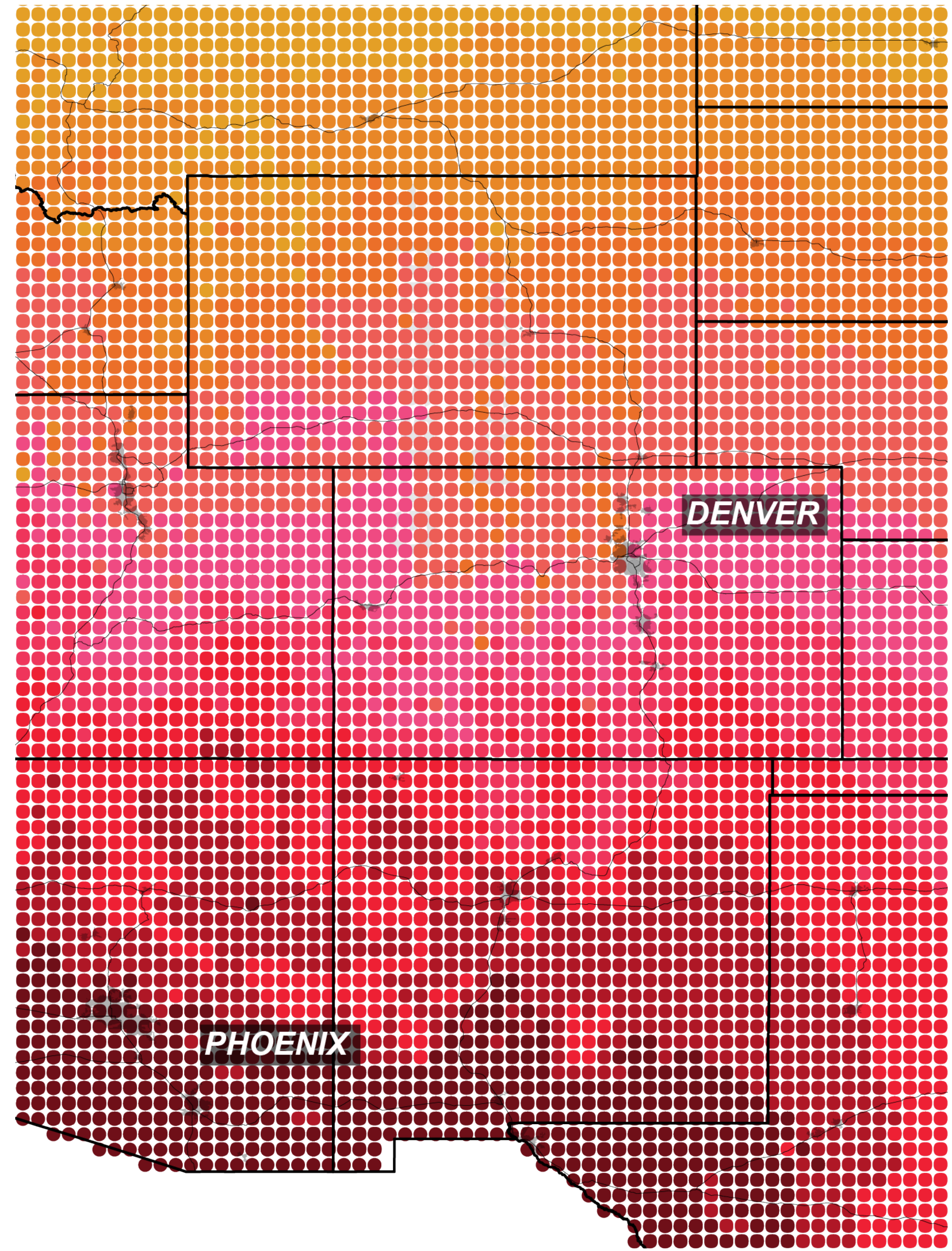


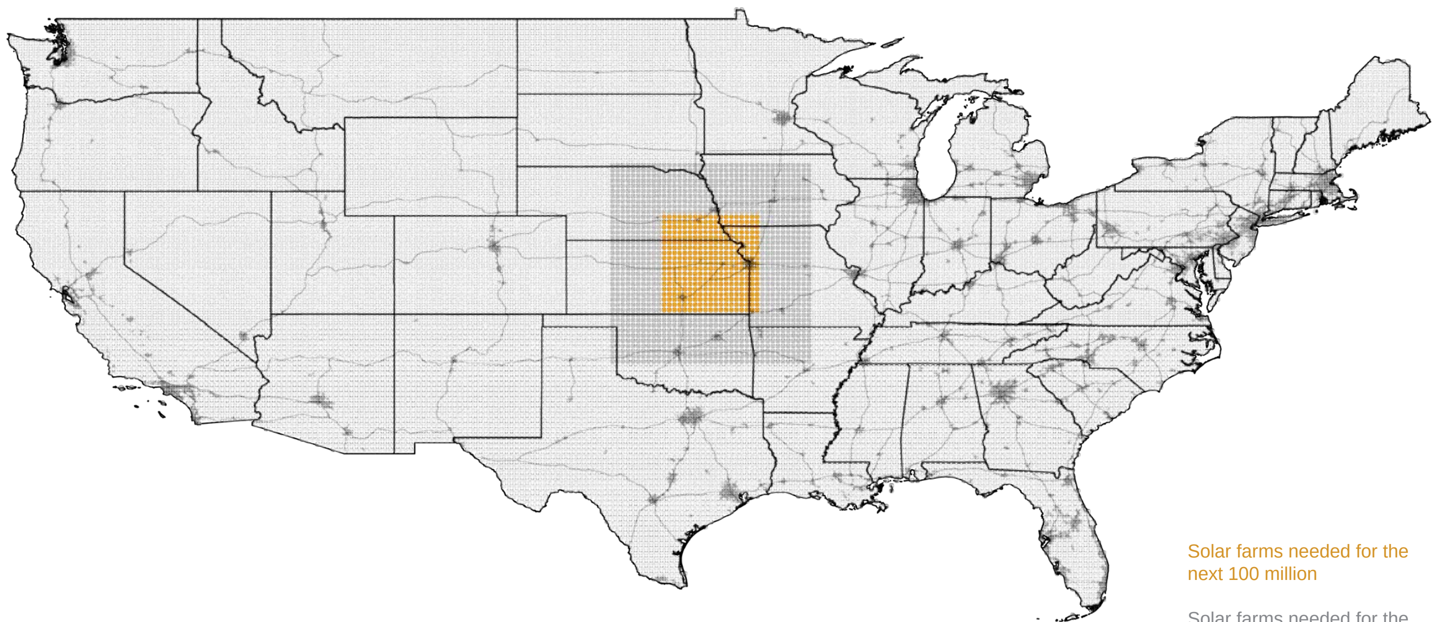
Solar Potential Potential

To maximize energy output, solar farms must be placed where there are long, sunny days. In the US, the areas with the most hours of sunlight a day are along the border with Mexico.[103] While the raw land area with sufficiently high sun exists to install millions of solar arrays, this land is sparsely populated by humans—though rich in biodiversity. Solar production has been challenged based on this ecological richness and the value placed on unobstructed views of the desert, diminishing the perceived economic and cultural viability of solar. Another limitation to solar power is the availability of the materials necessary to construct solar panels, rare metals that have limited global availability, must be mined, and cause their own environmental problems.[104]

[103] "Global Horizontal Solar Irradiance." Billy J. Roberts, National Renewable Energy Laboratory, U.S. Department of Energy. February 22, 2018. Accessed August 19, 2019. https://www.nrel.gov/gis/images/solar/solar_ghi_2018_usa_scale_01.jpg

[104] "Metal Demand for Renewable Electricity Generation in the Netherlands." Pieter van Exter, Sybren Bosch, Branco Schipper, Dr. Benjamin Sprecher, and Dr Rene Kleijn. Springtij Forum. 2018. Accessed Accessed August 19, 2019. https://www.metabolic.nl/publications/metal-demand-for-renewable-electricity-generation-in-the-netherlands/





[Figure B]Solar Power on Land: the next 100 Million Needed Solar Farms (based on current trends)

Solar Power Demands

Solar Arrays [Figure A]

26,190,307,857 solar panels of standard commercial dimension (77 by 39 inches) would be needed to generate energy for the next 100 million. This does not include the massive storage capacity that would be needed to be maintain provide power when sunlight is not available.

Solar Power on Land [Figure B]

The Topaz Solar Farm in California, one of the country's largest, has a capacity of 550 MW and occupies 4,700 acres.[105] To produce the power needed for the next 100 million, 36,666,431 acres of solar farms, or over 7,800 Topaz Solar Farms, would need to be constructed—or nearly the same size as the state of Iowa (36,014,720 acres).[106] The total US population in 2060 would need would need 152,899,017 acres of solar farms, 7.6% of the total land area of the conterminous US.

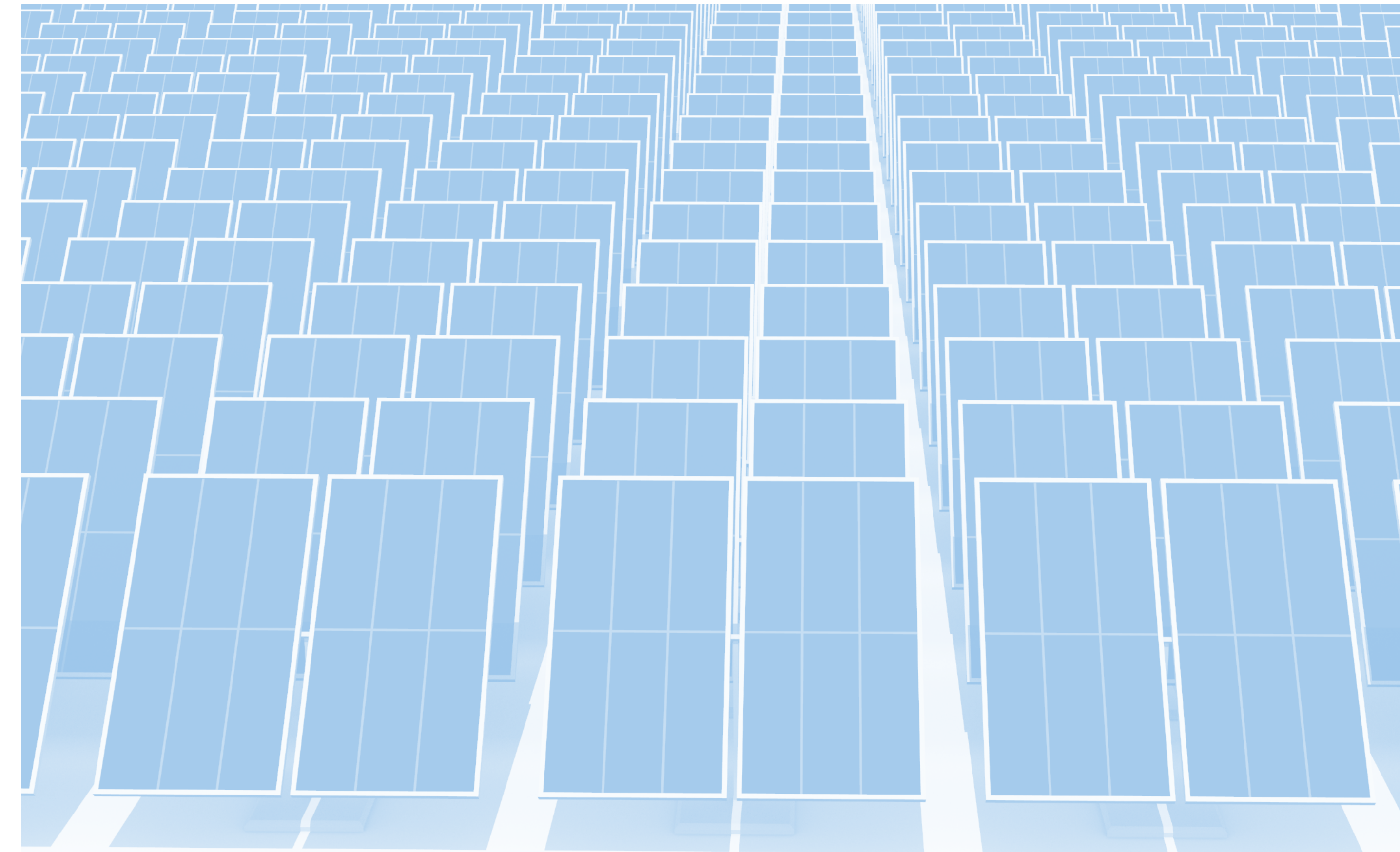
Energy Storage [Figure C]

One Tesla Powerpack has a storage capacity of 0.21 MWh.[107] To store the average annual power usage of the next 100 million, the grid would need to add 4,116,670,476 Powerpacks. There is considerable uncertainty about this figure. Most energy systems scholars agree that a clean or renewable energy grid powered by wind and solar would require a massive overbuild in its storage capacity to offset the volatility in wind and solar power generation. But the extent of the necessary overbuild is unclear. Estimates range from as low as 15% of the current grid's size to more than 40%.

[105] "Just the Facts: Topaz Solar Farm." BHE Renewables. February 2018. Accessed April 12, 2018.https://www.bherenewables.com/include/pdf/fact_sheet_topaz.pdf.

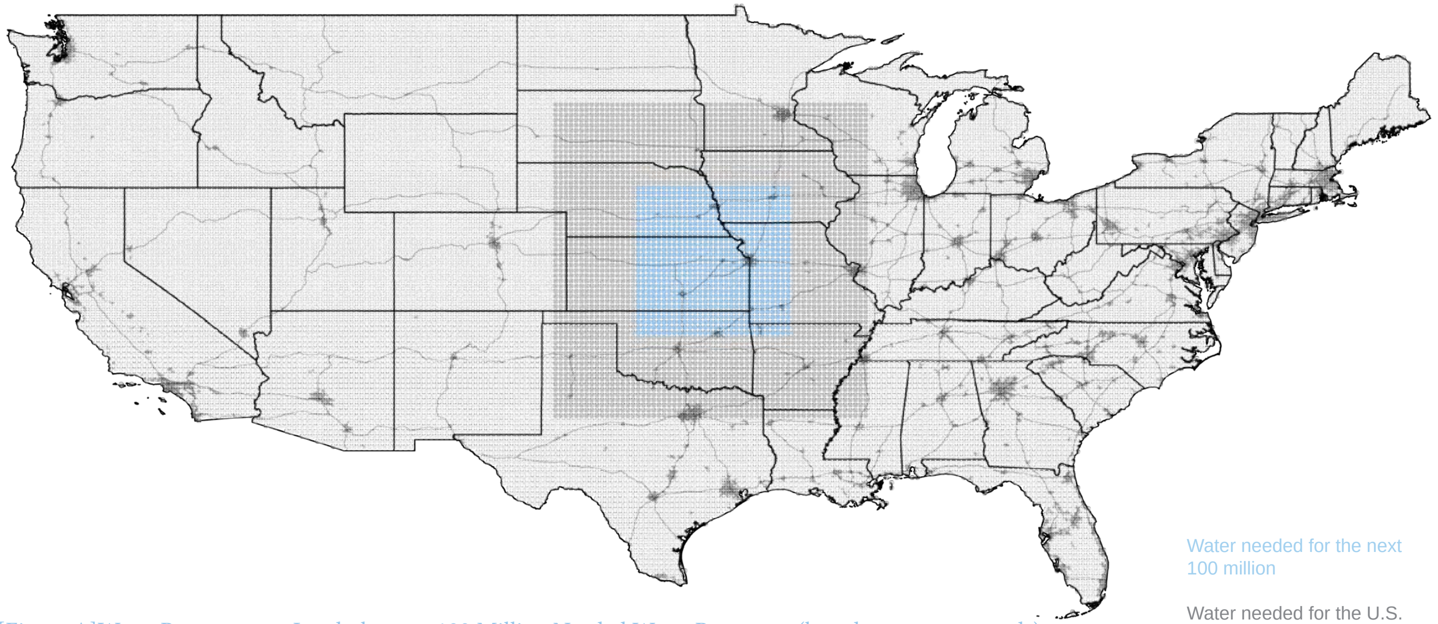
[106] "State Area Measurements and Internal Point Coordinates." U.S. Census Bureau Geography. December 01, 2012. April 10,. 2018. https://www.census.gov/geo/reference/state-area.html.

[107] "Powerpack - Commercial & Utility Energy Storage Solutions: Tesla." Tesla, Inc. Accessed July 25, 2019. http://www.tesla.com/powerpack.



[Figure A]Needed Solar Capacity: The next 100 Million Americans need 26,190,307,857 solar panels

[Figure C]Needed Energy Storage Capacity: The next 100 Million Americans needs 112, 785, 497 Tesla Powerpacks



[Figure A]Water Resources on Land: the next 100 Million Needed Water Resources (based on current trends)

Water Resource Demands

Water Resources on Land [Figure A]

Average daily US water consumption is 88 gallons per person.[108] The next 100 million will need 8.8 billion gallons of water per day, if current consumption patterns continue.

Water Consumption [Figure B]

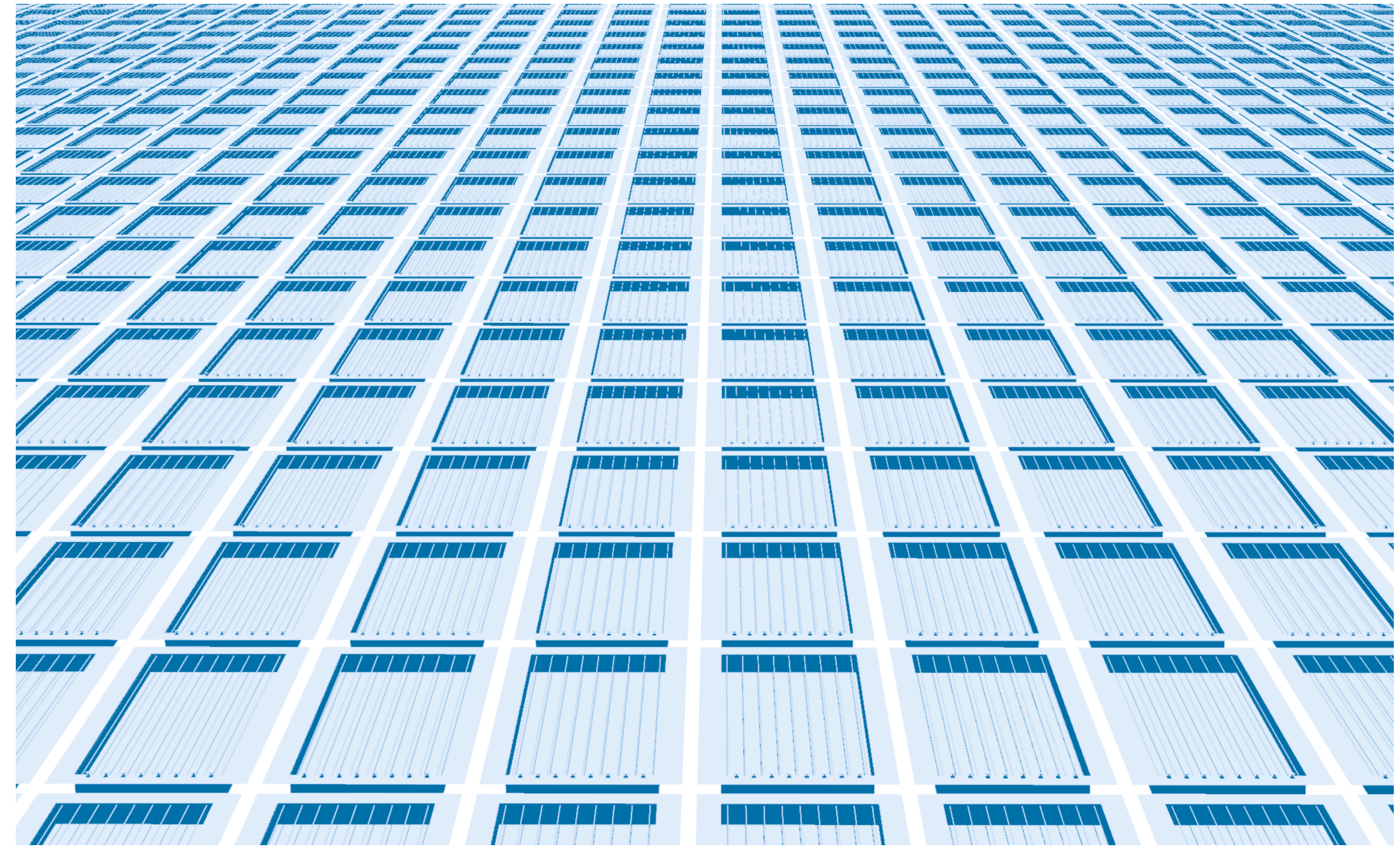
8.8 billion gallons of water is equivalent to 13,333 Olympic-size swimming pools, approximately 4,133,000 acres—an area larger than Connecticut.

Irrigation Consumption [Figure C]

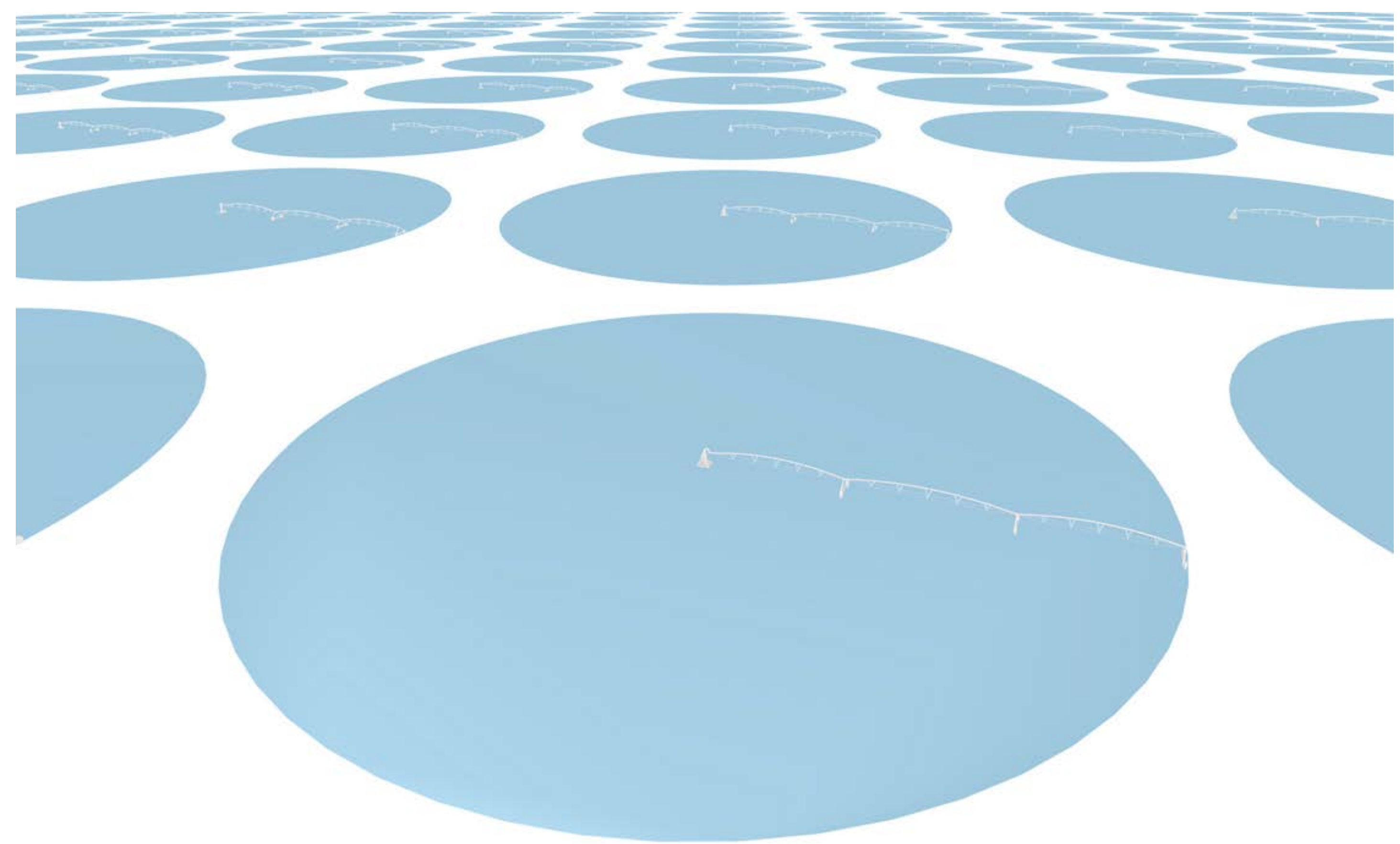
The US uses a total of 115 billion gallons of water per day for irrigation.[109] At that rate, the amount of water needed for the irrigation to support 100 million more individuals would be 36 billion gallons per day, the equivalent of 54,545 Olympic-size swimming pools. The footprint of these pools would occupy 16,909 acres.

[108] Maupin, Molly A., Joan F. Kenny, Susan S. Hutson, John K. Lovelace, Nancy L. Barber, and Kristin S. Linsey. Estimated use of water in the United States in 2010. No. 1405. US Geological Survey, 2014.

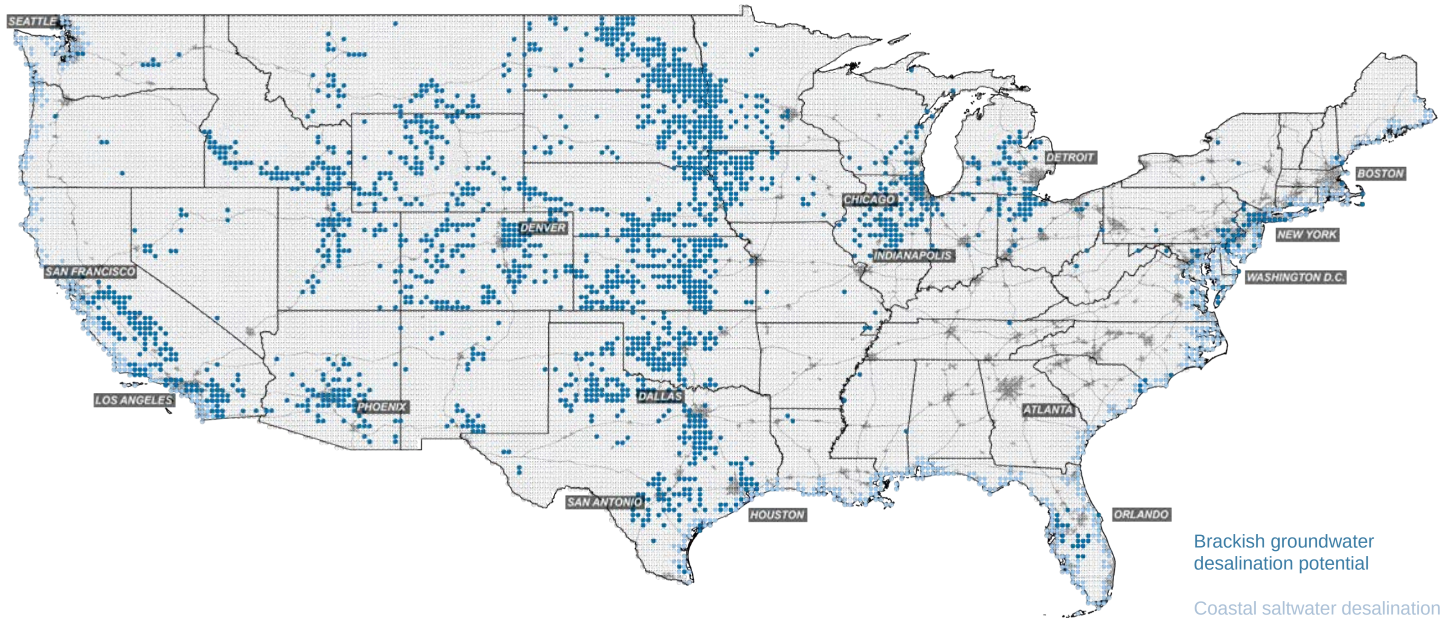
[109] Maupin, Molly A., Joan F. Kenny, Susan S. Hutson, John K. Lovelace, Nancy L. Barber, and Kristin S. Linsey. Estimated use of water in the United States in 2010. No. 1405. US Geological Survey, 2014.



[Figure B]Needed Daily Water Consumption



[Figure C]Needed Irrigation Water Consumption



Brackish groundwater desalination potential

Coastal saltwater desalination potential

Desalinization Plant Potential

While coastal desalination is the most common form of desalination for potable water, brackish groundwater may offer a less energy intensive, and thus cheaper, source of water for desalination than seawater.[110] There is approximately 35 times more brackish groundwater available than the total annual fresh groundwater withdrawal in the US.[111]

Since becoming fully operational in 2015, the Carlsbad Desalination Plant has produced 50 million gallons of desalinated water per day from the Pacific Ocean on a six-acre site in San Diego County.[112] This energy-intensive process pumps water from the ocean, removes salt through reverse osmosis, conveys the drinking water through a pipeline, and returns the waste brine to the ocean.[113] While the main product of the process is the drinking water, able to support 400,000 county residents, the waste brine is produced at 1.5:1, a significant amount of highly saline discharge.[114] Research is ongoing into the local effects of the reintroduced water (which is relatively warm and contains potentially toxic additives) as well as the broader impacts on increasing global ocean salinity.[115]

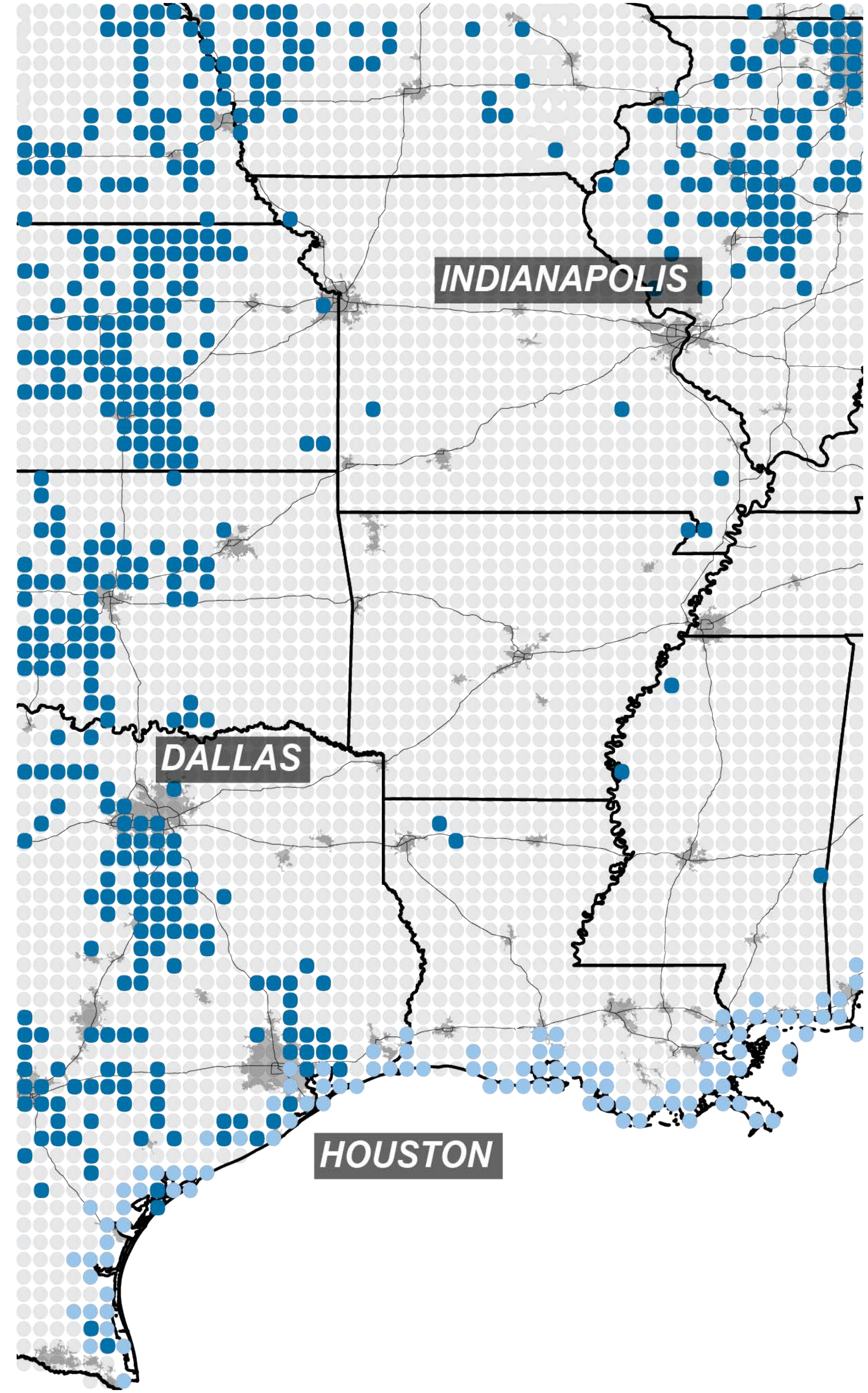
Providing drinking water to the next 100 million would require at least 176 new desalination plants. The Carlsbad plant cost $1 billion. At that rate, these new desalination plants would cost $176 billion dollars and require 1,056 acres for deployment.[116] Because the costs of plant construction and desalination are high, the total cost of desalinated water is currently 1.8 times higher than water from other sources for California.[117] As technology evolves and the cost of other water increases, however, desalinated water may become commensurate with other sources.[118] However, desalination plants produce considerable waste in the form of brine and heat that can disrupt entire ecosystems.

[110] Chandler, David L., and MIT News Office. "Study Finds Potential in Brackish Groundwater Desalination." MIT News. July 04, 2018. Accessed August 19, 2019. https://news.mit.edu/2018/study-finds-potential-brackish-groundwater-desalination-0705.

[111] Stanton, Jennifer S., David W. Anning, Craig J. Brown, Richard B. Moore, Virginia L. McGuire, Sharon L. Qi, Alta C. Harris et al. Brackish groundwater in the United States. No. 1833. US Geological Survey, 2017.

[112] Robbins, Jim. "As Water Scarcity Increases, Desalination Plants Are on the Rise." Yale E360. Yale School of Forestry & Environmental Studies. June 11, 2019. Accessed July 25, 2019. https://e360.yale.edu/features/as-water-scarcity-increases-desalination-....

[113] Peterson, Bobbi. "Desalination and Energy Consumption." Desalination and Energy Consumption | Energy Central. The Energy Collective Group. January 20, 2017. Accessed July 29, 2019. https://www.energycentral.com/c/ec/desalination-and-energy-



consumption.

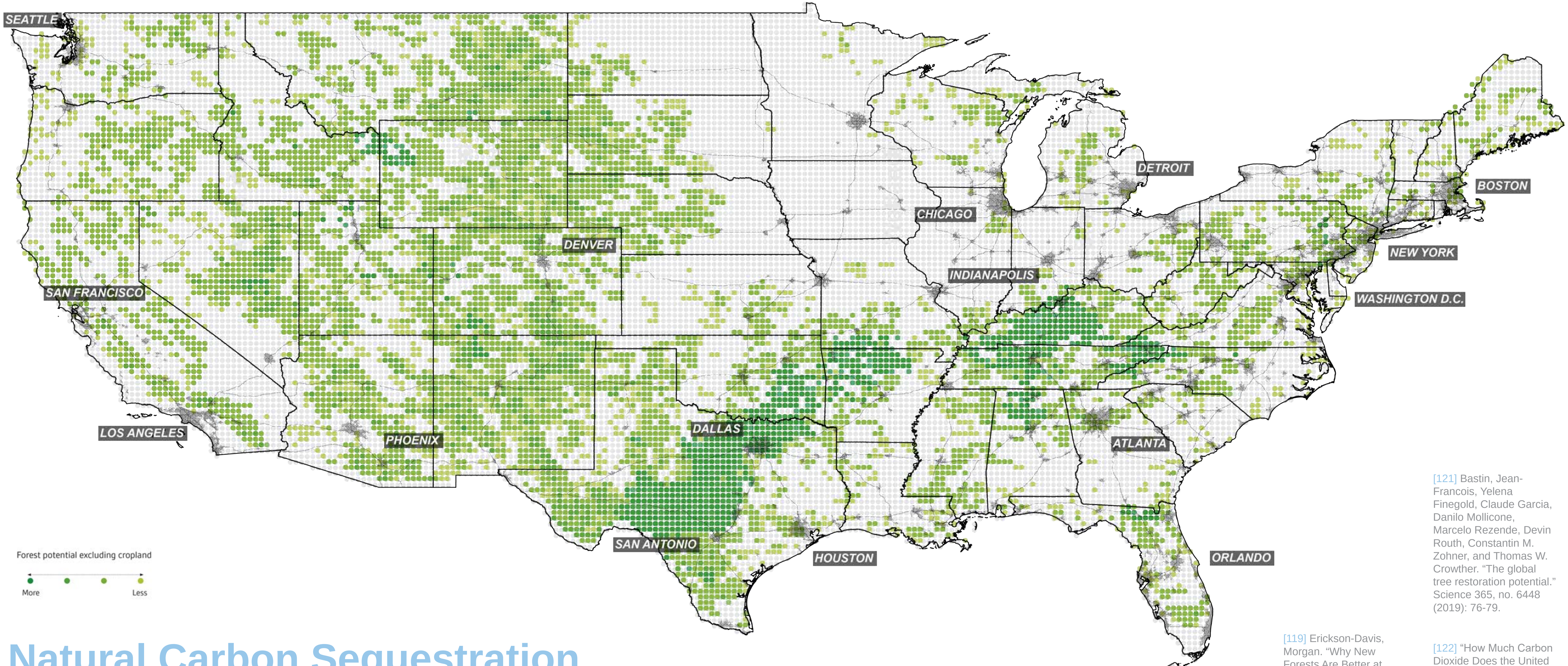
[114] Root, Tik. "Desalination Plants Produce More Waste Brine than Thought." National Geographic. January 14, 2019. Accessed July 26, 2019. https://www.nationalgeographic.com/environment/2019/01/desalination-plants-produce-twice-as-much-waste-brine-as-thought/

[115] Root, Tik. "Desalination Plants Produce More Waste Brine than Thought." National Geographic. January 14, 2019. Accessed July 26, 2019. https://www.nationalgeographic.com/environment/2019/01/desalination-plants-produce-twice-as-much-waste-brine-as-thought/

[116] Bienkowski, Brian. "Desalination Is an Expensive Energy Hog, but Improvements Are on the Way." Public Radio International. May 15, 2015. Accessed July 26, 2019. https://www.pri.org/stories/2015-05-15/desalination-expensive-energy-hog-improvements-are-way

[117] Robbins, Jim. "As Water Scarcity Increases, Desalination Plants Are on the Rise." Yale E360. Yale School of Forestry & Environmental Studies. June 11, 2019. Accessed July 25, 2019. https://e360.yale.edu/features/as-water-scarcity-increases-desalination-plants-are-on-the-rise

[118] Robbins, Jim. "As Water Scarcity Increases, Desalination Plants Are on the Rise." Yale E360. Yale School of Forestry & Environmental Studies. June 11, 2019. Accessed July 25, 2019. https://e360.yale.edu/features/as-water-scarcity-increases-desalination-plants-are-on-the-rise



Natural Carbon Sequestration Potential

Carbon sequestration from newly planted forests (newly planted forests are better at sequestering carbon than old-growth forests) is only viable in unforested areas. More than half of global forest restoration potential is located in just six countries; Russia, the US, Canada, Australia, Brazil and China.[120] The US has the space for 254,518,543 acres of new forest without encroaching on existing urban areas or agriculture—approximately 13% of the conterminous US, equivalent to half of what is currently categorized as forest.[121] This acreage could sequester about 23.5 gigatons of carbon; if the US emits 5.1 billion tons of carbon a year, the total reforesting of the US would only account for 5 years of carbon emissions though the life of the forest.[122]

Not only is this a small percentage of carbon emissions, but most carbon offset, sequestration, and credit programs are ineffective, and may in fact be a net negative—as they allow people and organizations to continue to emit as usual, and may have a leakage effect whereby one area of land is conserved at the cost of another.[123]

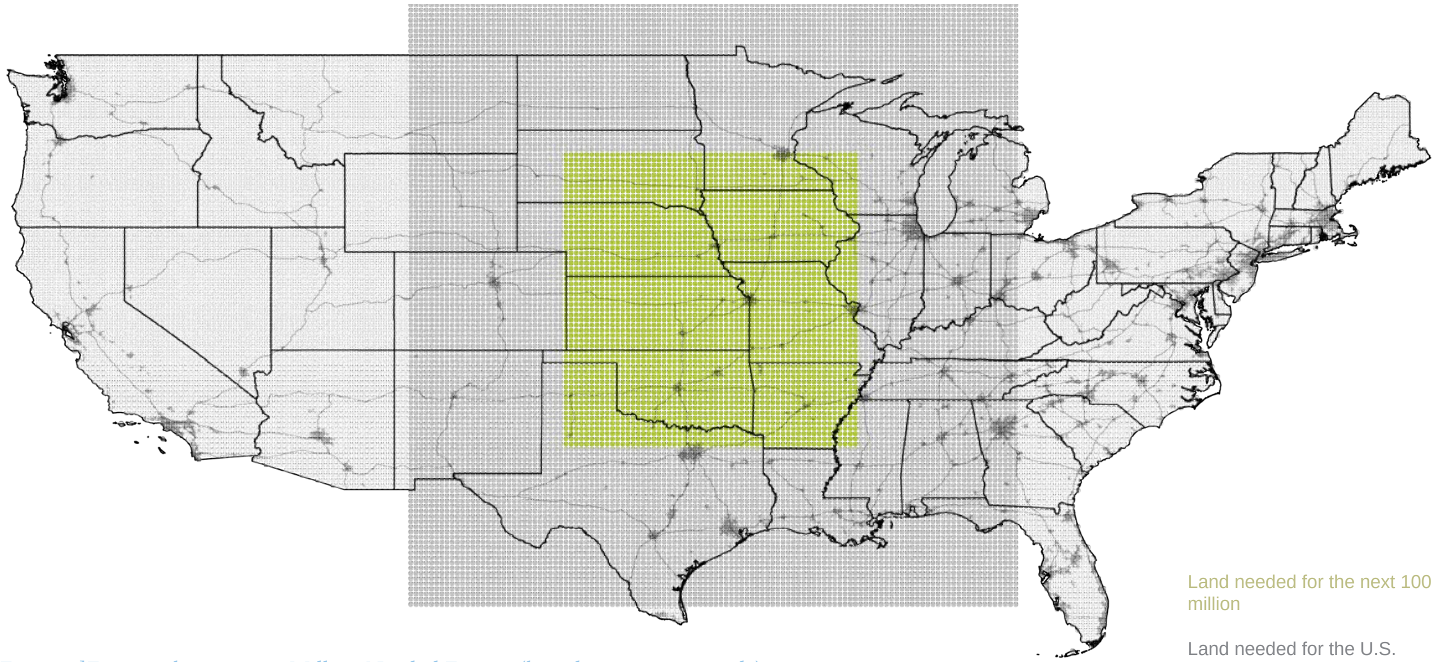
[119] Erickson-Davis, Morgan. "Why New Forests Are Better at Sequestering Carbon Than Old Ones." Pacific Standard. February 27, 2019. Accessed August 20, 2019. https://psmag.com/environment/young-trees-suck-up-more-carbon-than-old-ones.

[120] Bastin, Jean-Francois, Yelena Finegold, Claude Garcia, Danilo Mollicone, Marcelo Rezende, Devin Routh, Constantin M. Zohner, and Thomas W. Crowther. "The global tree restoration potential." Science 365, no. 6448 (2019): 76-79.

[121] Bastin, Jean-Francois, Yelena Finegold, Claude Garcia, Danilo Mollicone, Marcelo Rezende, Devin Routh, Constantin M. Zohner, and Thomas W. Crowther. "The global tree restoration potential." Science 365, no. 6448 (2019): 76-79.

[122] "How Much Carbon Dioxide Does the United States and the World Emit Each Year from Energy Sources?" U.S. Geologic Survey. Accessed August 20, 2019. https://www.usgs.gov/faqs/how-much-carbon-dioxide-does-united-states-and....

[123] Song, Lisa. "An Even More Inconvenient Truth." ProPublica. May 22, 2019. Accessed August 19, 2019. https://features.propublica.org/brazil-carbon-offsets/inconvenient-truth-carbon-credits-dont-work-deforestation-redd-acre-cambodia/



[Figure 1]Forests: the next 100 Million Needed Forests (based on current trends)

Natural Carbon Sequestration Demands

Sequestration through Afforestation [A]

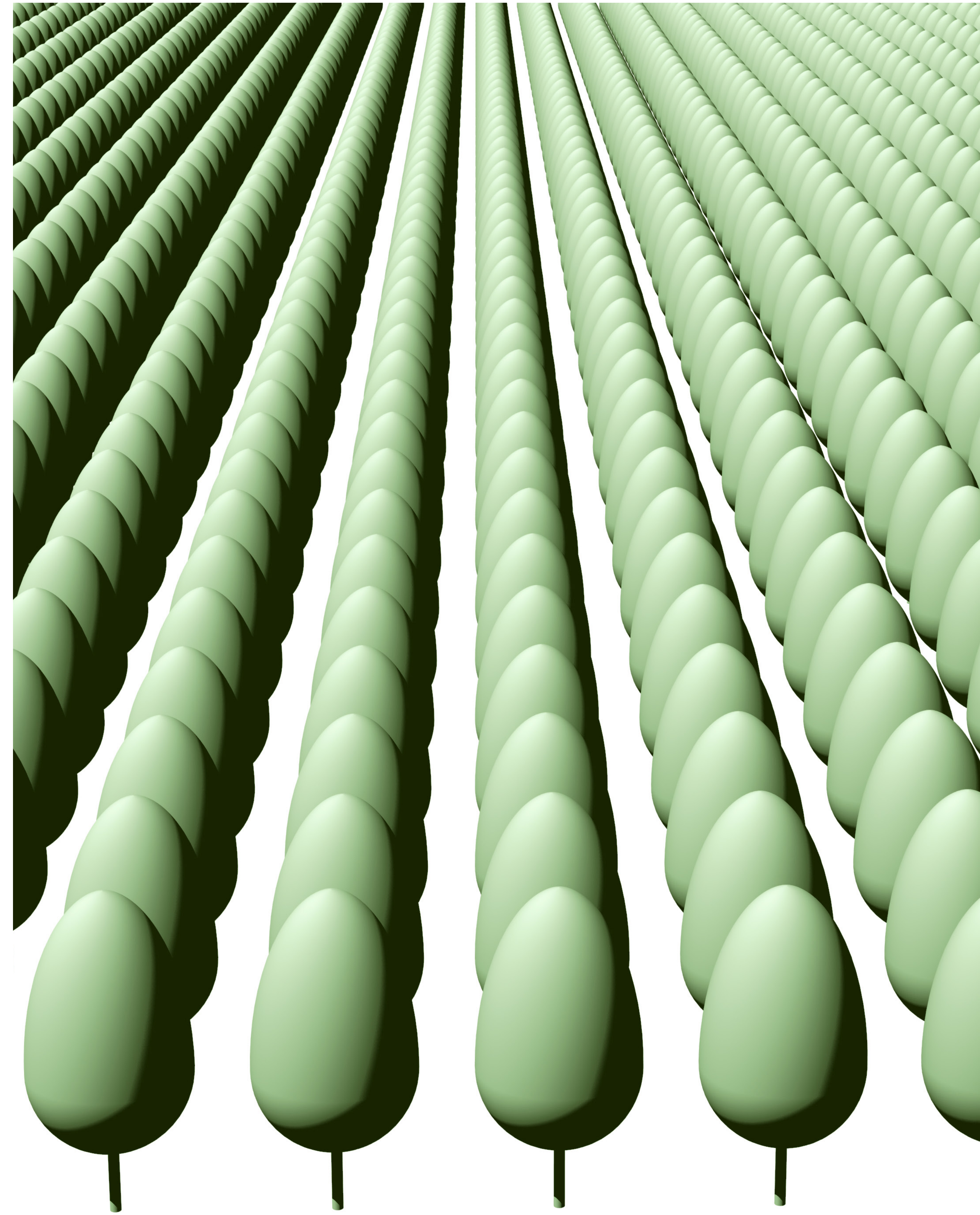
The US emits 6,456.7 million metric tons of CO2 equivalents annually—around 20 metric tons per person.[124] If a mature tree can absorb up to 21.77 kg of CO2 a year, about 930 trees would be required to sequester the carbon emissions of one individual.[125] At this rate, the next 100 million people would need 93 billion new trees.

Carbon Sequestration on Land [Figure B]

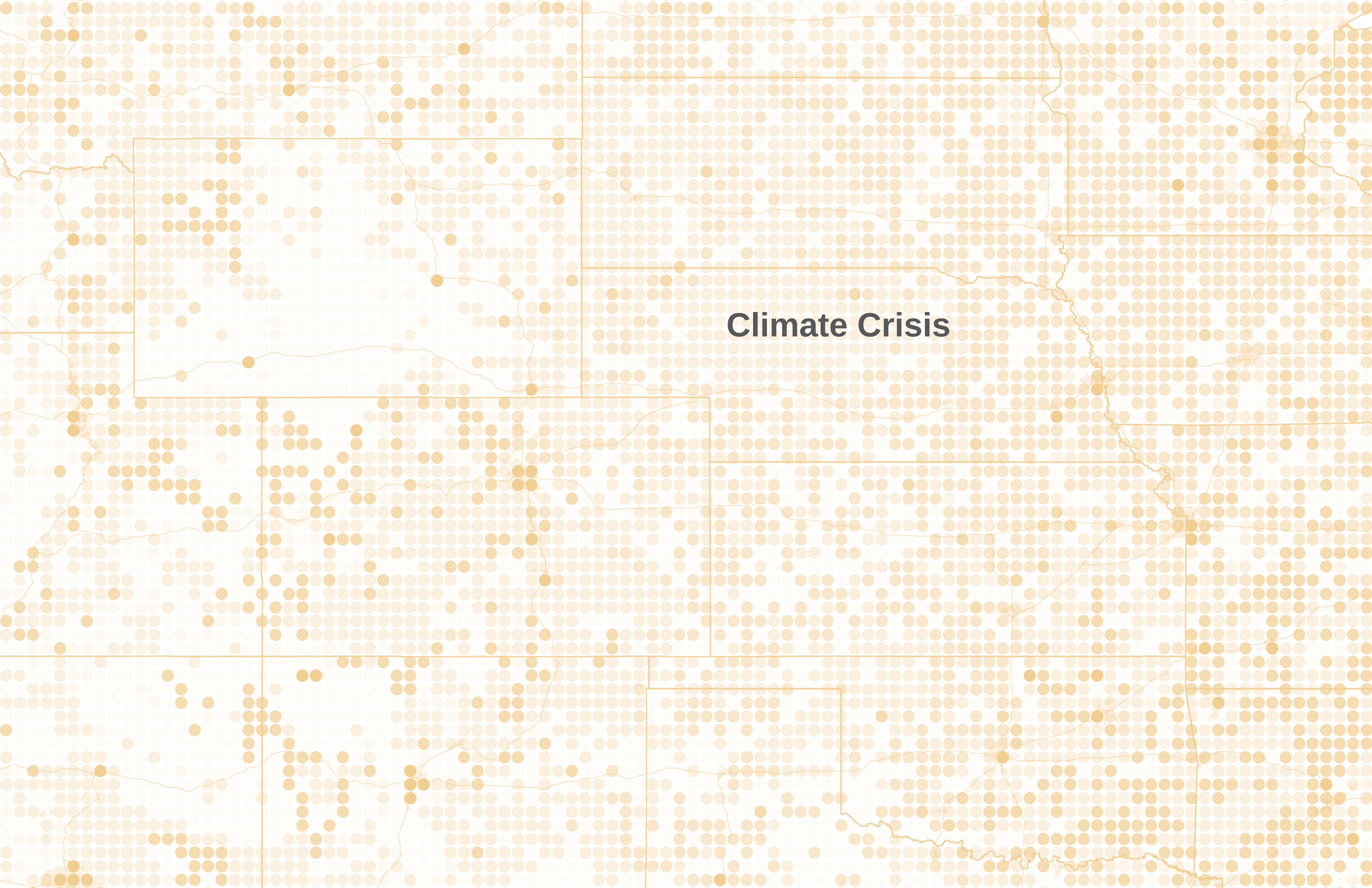
93 billion trees require land on which to grow. With 3.65 meters of spacing between trees, this would total 1,247,600 square kilometers or 308,288,674 acres of forest—a footprint equivalent to 15% of the total land area of the conterminous US. In 2017, 27% of US land was forest; this would need to increase to 15% by 2060 in order to sequester the carbon produced by the next 100 million; sequestering carbon for the total 2060 population of 417 million would require 62.6% of the total land of the conterminous US in addition to the current forest, for a total of 89.6% of the United States.

[124] "Inventory of U.S. Greenhouse Gas Emissions and Sinks." Environmental Protection Agency. April 11, 2019. Accessed July 26, 2019. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

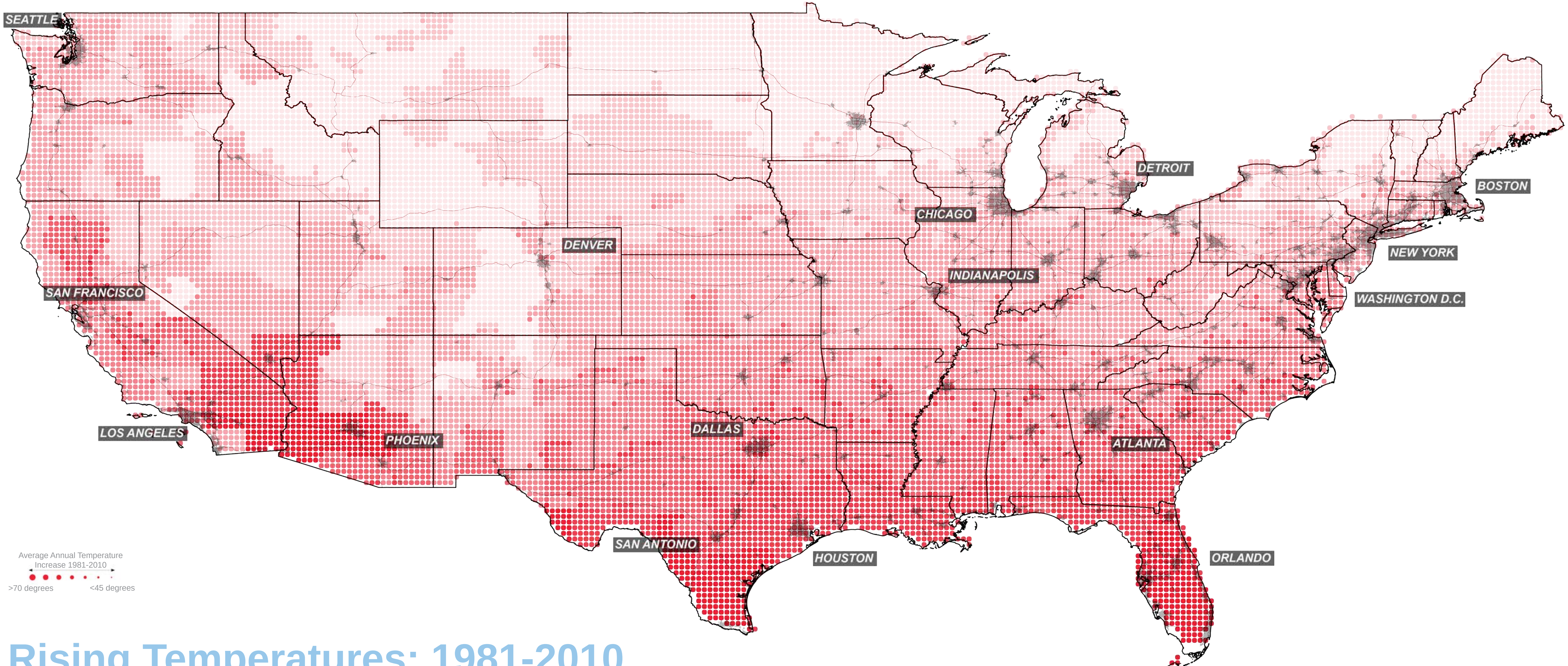
[125] NC State University College of Agriculture & Life Sciences. "Tree Facts." Accessed June 01, 2016. http://www.ncsu.edu/project/treesofstrength/treefact.htm



[Figure 1]The next 100 Million Americans needs 326, 796,800 acres of forests



Climate Crisis

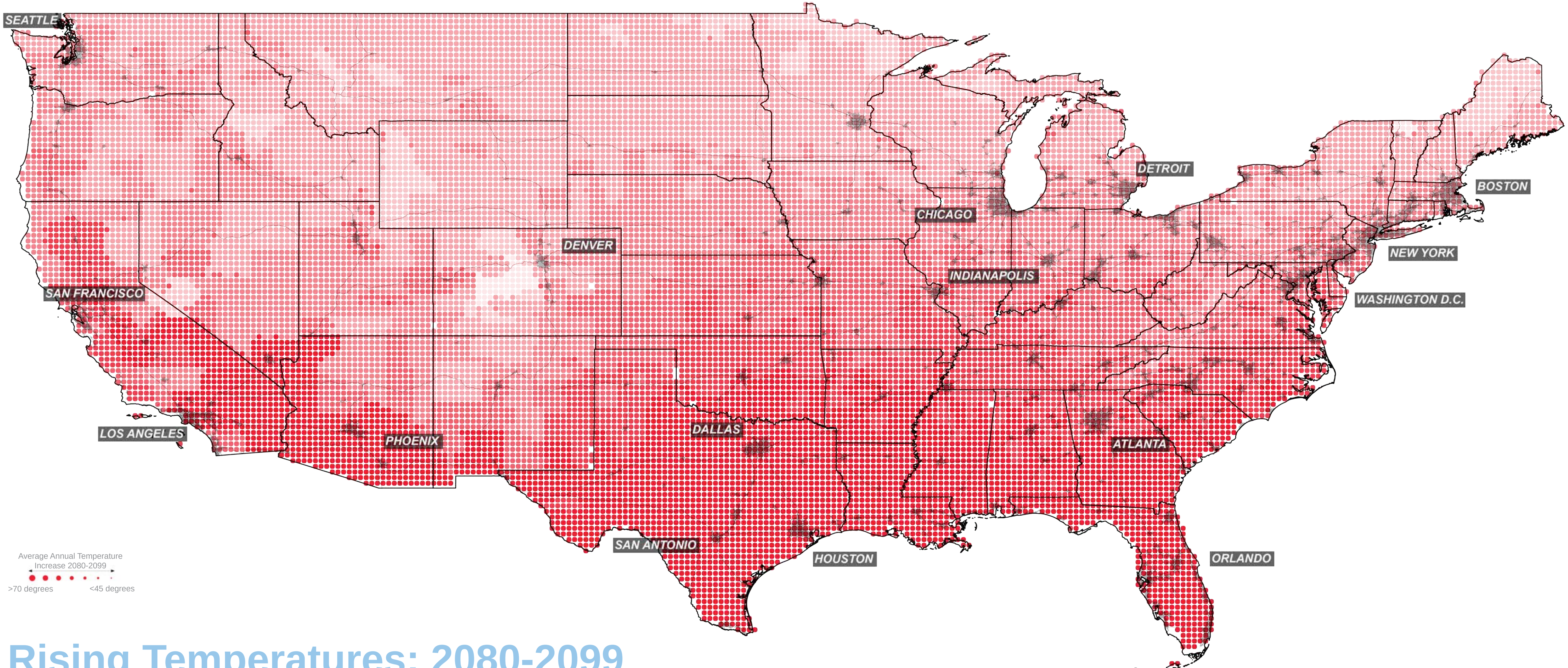


Rising Temperatures: 1981-2010

By the end of the twenty-first century, global temperatures will increase by an average of around ten degrees Fahrenheit. In the US, northern states will generally face the highest average annual change, with West Coast and Gulf Coast states facing less, though still dramatic, warming.[127]

[126] "Impact Map." Climate Impact Lab. Accessed July 10, 2019. http://www.impactlab.org/map/#usmeas=change-from-hist&usyear=2080-2099&gmeas=absolute&gyear=1986-2005&usvar=tas_ann

[127] "Impact Map." Climate Impact Lab. Accessed July 10, 2019. http://www.impactlab.org/map/#usmeas=change-from-hist&usyear=2080-2099&gmeas=absolute&gyear=1986-2005&usvar=tas_ann

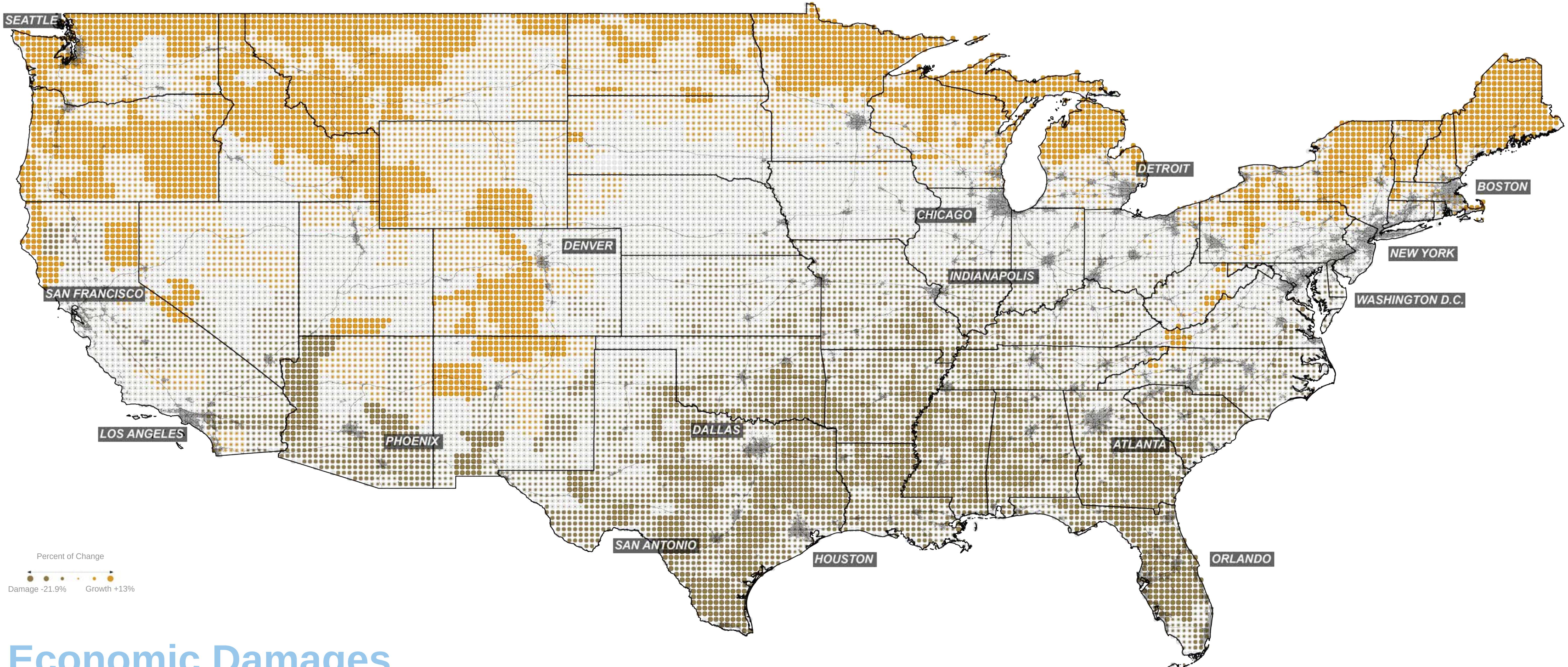


Rising Temperatures: 2080-2099

By the end of the twenty-first century, global temperatures will increase by an average of around ten degrees Fahrenheit. In the US, northern states will generally face the highest average annual change, with West Coast and Gulf Coast states facing less, though still dramatic, warming.[127]

[126] "Impact Map." Climate Impact Lab. Accessed July 10, 2019. http://www.impactlab.org/map/#usmeas=change-from-hist&usyear=2080-2099&gmeas=absolute&gyear=1986-2005&usvar=tas_ann

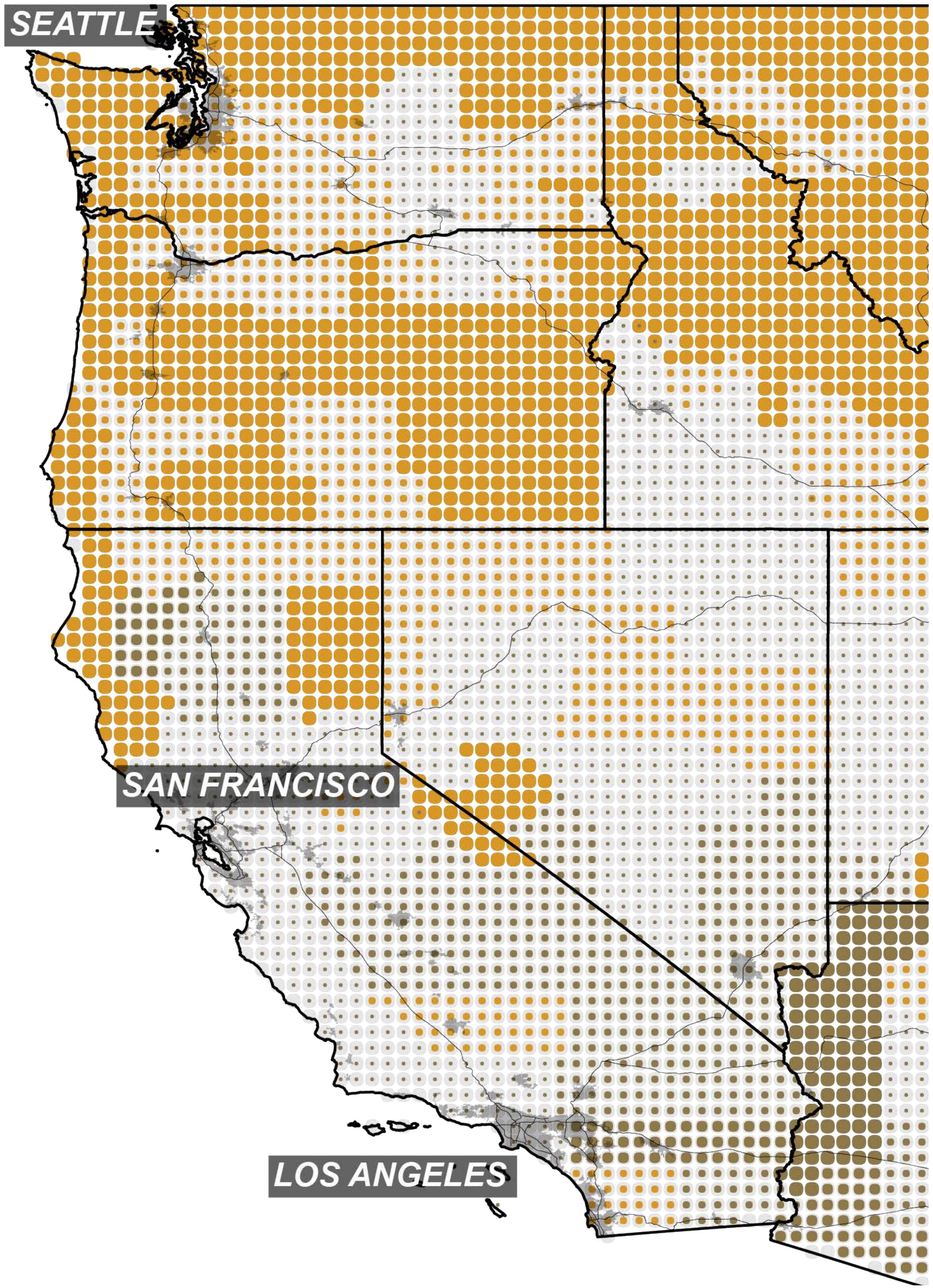
[127] "Impact Map." Climate Impact Lab. Accessed July 10, 2019. http://www.impactlab.org/map/#usmeas=change-from-hist&usyear=2080-2099&gmeas=absolute&gyear=1986-2005&usvar=tas_ann



Economic Damages

The economic impacts of the climate crisis will be complex and pervasive over the next century, with at least three quarters of US counties projected to suffer economically due to climate change. The climate crisis will impact agriculture, crime rates, coastal storms, energy, human mortality, and labor, all with potential major economic ramifications.[128] Projected losses will be greatest in regions that are already poorer on average, increasing geographic inequality as value transfers from the South and the inland US to the Pacific Northwest, the Great Lakes, and the Northeast.

[128] Hsiang, Solomon, Robert Kopp, Amir Jina, James Rising, Michael Delgado, Shashank Mohan, D. J. Rasmussen et al. "Estimating economic damage from climate change in the United States." Science 356, no. 6345 (2017): 1362-1369.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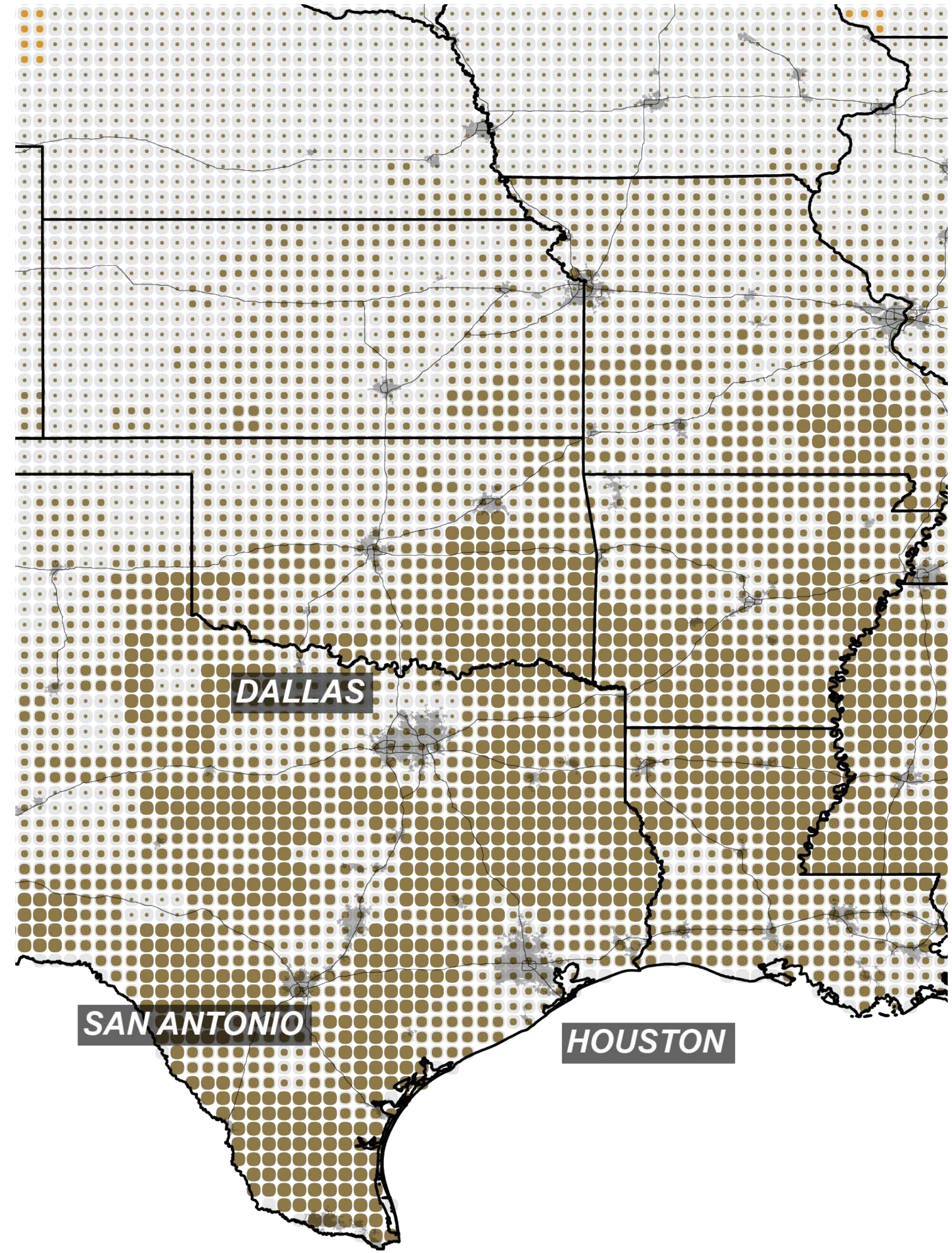
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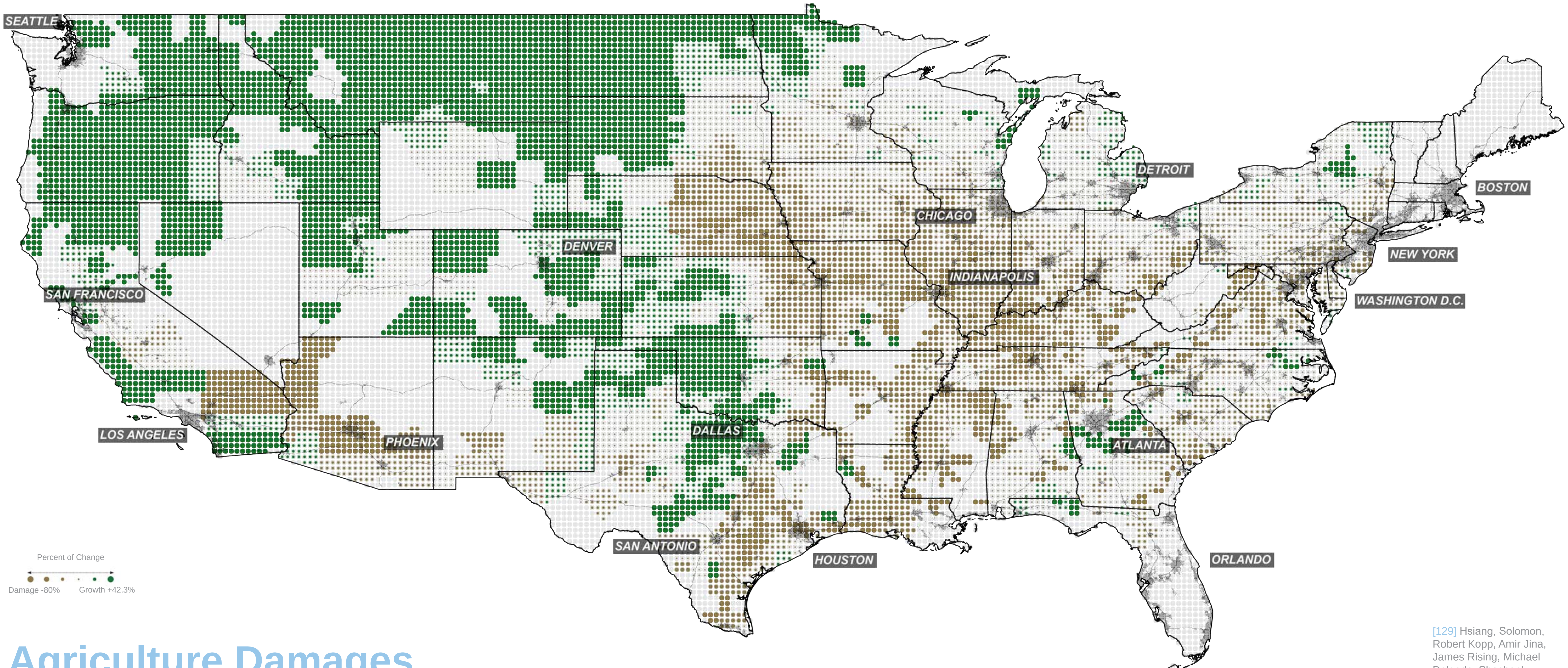
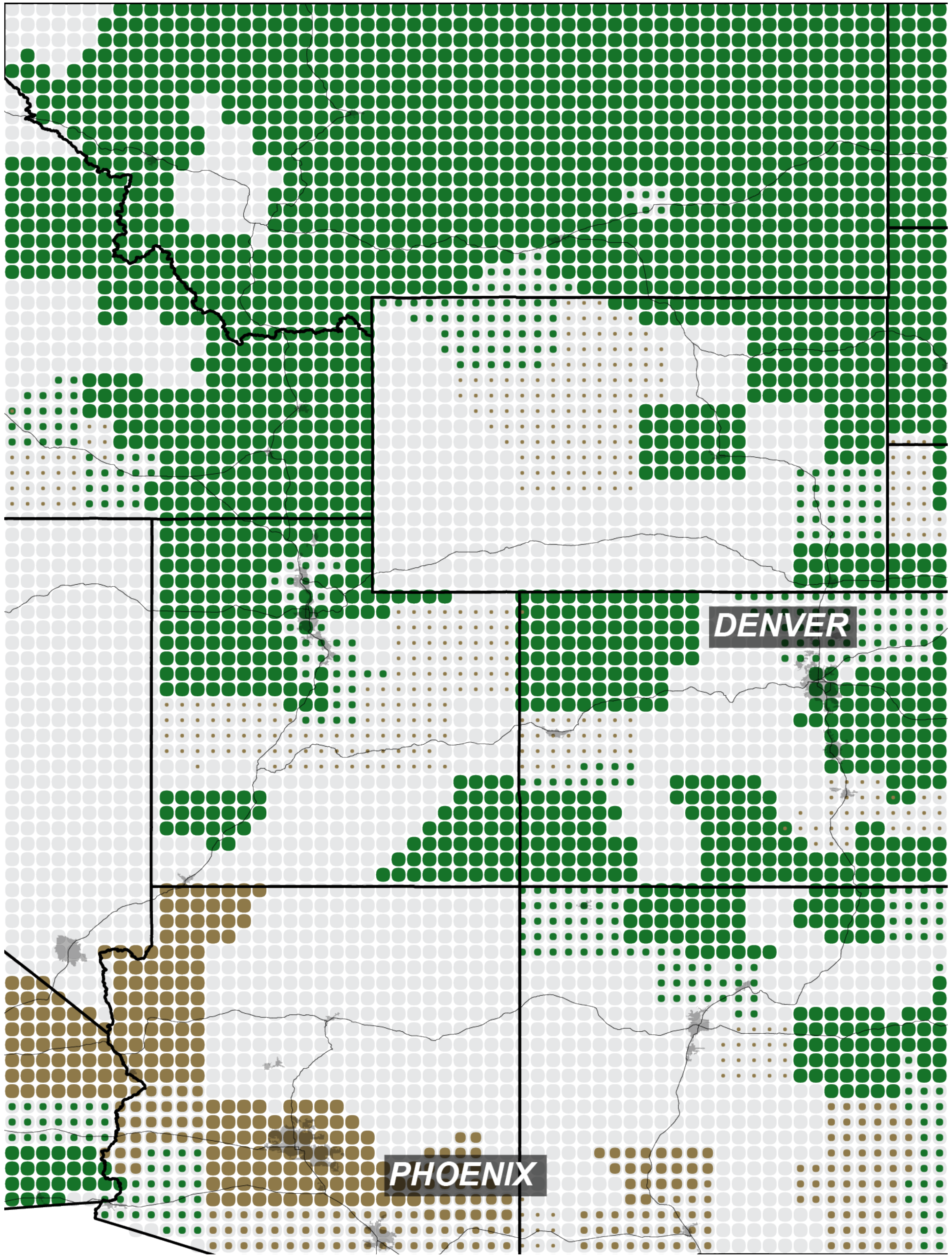


Agriculture Damages

Accounting for estimated effects on crop growth of CO2 fertilization and altered precipitation patterns, national crop yields will be reduced by 9.1% to 12.1% per degree Celsius increase in global mean surface temperature.[129] These calculations account for percent change in area-weighted yields for corn, wheat, soybeans, and cotton. The Midwest and Southern California, where a significant proportion of US agriculture takes place, will see a decrease of at least 50% of yields; The north and west of the country, from the Dakotas to Northern California, will see an increase of 45%.[130]

[129] Hsiang, Solomon, Robert Kopp, Amir Jina, James Rising, Michael Delgado, Shashank Mohan, D. J. Rasmussen et al. “Estimating economic damage from climate change in the United States.” Science 356, no. 6345 (2017): 1362-1369.

[130] Hsiang, Solomon, Robert Kopp, Amir Jina, James Rising, Michael Delgado, Shashank Mohan, D. J. Rasmussen et al. “Estimating economic damage from climate change in the United States.” Science 356, no. 6345 (2017): 1362-1369.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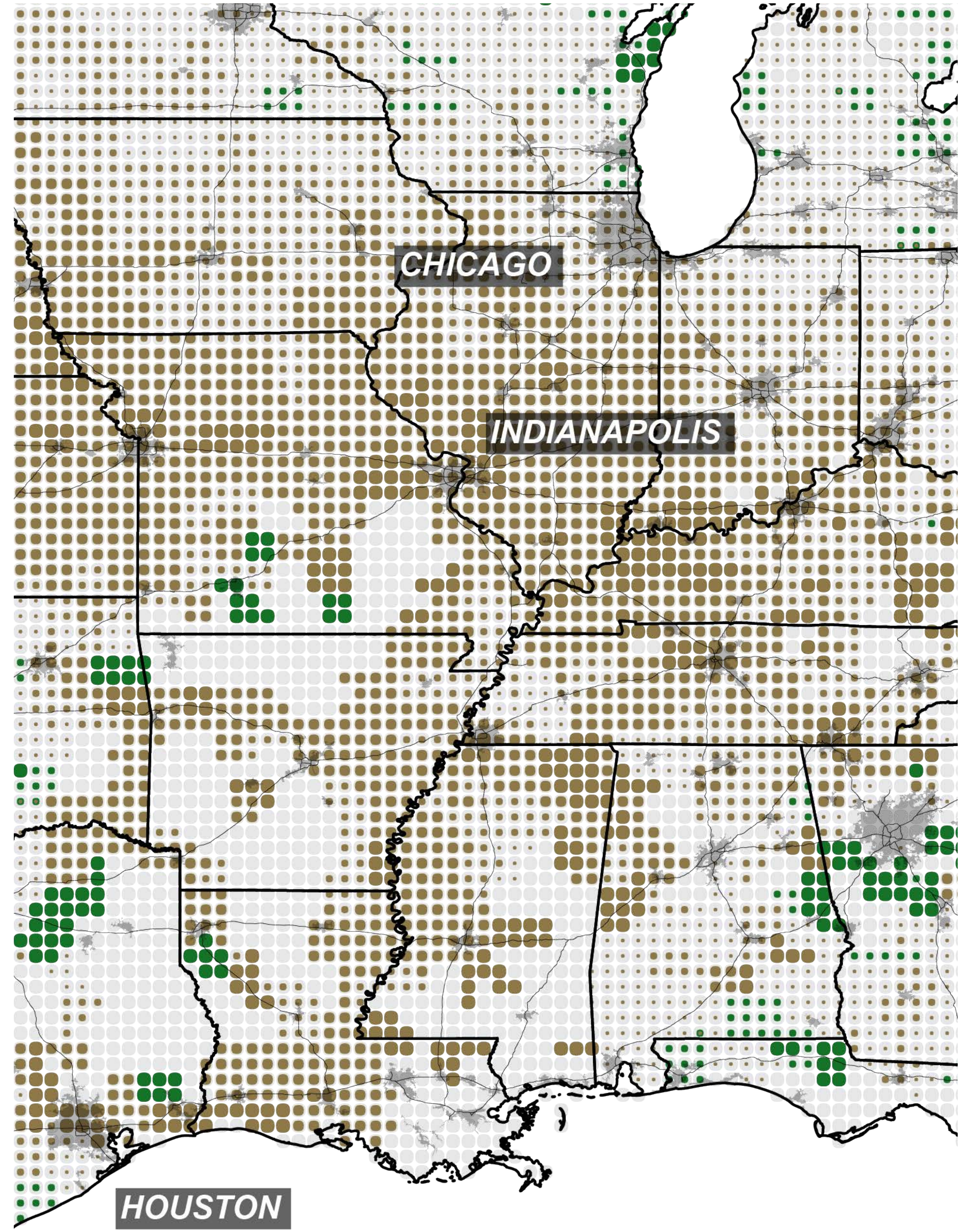
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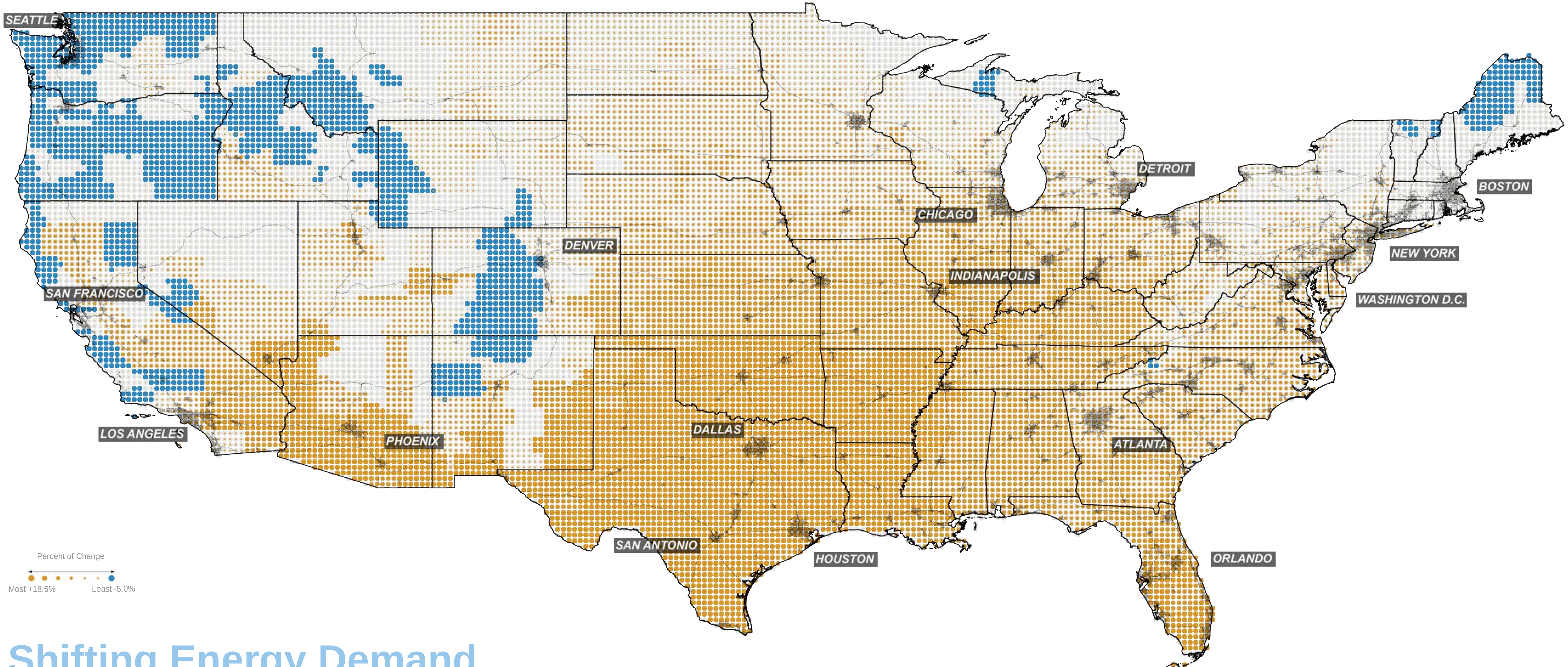
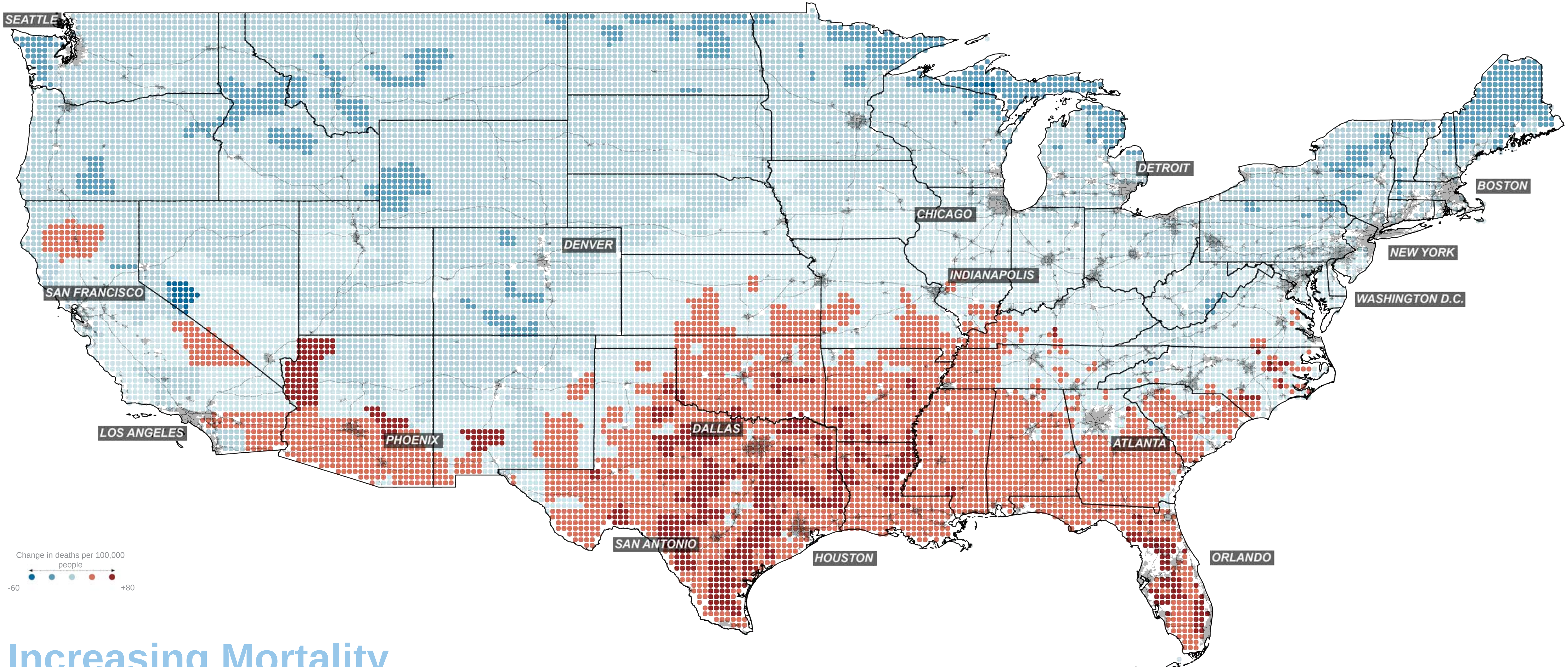


Shifting Energy Demand

For every degree Celsius of global mean surface temperature increase, electricity demand will rise by roughly 5.3%. Rising cooling demand on hot days will more than offset falling heating demand on cool days.[131] This trend is most evident in the South, particularly in Texas, where increasing annual temperatures will result in a 20% increase in energy use. While nearly the entirety of the US will see increased energy expenditures, areas of the Cascadia, Northern California, Southern California, and Front Range megaregions may see a net decrease—possibly due to increased efficiency, decreased heating costs, and warmer winters.

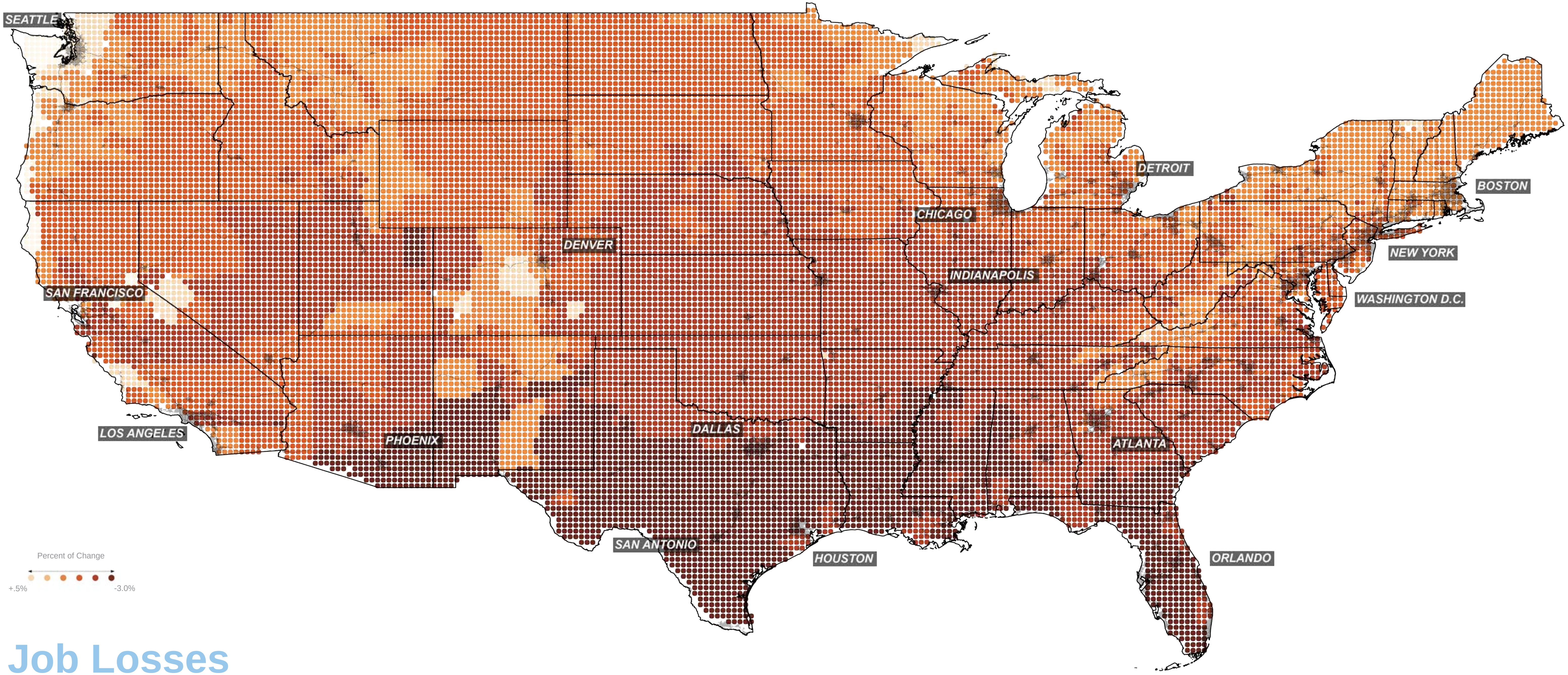
[128] Hsiang, Solomon, Robert Kopp, Amir Jina, James Rising, Michael Delgado, Shashank Mohan, D. J. Rasmussen et al. "Estimating economic damage from climate change in the United States." Science 356, no. 6345 (2017): 1362-1369.



Increasing Mortality

This map shows the change in all-cause mortality per 100,000 people across all age groups.[132] Increasing temperatures will drive an increase in heat-related deaths in the southern US, as well as a decrease in cold-related deaths in northern states.

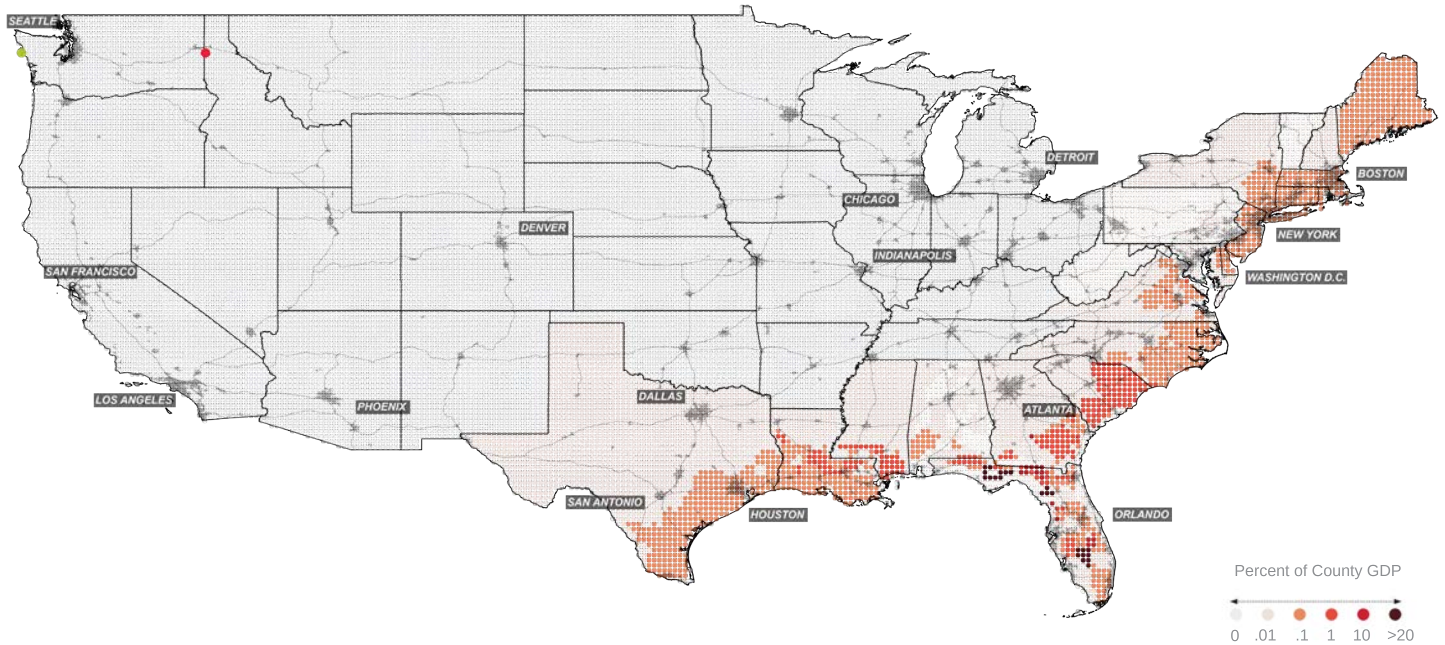
[133] Hsiang, Solomon, Robert Kopp, Amir Jina, James Rising, Michael Delgado, Shashank Mohan, D. J. Rasmussen et al. "Estimating economic damage from climate change in the United States." Science 356, no. 6345 (2017): 1362-1369.



Job Losses

Rising temperatures will increase health risks to workers exposed to outdoor temperatures. This map illustrates the change in labor supply of full-time equivalent workers in high-risk jobs. Following the temperature gradient, Texas and the Gulf Coast will have the highest increase in unsafe exposure at 3%, though the entire country, barring pockets in Washington, California and Colorado, will see an overall increase in risk.[133]

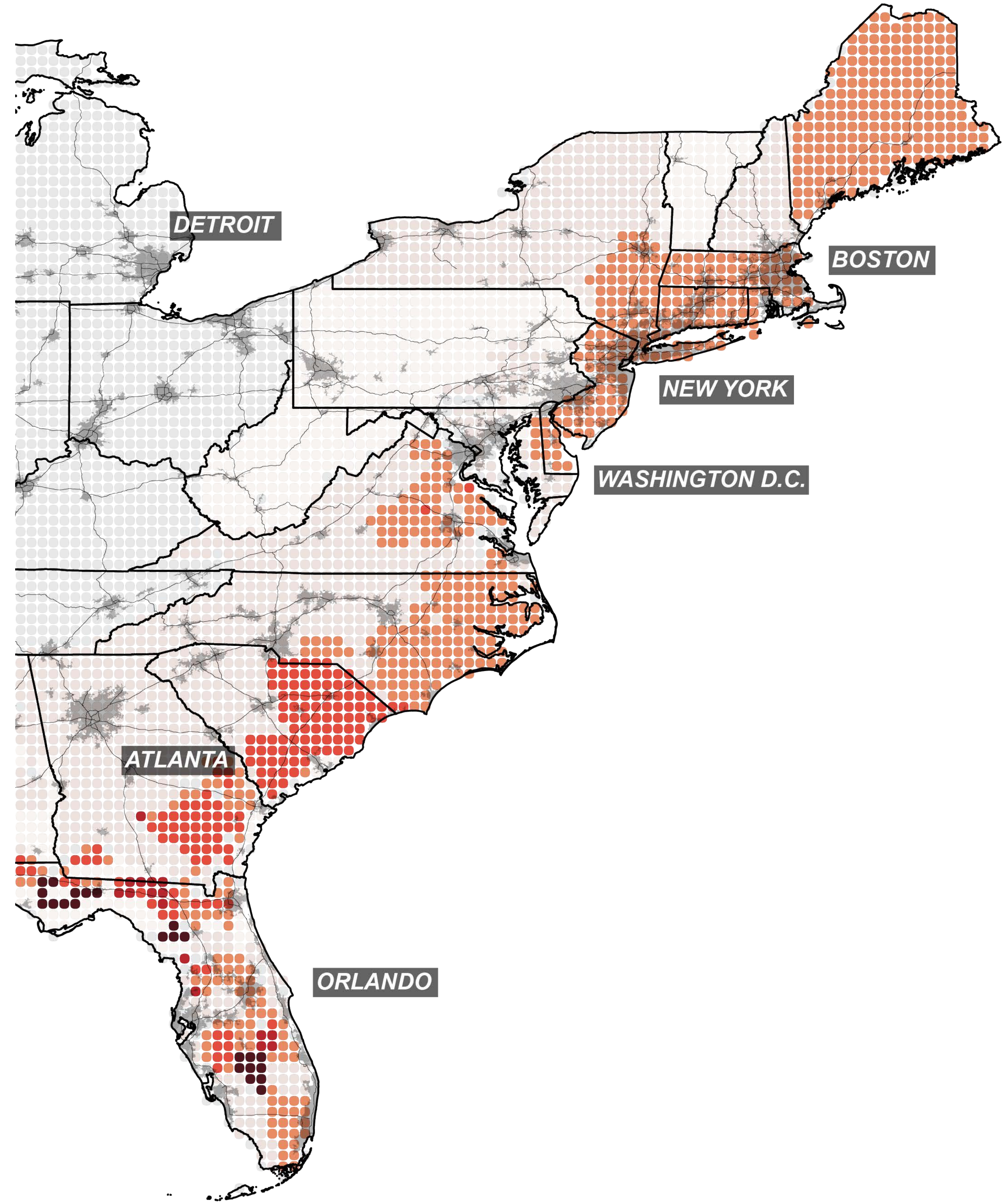
[133] Hsiang, Solomon, Robert Kopp, Amir Jina, James Rising, Michael Delgado, Shashank Mohan, D. J. Rasmussen et al. "Estimating economic damage from climate change in the United States." Science 356, no. 6345 (2017): 1362-1369.

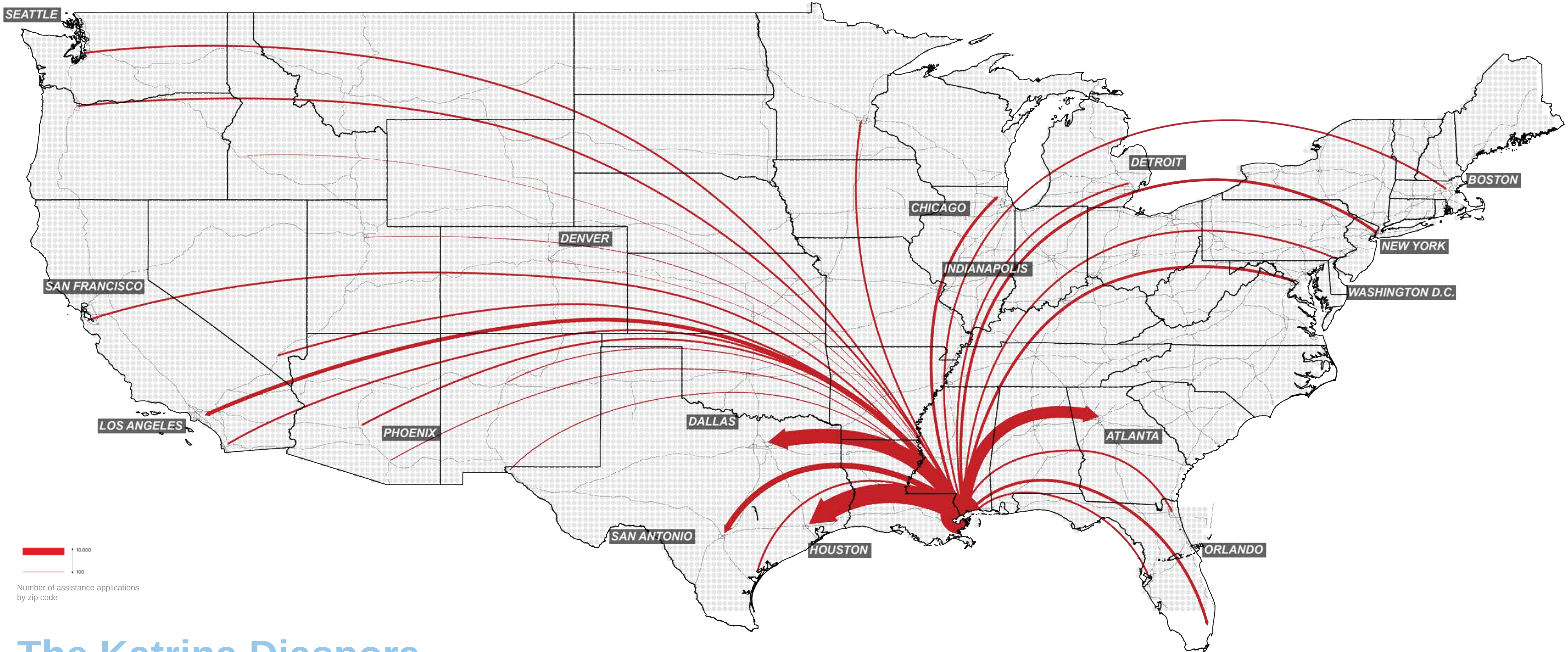


Coastal Economies

This map illustrates the levels of risk from sea level rise along the southeastern coast, accounting for susceptibility to change and adaptation measures. The Coastal Vulnerability Index incorporates tidal range, wave height, coastal slope, shoreline change, landform and processes, and the historical rate of relative sea level rise.[134]

[134] USGCRP (2014). Carter, L. M., J. W. Jones, L. Berry, V. Burkett, J. F. Murley, J. Obeysekera, P. J. Schramm, and D. Wear, 2014: Ch. 17: Southeast and the Caribbean. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 396-417.

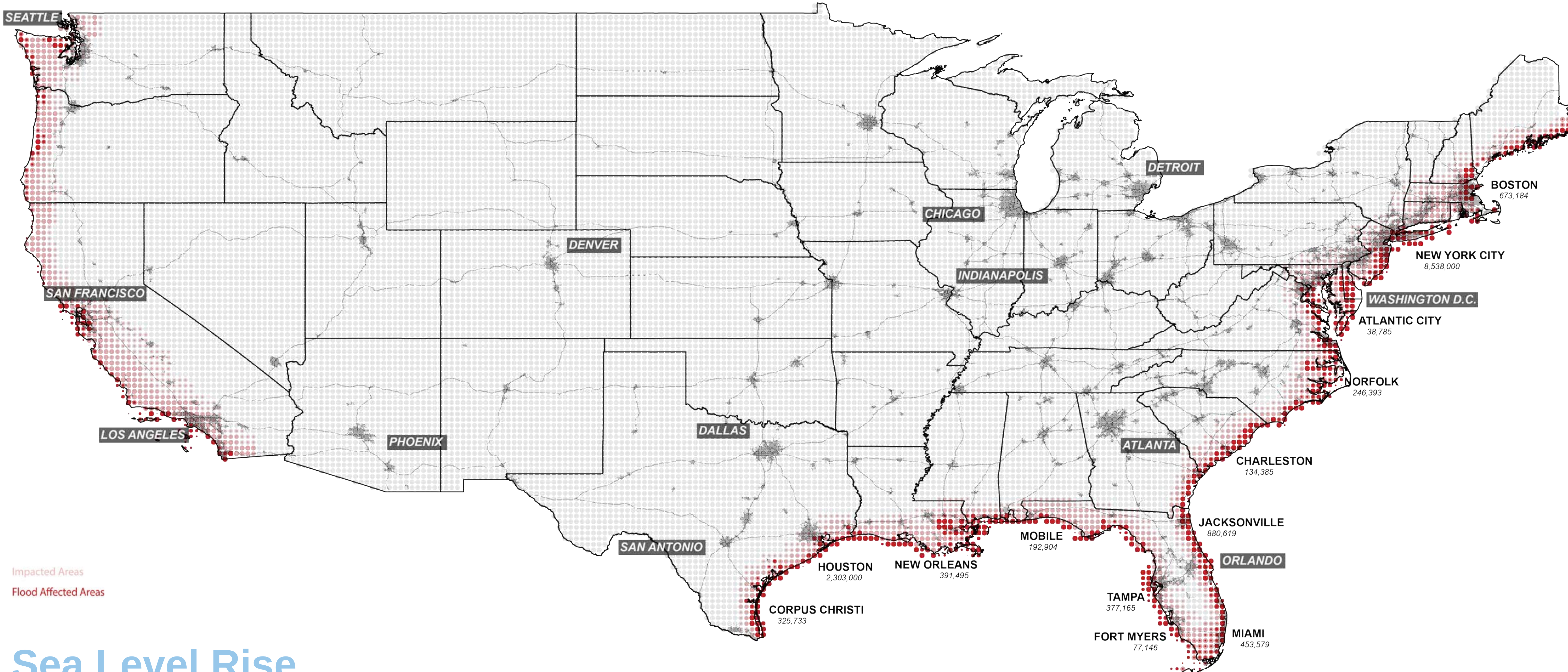




The Katrina Diaspora

Hurricane Katrina victims have filed for FEMA assistance from every state. This map illustrates the distribution and number of the 1.36 million individual assistance applications in the months following the disaster.[135]

[135] Ericson, Matthew, Archie Tse, and Jodi Wilgoren. "Katrina's diaspora." NY Times (October 2) (2005).



Sea Level Rise

By the end of the twenty-first century, as many as 13.1 million people will have been displaced by sea level rise in the US—an average of 159,756 per year—and 6.8 million may be displaced by 2060.[136] In 2017 alone, around 1 million people migrated inside the US due to climate-related events.[137] In comparison, the Dust Bowl of the 1930s saw an estimated 3.5 million people migrate from the Great Plains.[138] The number of migrants fleeing sea level rise in the US will equal 10 times the population displaced by Katrina.


New Orleans = 393,292 people

[136] Hauer, Mathew E., Jason M. Evans, and Deepak R. Mishra. "Millions projected to be at risk from sea-level rise in the continental United States." Nature Climate Change 6, no. 7 (2016): 691.

[137] Goodell, Jeff. "Welcome to the Age of Climate Migration." Rolling Stone Magazine (2018).

[138] Worster, Donald. Dust bowl: the southern plains in the 1930s.Oxford University Press, 2004. 49.

Author Bios

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Billy Fleming is the Wilks Family Director of the Ian L. McHarg Center in the Weitzman School of Design. and a senior fellow with Data for Progress. He has worked as a landscape architect, city planner, organizer, and, later, in the Obama Administration's White House Domestic Policy Council. He holds a BLA(University of Arkansas), master's of community and regional planning (University of Texas), and a doctorate of city and regional planning (University of Pennsylvania).

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Xan is a landscape architecture student at the School of Design with a bachelor's of arts with honors in letters from Wesleyan University. Prior to Penn, she farmed in the South, worked for an art gallery in New Orleans, and lived on a boat doing conservation work in Florida. She is the co-founder and editor of Cline. After studying at Penn for two years she took a gap year and worked at Vogt Landschaft in Berlin and SCAPE in New Orleans.

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Zach Hammaker is studying towards a dual master's of landscape architecture and master's of city planning degree at the University of Pennsylvania Stuart Weitzman School of Design. He earned his bachelor's of science in landscape contracting and horticulture from Pennsylvania State University and has previously ran his own landscape design firm in the Philadelphia area.

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James Andrew Billingsley

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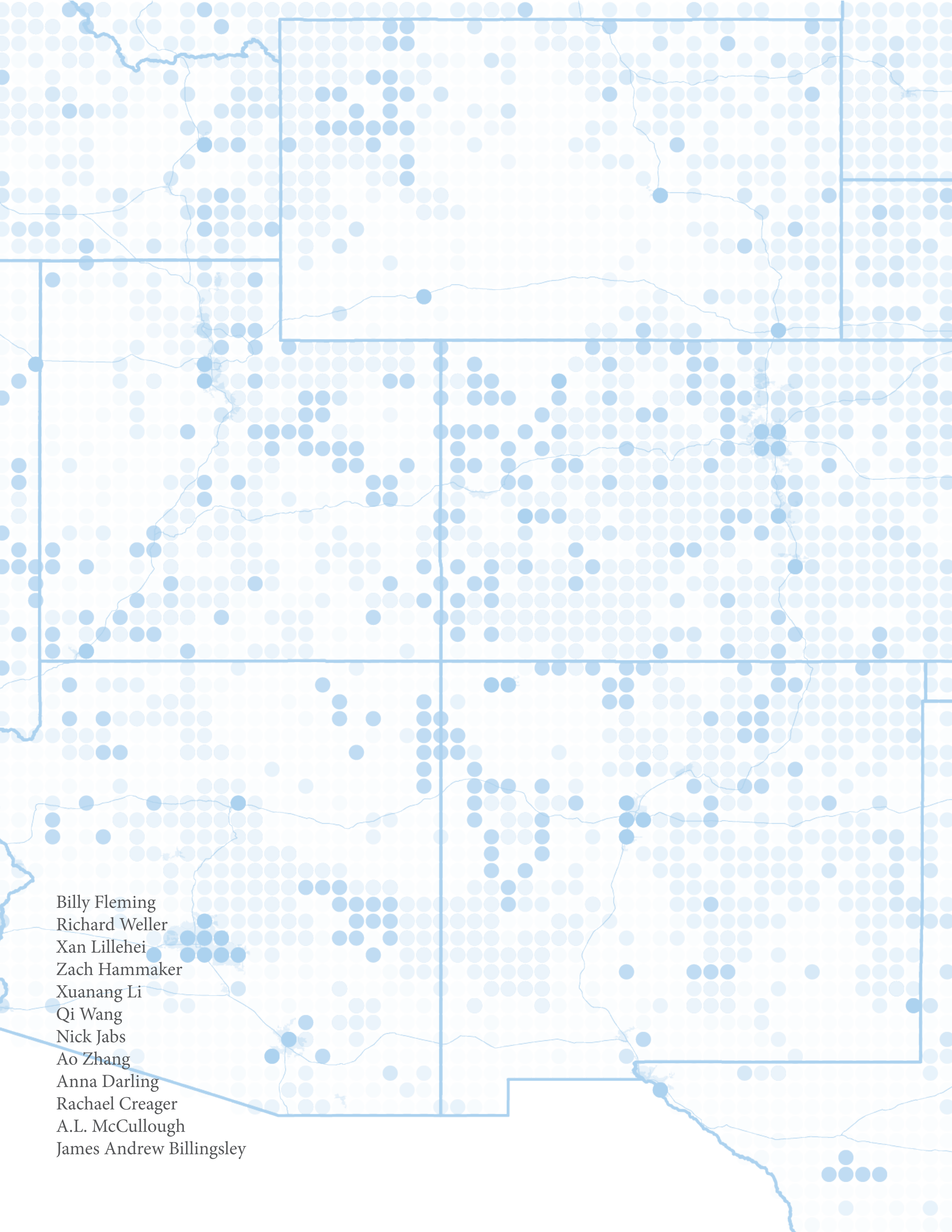

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