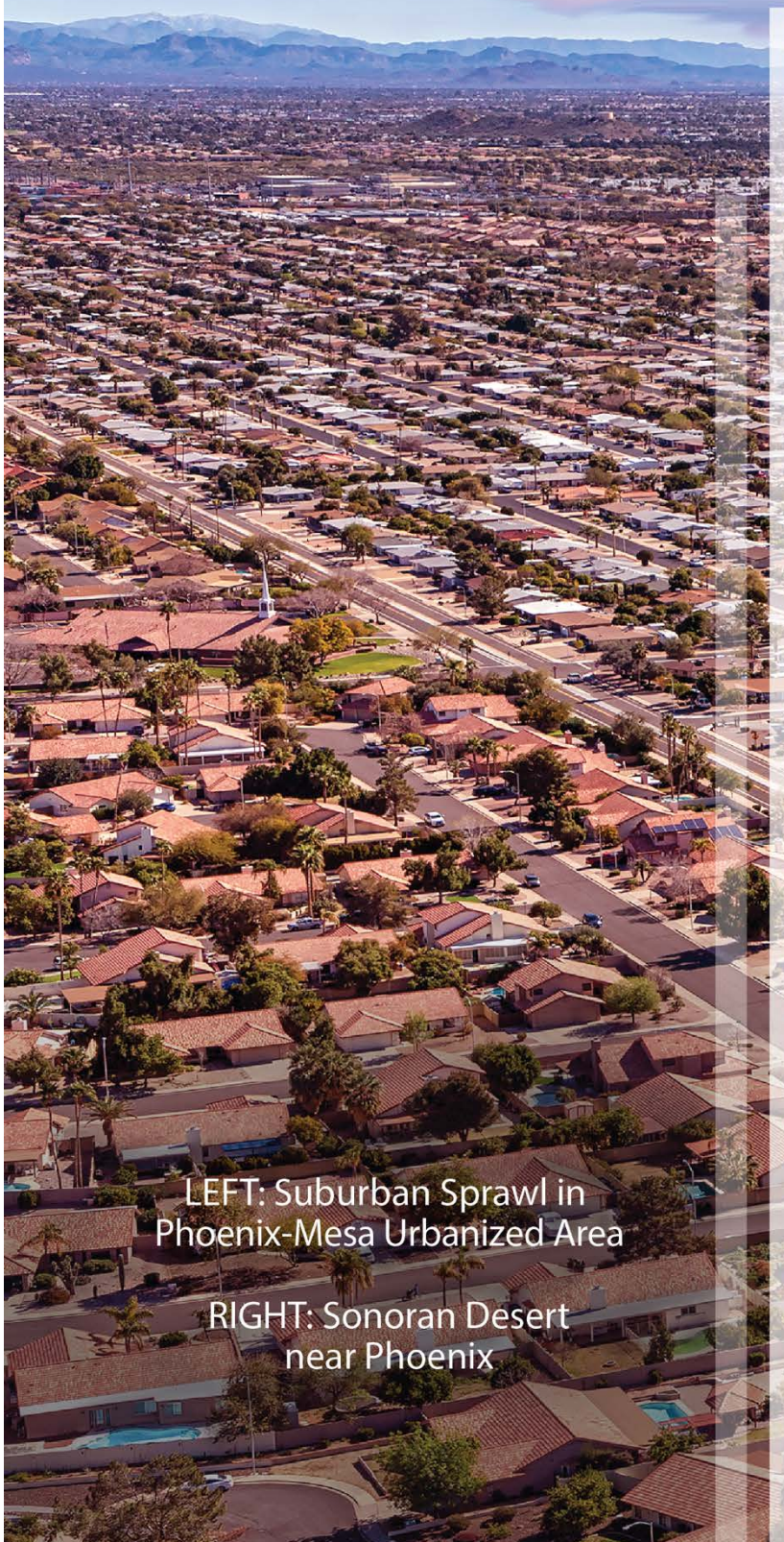


POPULATION GROWTH and the DIMINISHING NATURAL STATE of ARIZONA

Analysis of National Resources Inventory & U.S. Census Data on
Development and Habitat Loss in a Thirsty Grand Canyon State



LEFT: Suburban Sprawl in
Phoenix-Mesa Urbanized Area

RIGHT: Sonoran Desert
near Phoenix



By Leon Kolankiewicz,
with Roy Beck and Eric A. Ruark

 **NumbersUSA**

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January 2021

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POPULATION GROWTH and the DIMINISHING NATURAL STATE of ARIZONA

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EXECUTIVE SUMMARY

To accommodate more than four million additional residents over the last four decades – mostly from other countries and other states – Arizona’s cities have sprawled over vast areas of fragile ecosystems, particularly the desert biomes surrounding Phoenix and Tucson.

- ✿ Compounding the challenges, Arizona has struggled to cope with what scientists believe may be a long-term mega-drought while the state continues to be flooded each year by new residents competing with nature and agriculture for diminishing water resources. ([Section 1.5](#))

The more than doubling of both Arizona’s population and its developed land were among the highest rates in the nation over the last four decades.

- ✿ Our study questions the wisdom and sustainability of state and local efforts to encourage population growth.

Key Findings for the 1982-2017 Period

THE LOSS: 1,744 square miles (1.1 million acres) of Arizona’s natural habitat and farmland disappeared under buildings, pavement, gravel and other surfaces, representing a profound, long-term loss of agricultural potential, ecological values and functions, and quality-of-life amenities for Arizonans. ([Section 1.2](#)) This destruction is not a sustainable trend.

CAUSE OF THE HABITAT/FARMLAND LOSS: Arizona’s population growth of 4.2 million was responsible for 12 times more sprawl than all other factors combined (Figure ES-1). ([Section 3.1.4](#)) All the other dozens of factors relate to the land utilization choices of individuals, businesses, and government entities. These combined factors contribute to a per capita land consumption figure, which in most Arizona cities not only did not increase but diminished by 2017. In other words, most Arizonans in 2017 were living on less land per person and more densely than in 1982. But population growth negated all the anti-sprawl benefits of that density. ([Section 2.4](#)) This population trend is not sustainable.

CAUSE OF THE POPULATION GROWTH: Federal immigration policies were the source of the largest part of Arizona’s population growth, when counting people born in other

countries and their U.S.-born children (whether they moved to the state from another country or through another state). The two additional sources of population growth were (1) other people moving from elsewhere in the country – often enticed by Arizona’s state and local pro-development policies and driven by population-related pressures elsewhere -- and (2) births to U.S.-born Americans in the state. *(Section 2.3)* **Current federal immigration rates are incompatible with maintaining the optimal quality and quantity of Arizona’s natural habitats and agricultural lands.**

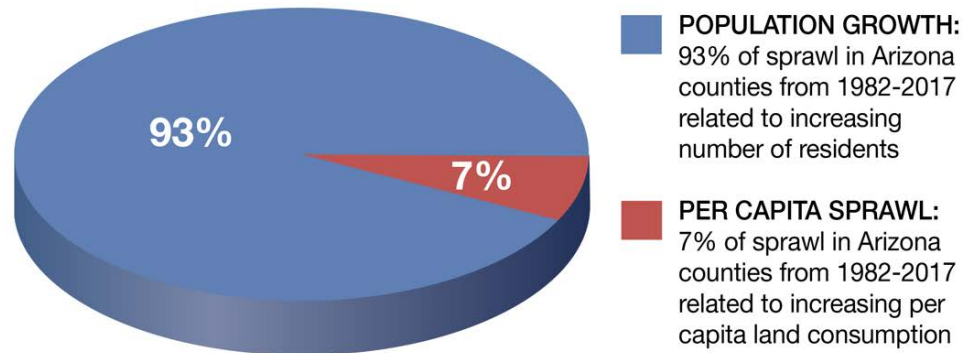


Figure ES-1. Sprawl Factors (Increasing Population and Increasing Per Capita Land Consumption) in all Arizona Counties, 1982-2017

The pie chart in **Figure ES-1** illustrates the main finding of this study which conforms with data available from the incomparable federal National Resources Inventory (NRI) of all U.S. lands. *(Section 2.2.2)* The NRI originated in 1982 and its most recently available data are from 2017. Our study examines the effects – and quantifies the roles – of per capita human consumption patterns and overall population growth in the loss of Arizona’s open space (which includes both natural habitat and farmland).

Survey: Arizonans Want Less Development & Population Growth

Most Arizonans are concerned about the development and population trends in their state, according to a scientific April 2020 survey of 1,000 likely voters in Arizona that was commissioned for this study and conducted by the polling firm Pulse Opinion Research. *(Appendix H)*

- **ARIZONANS WANT LESS NEW DEVELOPMENT:** Asked about the amount of current development in their state, only 8% said there is “too little” development. An overwhelming majority (86%) of Arizona voters indicated they would rather see no additional development, or not much more.

That result is not surprising given the relentless development Arizonans have endured at a rate faster than any state except Nevada (Table ES-1). Arizonans may be worn out from the rapid change and disruption.

Table ES-1. Top 2 Sprawl States, 1982-2017					
State	Developed Land Area 1982	Developed Land Area 2017	Overall Sprawl 1982-2017	% Increase in Area of Developed Land	National Ranking by % Increase
Nevada	336 sq. mi.	850 sq. mi.	514 sq. mi.	153%	1
Arizona	1,536 sq. mi.	3,280 sq. mi.	1,744 sq. mi.	114%	2

- **ARIZONANS WANT LESS NEW POPULATION GROWTH:** Informed that the state’s demographers project that Arizona’s population of 7.4 million is trending toward an additional 3 million by 2050, joining Tucson and Phoenix together into a single mega-city, voters found the prospect more negative than positive by a 69-17 ratio.

Only 8% said they desire Arizona’s population growth to continue at its present pace. Nearly all (88%) expressed a desire for much less population growth, either by growing “much more slowly” (48%), not growing at all (26%) or reducing current population size (14%).

Population Growth Negated Density Benefits

Two overall factors create the spread in development over Arizona's ecosystems and farmland:

1. **Population growth.** The increase created by births and newcomers minus deaths and outmigration to other destinations.
2. **Growth in per capita land consumption.** This is the measurement of the average amount of developed land that is required for each resident's employment, parks, other recreation, education, religion and culture, transportation, commerce, utilities, waste handling, and other urban needs.

We examined these factors as well as overall habitat and farmland destruction in all 15 Arizona counties and applied a standard scientific formula for apportioning cause between the two factors (Appendix C).

The pie chart in Figure ES-1 above displays the bottom-line finding of this study. Only 7% of the loss of Arizona’s habitat and farmland statewide was found to be related to growth in per capita land consumption (that is, factors beyond the massive population growth between 1982 and 2017). (Section 3.1.4)

Table ES-2. Population Growth vs. Growth in Per Capita Developed Land Consumption in Arizona Counties, 1982-2017		
County	% POPULATION GROWTH, 1982-2017	% GROWTH IN PER CAPITA LAND CONSUMPTION, 1982-2017
Apache	37%	18%
Cochise (Sierra Vista UA)	41%	28%
Coconino (Flagstaff UA)	78%	-3%
Gila	38%	23%
Graham	57%	35%
Greenlee	-20%	98%
La Paz	63%	63%
Maricopa (Phoenix UA)	168%	-4%
Mohave (Lake Havasu City UA)	231%	-5%
Navajo	63%	-16%
Pima (Tucson UA)	81%	-14%
Pinal	346%	-24%
Santa Cruz	115%	-18%
Yavapai (Prescott UA)	208%	-23%
Yuma	158%	65%
Total	144%	-12%

As shown in **Table ES-2**, all but one of the counties had explosive population growth from 1982 through 2017. But only about half the counties (7 of 15) experienced any growth at all in per capita land consumption.

In the other eight counties, per capita land consumption did not grow and, in fact, shrank. Their negative percentages for per capita growth are shown in green-highlighted boxes (as are all negative percentages throughout this study).

Government restrictions, land costs, and personal choices in those eight counties resulted in residents living in higher density (more people per square mile of developed area). The average individual in those counties has less developed land than in 1982 for all urban purposes.

Nonetheless, the per capita land *reductions* in the eight counties did not stop the counties from devouring large expanses of additional acreage of natural habitat and farmland for urban development. As you will see in **Table ES-4**, all eight of those counties with less per capita land consumption nonetheless had major increases in sprawl because galloping population growth negated the anti-sprawl benefits of increasing density.

For example, Maricopa County reduced its per capita land consumption by 4% but still sprawled by 157% because of 168% population growth. Pinal County sprawled even more (238%) despite reducing per capita consumption by 24%, because its population soared 346%.

In 1915, there were just over one-quarter million residents in Arizona (263,000). A little over a century later (2018), this number had exploded by about 28 times to almost 7.2 million. The fact that this function on **Figure ES-2** is curving upward is suggestive of exponential growth for much of the period of record.

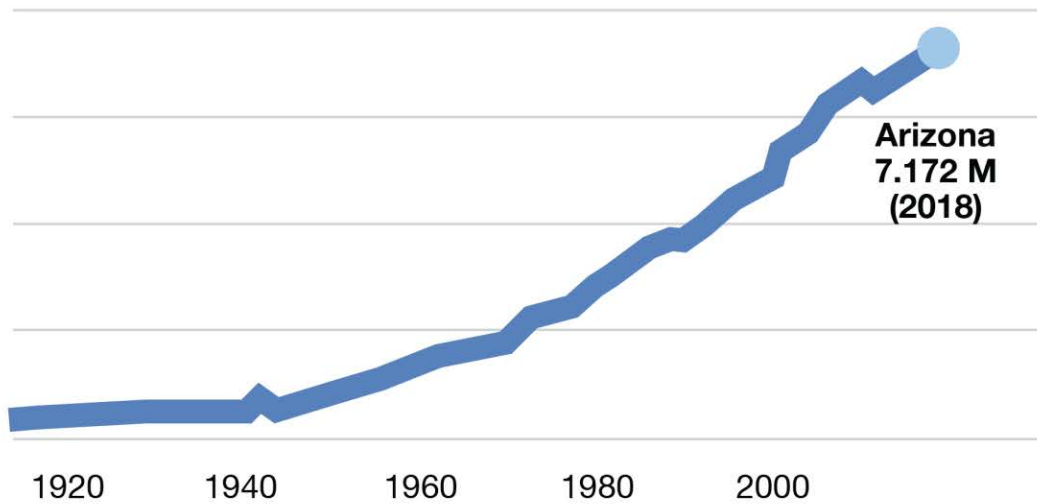


Figure ES-2. Population Growth in Arizona, 1915-2018

How Much to Sacrifice to Provide Water for Growing Desert Cities?

By the 1982 beginning of this report’s study period, Arizona was already struggling to deal with water resource challenges. Rather than apply the brakes to population growth, government officials and developers have elected to entice and accommodate an additional 4.2 million residents to compete for water.

During the same period, Members of Congress have more than doubled the national population growth that is driven by immigration policies. Besides the direct effect in Arizona, immigration policies have created acute population issues in neighboring California from which millions of its previous residents have fled into less-densely-populated neighboring states. California is the No. 1 state source of Arizona’s population growth. (*Section 2.3.3*)

Most of the water to handle this exploding Arizona population is supplied by surface water sources: 38% from the Colorado River, 18% from in-state streams and rivers (such as the Verde and Salt), and 3% from high-quality treated wastewater, that is, reclaimed water or effluent. The other 41% of Arizona’s water is pumped from groundwater sources, aquifers beneath the ground surface, which are being drained or depleted to dangerously low levels.

If current water resources seem inadequate for the current population challenges, it appears that Arizona will have to make do with even less in the future. According to the National Climate Assessment conducted by experts in 13 federal agencies, there will be declines in snowpacks and streamflows in the American Southwest during this century, particularly in the Rocky Mountains, leading to “decreasing surface water supply reliability for cities, agriculture, and ecosystems.” Lake Mead already has shrunk to less than 36% of its capacity (**Figure ES-3**). Freshwater aquatic ecosystems are expected to be especially hard-hit. Competition to drain the Colorado River will increase. Other states will be facing challenges similar to Arizona’s and will also be dependent even more on the declining resources of the Colorado.



Figure ES-3. Drought and human demands are overstressing the Colorado River. In July 2019, the water level in Lake Mead stood at just 40% of full capacity

Transferring water rights from agriculture to municipalities, plus forcing higher population-density development and xeriscaping (landscaping designed to obviate the need for irrigation or supplemental watering), are all among the options entertained by the state’s - elected officials to accommodate additional residents.

Arizona water resource managers are engaged in protracted discussions about expensive plans to recycle municipal waste and to run pipelines of desalinated seawater from the Pacific Ocean and the Gulf of California in order to satisfy this increasing demand for additional water resources, which is critical to the state’s continued population growth.

But the wisdom of this pattern of endless population growth goes unquestioned by those in authority.

Tough Water Choices Ahead

One answer to Arizona's water problems, at least in the short term, is to divert the vast amounts of water used in agriculture and provide it for urban use. But citizens' opinions about their state's farming make this an unpopular option.

- By a 55-19 ratio in the Pulse Opinion Research survey, Arizonans opposed diverting water “used to cultivate crops” to “support additional population growth.”
- 66% said it is very important “to protect U.S. farmland from development so the United States is able to produce enough food to feed its own population in the future.” Another 25% said “somewhat important.” Only 6% dismissed the importance. When it comes to producing food, taking water from agricultural use is viewed much the same as developing the land.

Another potential water source for an expanding population would be to further deplete the streams of the state. But they are more than sources of water for agriculture and urban use; they are complex ecosystems that support aquatic life, birds and other wildlife, which already are under stress due to current draining, channeling and other terrain-altering practices that manipulate streams and marshes.

- 39% of Arizonans now conclude it is “more important to use remaining water for farms and a growing urban population than to support wildlife habitat, fish and water birds.”
- But a plurality of 47% still resist using the prospect of seemingly uncontrollable population growth as justification for further diminishing the aquatic ecosystems.

When the survey for this study presented citizens with several options and asked which they most preferred as a way to provide water for the 3 million additional residents projected by 2050:

- Only 10% chose diverting “water from the state's remaining surface water and aquifers” as their preferred option.
- Even less (7%) chose diverting water from agriculture as the best option.
- 31% declined to choose any diversion of water from inside the state and instead stated a preference for the construction of “a pipeline across Mexico and California to transport desalinated Pacific Ocean water.”

- The most popular water option, though, was people refusing to accept the inevitability of the population growth – 44% chose “it is better not to add another 3 million residents,” rather than try to find water to support them.

That publicly preferred water option of not adding another 3 million residents is rarely if ever offered by Arizona’s public officials, policy experts, or the media. Arizona’s previous 4 million growth (1982-2017) is shown by county in **Table ES-3**. The concept of slowing that kind of population growth in a thirsty desert – let alone the halting of it – is deemed not a topic for public discussion.

Table ES-3. Population Growth in Arizona Counties – 1982 to 2017

County	1982 Population	2017 Population	% growth
Apache	52,152	71,545	37%
Cochise (Sierra Vista UA)	88,373	124,864	41%
Coconino (Flagstaff UA)	79,156	141,001	78%
Gila	38,924	53,578	38%
Graham	23,830	37,481	57%
Greenlee	11,747	9,443	-20%
La Paz	12,692	20,706	63%
Maricopa (Phoenix UA)	1,611,847	4,327,184	168%
Mohave (Lake Havasu City UA)	62,539	207,017	231%
Navajo	66,910	109,079	63%
Pima (Tucson UA)	568,004	1,026,391	81%
Pinal	96,802	431,564	346%
Santa Cruz	21,689	46,566	115%
Yavapai (Prescott UA)	74,009	228,082	208%
Yuma	81,186	209,507	158%
All Arizona Counties	2,889,860	7,044,008	144%

The Necessary Choices to Stop Habitat/Farmland Destruction

Our study did find some good news. Arizona's rate of sprawl slowed down late in the first decade of this century. Among the factors playing a role in this easing of environmental stresses were the adoption of smart-growth policies: higher gasoline prices, fiscal and budgetary constraints (limiting new road-building, for example), the increasing popularity of denser city living and its accompanying cultural amenities, and the recession-inducing mortgage meltdown in 2008.

Nonetheless, our most recent data for the past decade or so show that sprawl continues to devour open space at a rate of almost 17,000 acres per year (26 square miles), or one square mile every two weeks. This -averages out to 46 acres per day. In all likelihood, this rate has accelerated with the gradual recovery from the Great Recession, although we do not yet have sufficient data to confirm this hypothesis.

Even at this reduced rate, sprawl would continue to convert an additional 170,000 acres (265 square miles) of Arizona's valuable rural lands, open space, agricultural acreage and wildlife habitat into pavement and buildings every decade.

That would be in addition to the losses reported in this study since 1982. The area of cropland in Arizona declined from 1,250,200 acres in 1982 to 906,400 acres in 2015, a decrease of 27 percent. Some of this land was retired from intensive and often irrigated cultivation and converted to pastureland, rangeland, forestland, and other rural land categories. However, much of it was also developed. "Asphalt is the land's last crop," remarked former U.S. Assistant Secretary of Agriculture and conservationist Rupert Cutler back in the 1970s. Once a piece of ground with its soils and the micro and macro-ecosystems they support are paved over, the probability of that patch of the Earth being restored within the foreseeable future to a functioning ecological habitat or productive agricultural land is very small.

None of that is a future that Arizonans indicated they want in this study's 2020 survey.

As noted earlier, most citizens strongly support protecting the agricultural ability of the state.

With virtually the same level of intensity, Arizona voters value the natural areas of the state.

- 73% said it is very important "from an environmental standpoint" to preserve Arizona's deserts, grasslands, woodlands, forests and canyons. Another 22% said "somewhat important." Only 4% said not very or not at all important.

In [Section 1.2](#) and [Section 1.3](#), this study reports on the specific threats and challenges to the sustainability of all those Arizona habitats as well as the animals, birds and plants most at-risk. **Table ES-4** shows, county by county, rural lands and habitats lost to sprawl from 1982 to 2017.

Table ES-4. Rural Land Lost (Overall Sprawl) in AZ Counties – 1982 to 2017		
County	Acres Lost – 1982 to 2017	Percentage Change
Apache	42,300	62%
Cochise (Sierra Vista UA)	56,300	81%
Coconino (Flagstaff UA)	34,900	72%
Gila	11,400	69%
Graham	19,500	112%
Greenlee	1,600	59%
La Paz	18,000	165%
Maricopa (Phoenix UA)	414,900	157%
Mohave (Lake Havasu City UA)	107,400	214%
Navajo	37,100	38%
Pima (Tucson UA)	112,300	56%
Pinal	126,700	238%
Santa Cruz	18,500	77%
Yavapai (Prescott UA)	52,300	137%
Yuma	63,000	326%
Total	1,116,200	114%

The majority of Arizonans particularly value the natural areas that they can explore, - experience, and enjoy.

- 57% said it is very important that they can easily spend time in the natural areas near where they live, the areas most in danger of disappearing under the developers' bulldozer blades. Another 33% said "somewhat important," with only 7% saying not very or not at all important.

We address that desire in "Americans and Arizonans Love Their Open Space" ([Section 1.7](#)) and also their need for easy access to nature in "Rejuvenating the Human Spirit: Physiological and Psychological Benefits of Open Space" ([Section 1.6](#)).

Arizonans also fear changes in their everyday quality of life – particularly congestion -- if population trends continue.

- Only 14% of Arizonans said they believe government will be able to build enough transportation capacity to accommodate the extra traffic if the population in their own communities continues to increase significantly; 78% said they expect that traffic "would become much worse."

State and local officials can do a number of things to mitigate the losses from population growth that citizens deplore. For example, they can accelerate their efforts to increase population density in the cities through zoning changes and regulations such as those that move more residents into apartment and condo buildings instead of single-family houses, thereby reducing the amount of land needed outside the urban boundaries to handle extra people.

- 38% of Arizonans said they strongly or somewhat favor those pro-density efforts.
- But 51% said they strongly or somewhat oppose such efforts; twice as many strongly opposed (24%) as strongly supported (12%) those increased-density goals.

Regardless of the willingness of citizens or the leadership of officials to embrace increased-density measures in Arizona, the findings of this study explain how those efforts can only slow down the rate of the destruction of habitat and agricultural land if population growth continues. **Figure ES-4** shows how decisively population growth has driven sprawl in Arizona.

This study confirms the conclusion of President Bill Clinton’s special Council on Sustainable Development in 1996 that full environmental protection is not possible without a stabilization of population.

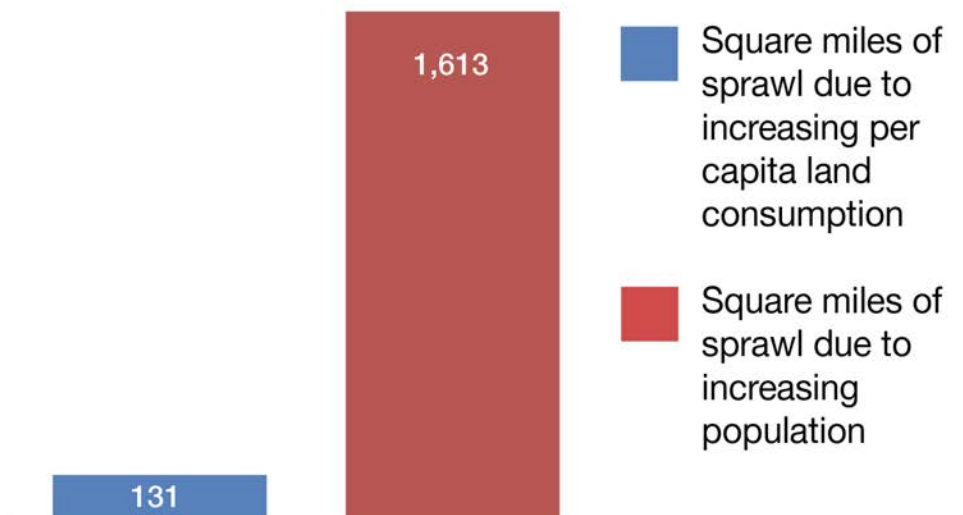


Figure ES-4. Rural Land Lost to Per Capita Sprawl vs. Population Growth in Arizona Counties, 1982-2017

In [Section 4.2.1](#), we discuss a number of ways that local and state officials can first stop enticing people to move to Arizona from other states and, secondly, discourage the migration.

- By a 49-33 margin, Arizona citizens like the idea of making it “difficult for people to move to Arizona from other states by restricting development.”

In the short term, this could provide for a greatly reduced pace of habitat and farmland destruction while at the same time slowing down the increased congestion in citizens’ lives.

Beyond the short term, though, local Arizona officials supportive of growth control and management can hope only to slow population growth in their jurisdictions if national population continues to increase by some 2-plus million additional residents each year.

These 20-25 million additional Americans each decade will nearly all settle in some community, inevitably leading to additional sprawl as far and as long as the eye can see. Many of these added millions will choose to seek a home in Arizona and create pressure to undo measures to stabilize the state's population.

The current national population growth of about 20 million a decade is mostly the result of federal immigration policies that, whether intended or not, operate as a forced U.S. population growth program. Federal immigration policies account for nearly all U.S. population growth.

Thus, long-term population growth in the United States and Arizona is in the hands of federal policy makers. It is they who have increased the annual official intake and settlement of immigrants from one-quarter million in the 1950s and 1960s to over a million since 1990. The total of new arrivals, though, fluctuates between one million and nearly two million, once net illegal immigration is included. Until the numerical level of national immigration is addressed, even the best local plans and political commitment will be unable to stop or arrest sprawl.

That is why President Clinton's Council on Sustainable Development in 1996 recommended: "This is a sensitive issue, but reducing immigration levels is a necessary part of population stabilization and the drive toward sustainability."

Informed in this study's survey that the government currently "allows one million legal immigrants each year," Arizonans by a 47-38 margin favored reducing immigration.

Any serious efforts to halt the loss of open space, farmland, and wildlife habitat in Arizona must include reducing the volume of population growth, which requires lowering the level of immigrants entering the country each year, unless Americans and new immigrants decide to move toward a one-child per woman average.

POPULATION GROWTH and the DIMINISHING NATURAL STATE of ARIZONA

Analysis of National Resources Inventory & U.S. Census Data on Development and Habitat Loss in a Thirsty Grand Canyon State

1. SPRAWL'S TOLL ON LANDSCAPES, ECOSYSTEMS, AND THE HUMAN SPIRIT

In the 29 years after the 1990 Census, Arizona added 2.9 million people to its population, growing by approximately 100,000 per year on average (**Table 1**). Measured by percentage increase, its 66 percent growth ranked fifth in the entire United States during this time period. Of the four states that grew faster by percentage – Nevada, Utah, Colorado, and Texas – only Texas added more absolute numbers of people than Arizona. All of the top 10 fastest-growing states were in the West, the South, or the Southwest, and with the exception of Washington (# 9) and Oregon (# 10), were located in the so-called Sunbelt.

Table 1. Ten Highest Population Growth States in the United States, 1990 to 2019, Ranked by Percentage

Top 10 states by rank	Population in 1990 ¹	Population in 2019 ²	Growth, 1990-2019	Annual Growth 1990-2019	% growth, 1990 to 2019
1. Nevada	1,201,833	3,080,156	1,878,323	64,770	156%
2. Utah	1,722,850	3,205,958	1,483,108	51,142	86%
3. Colorado	3,294,394	5,758,736	2,464,342	84,977	75%
4. Texas	16,986,510	28,995,881	12,009,371	414,116	71%
5. Arizona	4,375,099	7,278,717	2,903,618	100,125	66%
6. Florida	12,937,926	21,477,737	8,539,811	294,476	66%
7. Georgia	6,478,216	10,617,423	4,139,207	142,731	64%
8. North Carolina	6,628,637	10,488,084	3,859,447	133,084	58%
9. Washington	4,866,692	7,614,893	2,748,201	94,766	56%
10. Oregon	2,842,321	4,217,737	1,375,416	47,428	48%

¹ From 1990 Census, at: <https://www2.census.gov/library/publications/decennial/1990/cp-1/cp-1-1.pdf>

² July 1, 2019 estimate from U.S. Census Bureau at: www.census.gov/quickfacts

Arizona shares a long border with California, which reached the milestone of 40 million residents in 2019, and is by far the nation's most populous state. For decades, much of Arizona's population growth has been due to in-migration from California, from the shedding

of California's surplus population, as it were. This mass exodus from California, 13 million strong between 1990 and 2015, has sent droves of former Californians to all other states in the West and beyond.¹

Over the much longer term, population growth in the American Southwest as a region has been nothing short of remarkable. Between 1900 and 2000, the combined populations of the five principal Southwestern states (California, Arizona, Nevada, Utah, and New Mexico) grew from 2.1 million to 45 million, an increase of more than 21 times. By 2050, the U.S. Census Bureau and the demographic agencies of the various states project that the regional population will have grown to more than 73 million (**Figure 1**).

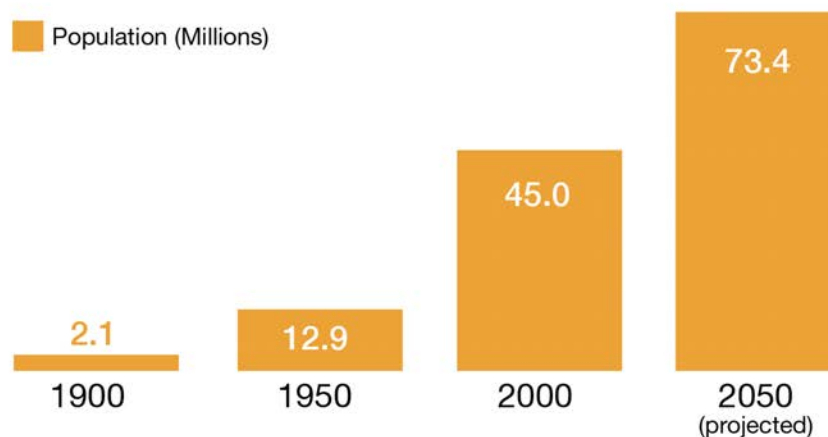


Figure 1. Combined Population of Five Southwestern States, 1900 to 2050 (millions)

Note: Includes California, Arizona, Nevada, Utah, and New Mexico

These millions of additional residents in Arizona and neighboring states all need additional space and land for their homes, workplaces, schools, hospitals, commercial areas, recreation sites, and surface transportation facilities, as well as infrastructure for energy, water, and other utilities, among other developed land uses that service their needs as modern American consumers.

Unsurprisingly, the development boom resulting from these intensifying population pressures has generated a backlash throughout the West.²

¹ Leon Kolankiewicz. 2019. How Not to Stabilize Our Population: Californians fleeing to other states in droves but are outnumbered by immigrants arriving from foreign shores. *CAPS News – Californians for Population Stabilization*, Vol. 60, No. 1, Summer. P. 3-4. Available online at: https://capsweb.org/wp-content/uploads/2019/11/caps_summer_newsletter_2019.pdf.

² Sophie Quinton. 2019. The West's Population Boom Leads to Development Backlash. PEW Stateline. November 25, 2019. Accessed online 12-1-2019 at: <https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2019/11/25/the-wests-population-boom-leads-to-development-backlash>.

In recent decades Arizona has been among the most sprawling of states in the nation. In fact, between 1982 and 2017, ranked by percentage increase in developed land, or what is called Overall Sprawl in this study, Arizona trailed only Nevada (**Table 2**). **Table 2** ranks the top ten of the 48 coterminous states in terms of the percentage increase in developed land area in the 35 years from 1982 to 2017, i.e., the percentage increase in the area of open space converted to developed or urbanized land uses in recent decades. These “open spaces” or rural lands are either natural habitats or agricultural lands (farmland) or some combination of both. Their permanent disappearance under pavement and buildings represents a profound, long-term loss of agricultural potential, ecological values and functions, and quality-of-life amenities for Arizonans and all Americans.

Table 2. Top Ten States Ranked by Percentage Increase in Developed Land (Overall Sprawl), 1982 to 2017*

State	Developed Land Area 1982 (sq. miles)	Developed Land Area 2017 (sq. miles)	Overall Sprawl (square miles), 1982-2017	% Increase in Area of Developed Land	Ranking by Percentage Increase
Nevada	336	850	514	153%	1
Arizona	1,536	3,280	1,744	114%	2
Georgia	3,480	7,390	3,910	112%	3
North Carolina	3,686	7,681	3,995	108%	4
South Carolina	2,133	4,269	2,136	100%	5
Florida	4,398	8,751	4,353	99%	6
Utah	738	1,451	713	97%	7
Tennessee	2,570	4,924	2,354	92%	8
New Mexico	1,122	2,141	1,019	91%	9
Kentucky	1,770	3,352	1,583	89%	10

Source: USDA Natural Resources Conservation Service, *2017 National Resources Inventory, Summary Report* (September 2020), Table 1

*See Appendix J for 48 Contiguous States Ranked by Percentage Increase in Developed Land (Overall Sprawl), 1982 to 2017

1.1 Sprawl and Habitat Loss Still a Problem After All These Years (and Americans and Arizonans Are Still Concerned)

When NumbersUSA published its first national level study on sprawl in 2001,³ sprawl was a hot topic, with many U.S. environmental organizations and the general public focused on the impacts of ever-expanding cities and the nation's steadily disappearing rural land.⁴ Nineteen years later, sprawl is still devouring valuable farmland and wildlife habitat, both in Arizona and nationwide, but national and state environmental groups, by and large, have reduced their attention to habitat issues in the United States as they have focused on global issues like climate change and on non-environmental matters. Despite our country's economic setbacks since the Great Recession of 2008, sprawl continues to be a major threat to rural land and natural habitats in the United States. Nationally, in just the ten years from 2007 to 2017, some 5.7 million acres (about 8,900 square miles) – an area larger than Connecticut, Delaware and Rhode Island combined – of previously undeveloped land succumbed to the bulldozer's blade.⁵

Although urban sprawl by name is not particularly salient in the news anymore, the consequences of sprawl continue to fuel numerous local controversies and are a factor in many of the nation's most pressing environmental challenges. Americans remain concerned and would like these unfavorable trends halted or at least curbed. A May 2020 survey of 1,500 likely American voters revealed that 79 percent thought that the destruction of farmland and natural habitat because of urban sprawl was a “major problem” (44%) or “somewhat of a problem” (35%). Eighty-five percent responded that the loss of natural wildlife habitat and woodlands to growing cities was “very” (51%) or “somewhat” (34%) significant.⁶

³ Kolankiewicz, L. and R. Beck. 2001. Weighing Sprawl Factors in Large U.S. Cities: A report on the nearly equal roles played by population growth and land use choices in the loss of farmland and natural habitat to urbanization. Analysis of U.S. Bureau of the Census Data on the 100 Largest Urbanized Areas of the United States. March 19. NumbersUSA: Arlington, VA. 64 pp. Available online at:

https://www.numbersusa.com/sites/default/files/public/from_drupal5/pdf/LargeCity%20Sprawl.pdf.

⁴ David P. Fan, David N. Bengston, Robert S. Potts, Edward G. Goetz. 2005. The Rise and Fall of Concern about Urban Sprawl in the United States: An Updated Analysis. Bengston, David N., tech. ed. 2005. *Policies for managing urban growth and landscape change: a key to conservation in the 21st Century*. Gen. Tech. Rep. NC-265. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 51 pp. Before he began his campaign for the U.S. presidency in 2000, and later still, a campaigner for awareness about climate change, Vice-President Al Gore spoke frequently on the need to confront urban sprawl.

⁵ United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). 2020. *Summary Report: 2017 National Resources Inventory*. September. Available online at:

<https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri/results/>.

⁶ Pulse Opinion Research. 2014. Sprawl & Population National Poll – Survey of 1,000 Likely Voters. Conducted April 1-2, 2014. Margin of Sampling Error, +/- 3 percentage points with a 95% level of confidence. See Appendix G of this study for entire poll.

Arizonans share these concerns with other Americans. In April 2020, NumbersUSA commissioned a survey of 1,000 likely voters in Arizona conducted by the polling firm Pulse Opinion Research.⁷ It found that most Arizonans not only value the natural areas where they live but want to spend time in them. For fifty-seven percent of them, these areas that tend to be the most vulnerable to the next suburban development are a matter of intense interest.

9. How important is it that you can easily spend time in natural areas near where you live?

- 57% Very important
- 33% Somewhat important
- 6% Not very important
- 1% Not at all important
- 2% Not sure

Nonetheless, the first question in the survey found a third of Arizonans reacting positively to the urban amenities that have been added in recent decades, and another fifth not feeling that the sprawl had had much effect on their own quality of life.

1. The U.S. Department of Agriculture calculates that Arizona over the last four decades has turned more than 1,700 square miles of natural habitat and agricultural land into housing, shopping malls, streets and other urban development. On balance, has this made Arizona a better place to live, a worse place to live or did it not have much effect?

- 32% This development has made Arizona a better place to live
- 37% A worse place to live
- 22% It did not have much effect
- 8% Not sure

While the survey found most Arizonans willing to accept the open-space loss thus far, nearly all of them indicated that development has gone far enough; only 8% said there has been too little development.

2. Has Arizona developed too much, too little, or about as much as it should?

- 37% Too much
- 8% Too little
- 49% About as much as it should
- 6% Not sure

⁷ Pulse Opinion Research. 2020. Arizona Survey of 1,000 Likely Voters. Conducted April 22-23 and 26-27, 2020. Most questions have a Margin of Sampling Error of +/- 3 percentage points with a 95% level of confidence. See Appendix H of this study for entire poll.

Clearly, Arizona voters' disenchantment with continued development of rural land is related to the high value they place on preserving agricultural production. Two-thirds say it is "very important" to protect farmland so the country can feed its own population.

3. Government data show that the United States now has about one-third less cropland for each American than it did 30 years ago. How important is it to protect U.S. farmland from development so the United States is able to produce enough food to feed its own population in the future?

66% Very important
 25% Somewhat important
 5% Not very important
 1% Not at all important
 3% Not sure

Since 1982, we can compare and track development of rural land in Arizona by means of the data gathered by the National Resources Inventory (NRI), conducted by the United States Department of Agriculture's (USDA) Natural Resources Conservation Service (or NRCS, formerly the Soil Conservation Service or SCS). Between 1982 and the most recent data point of 2017, approximately 1,744 square miles (1,116,200 acres) of open space, natural habitats, and farmland in Arizona were converted into "Developed Land," including housing, shopping malls, streets, schools, government buildings, utility infrastructure, waste treatment facilities, parking lots, vacation homes, resorts, highways, and places of work, worship, and entertainment. Including all the lands that had previously been developed in Arizona (prior to 1982), by 2017 the total amount of developed land in the state was 3,280 square miles (2,098,900 acres). In just the 35 years between 1982 and 2017, almost as much land was developed as in Arizona's entire previous history, including 70 years (1912-1982) as a state and another five decades as a U.S. territory before statehood.⁸

Arizona Residents Speak Out On Sprawl

"Sprawl is Out of Control..."

Sprawl is out of control here in Scottsdale. Every inch of scenic desert being torn up. Traffic getting horrendous. Some nice outdoor restaurants in the desert demolished to make room for ugly condos and townhouses....

-- Arizona resident Doug Miller

This sprawling urbanization has put pressure on natural resources, habitats, and species in many ecologically sensitive and aesthetically scenic areas, a diminishment of the natural world that warrants this separate study of Arizona's sprawl. Our previous research of the factors that cause sprawl included three national-level studies (2001, 2003, and 2014), two on Florida

⁸ Op. Cit. Footnote #5. USDA NRCS. 2020. *Summary Report: 2017 National Resources Inventory*.

(2000 and 2015), one on California (2000), one on the Chesapeake Bay watershed (2003), one on the Southern Piedmont (portions of North Carolina, South Carolina, and Georgia) in 2015-2016, one on Texas in 2017, and one on Oregon in 2020. These studies are available at the NumbersUSA website, www.numbersusa.com and have been cited numerous times in the technical and popular literature.

The remainder of this section provides some background on what sprawl is and what is at stake due to its relentless outward march. Section 2 then describes our methodology, sources and definitions. Section 3 presents our findings.

1.2 Loss of Wildlife Habitat, Farmland and Open Space

One of the primary concerns about urban sprawl has been that it is replacing our nation's forests, wetlands, and prime farmland with subdivisions, new and expanded roads, strip malls, and industrial parks. As the NRCS described it in their 2007 summary report, reviewing the 1982-2007 quarter-century:

The net change of rural land into developed land has averaged 1.6 million acres per year over the last 25 years, resulting in reduced agricultural land, rangeland, and forest land. Loss of prime farmland, which may consist of agriculture land or forest land, is of particular concern due to its potential effect on crop production and wildlife.⁹

In Arizona, according to the NRCS and its NRI, the amount of developed land increased by 114 percent (i.e., more than doubled) in the 35 years between 1982 and 2017, from 982,700 acres (1,535 square miles) to 2,098,900 acres (3,280 square miles). **Table 3** and **Figure 2** show the inexorable increase in developed land in Arizona at five-year intervals from 1982 to 2017. It is worth reiterating once more that all of the land developed during this 35-year period was land removed permanently from Arizona's agricultural land base or its natural habitats. These lost croplands, pasturelands, rangelands, open spaces, and wildlife habitats are irreplaceable on any relevant time scale.

Table 3. Cumulative Increase in Developed Land in Arizona, 1982-2017

Year	Area of Developed Land (thousand acres)	Period	Added annual increment of Developed Land during period (acres)	Average daily amount of land consumed by sprawl during period (acres)
1982	982.7			
1987	1,138.3	1982-1987	31,120	85

⁹ Natural Resources Conservation Service (NRCS). 2013. 2007 National Resources Inventory: Development of Non-Federal Rural Land. March.

1992	1,231.0	1987-1992	18,540	51
1997	1,325.8	1992-1997	18,960	52
2002	1,742.6	1997-2002	83,360	228
2007	1,943.4	2002-2007	40,160	110
2012	2,051.2	2007-2012	21,560	59
2017	2,098.9	2012-2017	9,540	26
Average		1982-2017	31,891	87

Source: Calculated from NRCS, 2020. *Summary Report: 2017 National Resources Inventory*, Table 1.

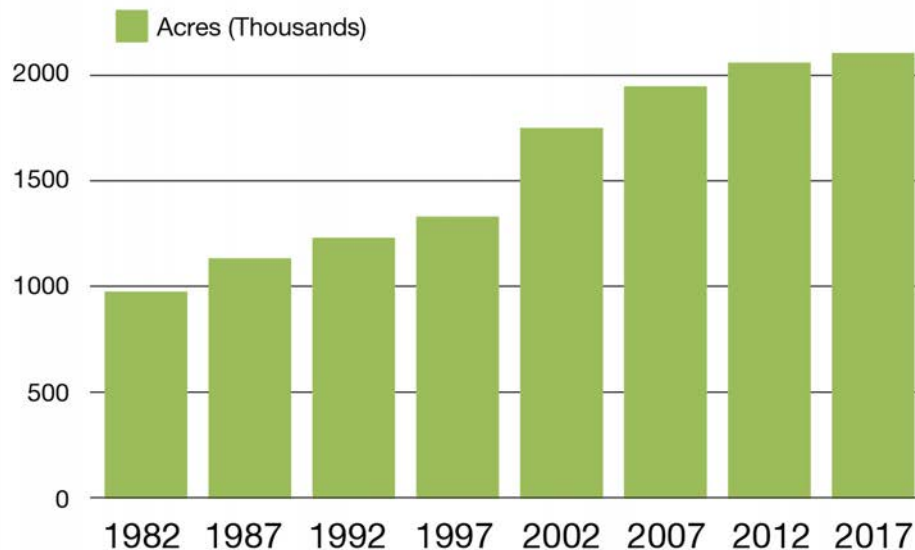


Figure 2. Growth in Acreage of Developed Land in Arizona, 1982-2017
 Data Source: Table 1 in *2017 National Resources Inventory, Summary Report* (NRCS, 2020)

On average, during each of the 12,783 days in the 35 years between 1982 and 2017, approximately 87 acres of open space in Arizona succumbed to the bulldozer’s blade, asphalt, concrete, and buildings. It is noteworthy that the amount of rural land converted to developed land rose and fell significantly during the 35-year time period, from 51 acres/day in the early 1990s to a peak of 228 acres per day in the early 2000s, and back down to 23 acres per day by 2012 to 2017, a reflection of increasing population density and also a response to the Great Recession of 2008 and its aftermath, which substantially slowed the rate of land development around the country.

The area of cropland in Arizona dropped from 1,250,200 acres in 1982 to 906,400 acres in 2017, a decrease of 27 percent. Some of this land was retired from cultivation and converted to pastureland, rangeland, and other rural land categories. However, much of it was also developed. “Asphalt is the land’s last crop,” remarked former U.S. Assistant Secretary of Agriculture and conservationist Rupert Cutler back in the 1970s.¹⁰ Once a piece of ground with its soils and the micro and macro-ecosystems they support are paved over, the probability of that patch of the Earth being restored within the foreseeable future to a functioning ecological habitat or productive agricultural land is miniscule.

The area of pastureland dropped even more precipitously than cropland, from 89,300 acres in 1982 to 52,100 acres in 2017, a drop of 42 percent. However, the much larger area of non-federal (state and private) rangeland remained essentially unchanged over these 35 years, staying at 33.5 million acres. However, the NRI does not indicate whether the quality of that rangeland may have changed, either positively from implementation of conservation measures, or negatively from factors such as erosion or invasive species like the inedible creosote bush (*Larrea tridentata*), the spread of which has been facilitated by overgrazing of livestock (**Figure 3**).

The adverse effects of encroaching development extend beyond the zone of impervious surfaces, pavement, and rooftops and penetrate into nearby natural habitats. The fact is that development disturbs adjacent natural habitat even without destroying or altering it directly with bulldozers and construction. Development can cause habitat fragmentation, that is, breaking up large, intact areas of natural habitat into smaller strips, shreds, and fragments.¹¹

In such cases, these smaller, disparate, disconnected habitats may be too small to support viable populations of various wild flora and fauna, which are prevented from interacting and breeding due to development barriers like buildings, walls, fences, and streets. Genetic diversity is lost and the risk of inbreeding and reduced survival fitness grows. Housing-induced habitat fragmentation aids the introduction of exotic or invasive species.¹² Due to “edge effects”, “patch-size effects,” and “isolation effects,” fragmentation is accompanied by biodiversity impoverishment and species loss, of both wild plants and wild animals.¹³

¹⁰ Lester R. Brown and Ed Ayers (eds.), 1998. *World Watch Reader on Global Environmental Issues*. W.W. Norton & Company (New York, London).

¹¹ The Wildlife Society. Fact Sheet – Wildlife Habitat Fragmentation. Available at: <http://wildlife.org/wp-content/uploads/2014/05/Wildlife-Habitat-Fragmentation.pdf>.

¹² V.C. Radeloff, R.B. Hammer, and S. I. Stewart. 2005. Rural and Suburban Sprawl in the U.S. Midwest from 1940 to 2000 and Its Relation to Forest Fragmentation. *Conservation Biology*. 19(3): 793-805.

¹³ Ibid.

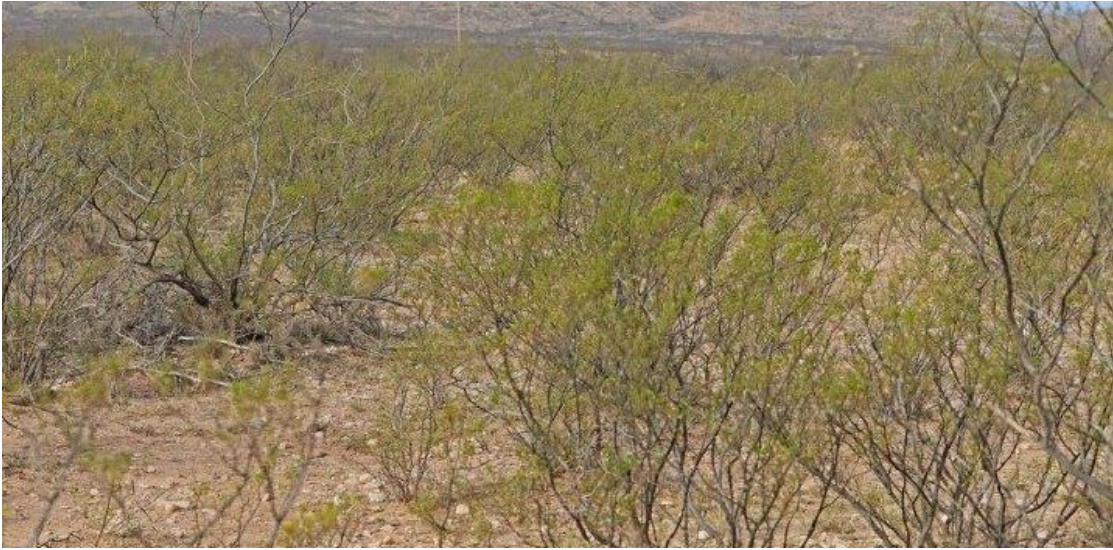


Figure 3. Stand of Creosote Bush – while a native species, creosote bush (inedible by livestock) is considered invasive because it is an aggressive competitor in the hot desert habitats of southern Arizona

It is estimated that about one-third of new houses in the United States are now constructed in undisturbed natural habitats.¹⁴ Roads connecting newly built residential subdivisions and commercial development break up the landscape and create hazards and barriers through wildlife home ranges.¹⁵ As any motorist knows from observing the carnage of roadkill, paved roads and streets are deathtraps for hapless vertebrates: mammals, reptiles, amphibians, and even some birds. An estimated one million animals are killed on American roads every day.¹⁶ Roadkill is now the leading cause of vertebrate mortality in the United States.

¹⁴ Radeloff, V. C., R. B. Hammer, S. I. Stewart, J. S. Fried, S. S. Holcomb, and J. F. McKeefry. 2005. The wildland-urban interface in the United States. *Ecological Applications* 15:799-805.

¹⁵ Carroll, C., R. F. Noss, P. C. Paquet, and N. H. Schumaker. 2004. Extinction debt of protected areas in developing landscapes. *Conservation Biology* 18:1110-1120.

¹⁶ Marc Bekoff. 2010. Animals and cars: One million animals are killed on our roads every day. *Psychology Today*. Accessed online 7-13-19 at: <https://www.psychologytoday.com/us/blog/animal-emotions/201007/animals-and-cars-one-million-animals-are-killed-our-roads-every-day>.



Figure 4. Clearing and Grading, the First Steps in Land Development. In Arizona and around the world, many patches of earth have succumbed to bulldozers, skidders, excavators, graders, and other heavy earth-moving equipment

Anthropogenic noise from cars, trucks, and motorcycles, railroads, airport takeoffs and landings, compressors, factories, oil and gas exploration and development, and even amplified music from loudspeakers encroaches deeply into natural habitats and adversely affects wildlife through behavioral disruption, acoustic masking, and increased stress response.¹⁷ One recent study found that human noise doubled background sound levels in a majority of our nation's protected natural areas, caused a 10-fold or greater increase in noise in 21 percent of these areas (surpassing noise levels known to interfere with human visitor experience), and significantly impaired habitats of endangered species.¹⁸

In a 2010 paper in the *Proceedings of the National Academy of Sciences* entitled, "Housing growth in and near United States protected areas limits their conservation value," the authors noted that protected areas are: "crucial for biodiversity conservation because they provide safe havens for species threatened by land-use change and resulting habitat loss." However, the

¹⁷ M. Brittingham. Noise impacts to wildlife: A review of pertinent studies. Department of Ecosystem Science and Management, Penn State University. Available online at: http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_20028837.pdf; Francis, C., C. Ortega, and A. Cruz. 2009. Noise Pollution Changes Avian Communities and Species Interactions. *Current Biology* 19:1415-1419; National Park Service. 2018. Effects of Noise on Wildlife. Available at: https://www.nps.gov/subjects/sound/effects_wildlife.htm.

¹⁸ Rachel T. Buxton, Megan F. McKenna, Daniel Mennitt, Kurt Fristrup, Kevin Crooks, Lisa Angeloni, and George Wittemyer. 2017. Noise pollution is pervasive in U.S. protected areas. *Science*. Vol. 356, Issue 6337, pp. 531-533.

effectiveness of protected areas in the United States is threatened by rural sprawl and housing development in particular. The study's findings show that housing development in close proximity may severely limit the ability of protected areas to serve as a modern "Noah's Ark." The authors found that between 1940 and 2000, 28 million housing units were built within 50 km of protected areas in the United States, and 940,000 homes were even constructed on private inholdings within national forest boundaries.¹⁹

Further, they found that in the 1990s, housing built within 1 km of protected areas grew at a decadal rate of 20 percent, outpacing the national average of 13 percent. If these trends continue over the long term, another one million housing units would be built within 1 km of protected areas by 2030 (and 17 million housing units within 50 km), greatly reducing their value for wildlife and biodiversity conservation. The habitats protected as publicly-owned and managed national parks, national wildlife refuges, national wilderness areas, and national forests are increasingly isolated spatially in an increasingly fragmented national landscape. In sum, protected areas in America, "are thus threatened similarly to those in developing countries. However, housing growth poses the main threat to protected areas in the United States whereas deforestation is the main threat in developing countries."

Nationwide, from 1982 to 2017, about 44 million acres (approximately 69 thousand square miles) – an area about the size of Florida – of previously undeveloped, non-federal rural land were paved over and otherwise developed to accommodate our growing cities and towns (**Figure 5**). The total amount of developed land was 72.1 million acres in 1982. By 2017, this had risen to 116 million acres.

Figure 5 shows the increase in the cumulative total of developed land in the United States from 1982 to 2017. By 2017, approximately 116 million acres (181,250 square miles) had been developed in the 48 coterminous states, Hawaii, and Caribbean territories (Puerto Rico and the U.S. Virgin Islands). Thus, more than one-third (38 percent) of all land developed in our nation's entire history has been developed in just the last 35 years. This is a rapid, accelerating rate of change. If this rate (1.26 million acres developed/year) had persisted for the entire 244-year history of the United States (since 1776), the total area of developed land in the country would be 308 million acres rather than 116 million acres, 2.7 times as much. Another way of stating this is that the annual rate of land development in the U.S. in recent decades is 2.7 times greater than the average rate throughout our history as a country.

¹⁹ Volker C. Radeloff, Susan I. Stewart, Todd J. Hawbaker, Urs Gimmi, Anna M. Pidgeon, Curtis H. Flather, Roger B. Hammer, and David P. Helmers. 2010. Housing growth in and near United States protected areas limits their conservation value. *Proceedings of the National Academy of Sciences*. 107 (2): 940-945.

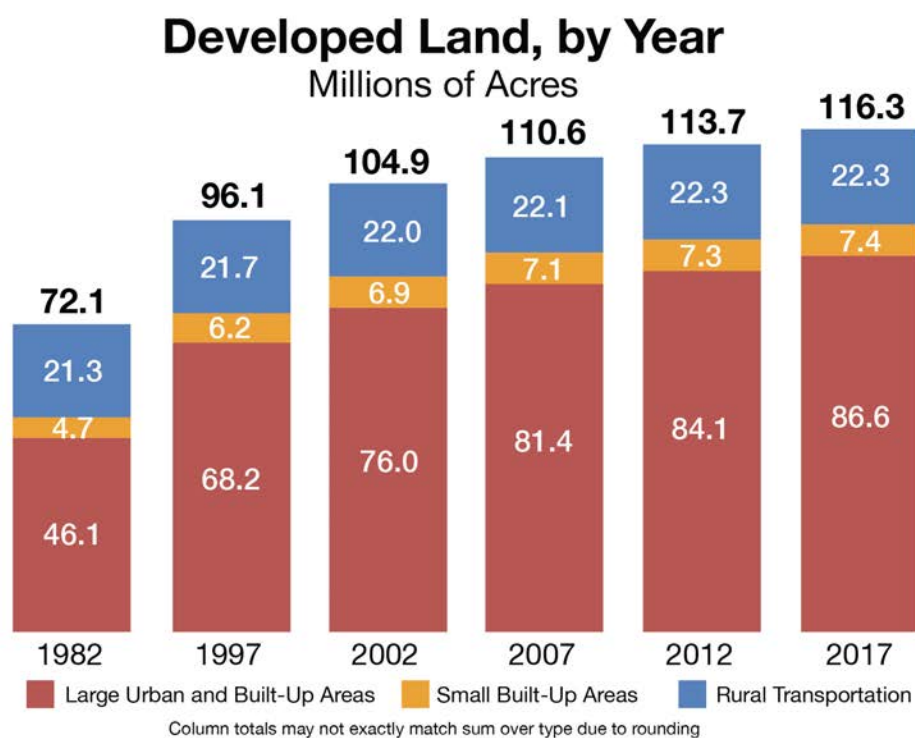


Figure 5. Cumulative Growth in Area of Developed Land Nationwide, 1982-2017

Source: NRCS. 2020. *Summary Report: 2017 National Resources Inventory*, p. 2-6 (Footnote #5).

The aggregate area of cumulative developed land in 2017 was about equal in size to the states of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, Delaware, New York, and Pennsylvania, in other words, all of New England and some of the Mid-Atlantic States. All of this land was developed from what was originally either agricultural land or natural habitat.

Where did these 44 million newly developed acres come from? What types of rural land uses were converted into developed land? These are quantified in **Figure 6**, the sources of newly developed land, including cropland, pastureland, rangeland, forestland, and other rural lands.

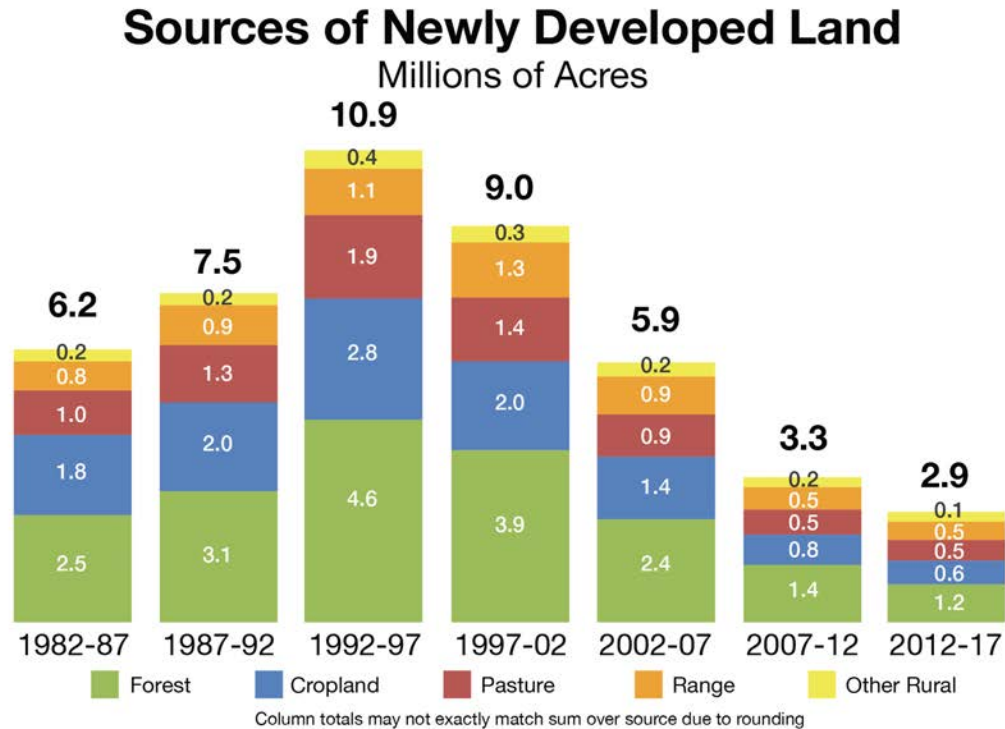


Figure 6. Sources of Newly Developed Land, 1982 to 2017

Source: NRCS. 2020. Summary Report: 2017 National Resources Inventory, p. 2-7 (Footnote #5).

Of these 44 million lost acres – or “converted acres” as land managers and planners generally refer to it more blandly – approximately 11.4 million acres were cropland, 13.5 million acres were pasture and rangeland, and 19.1 million acres were forestland.

However, reports the NRCS, “as the population has increased, the acres developed per person has [sic] dropped off.”²⁰ Nationally (excepting Arizona), the five-year period from 1992 to 1997 experienced the greatest loss of open space because of development, at 10.9 million acres. A decade later, from 2002 to 2007, this figure had dropped by almost half to 5.9 million acres. Population growth at 5-year intervals over the same 35-year time frame is depicted by NRCS in **Figure 7**. The U.S. population grew by more than 90 million during this period, at a rate of about 27 million new residents per decade, a very rapid (and unsustainable) rate of increase that added nearly a new Texas (our second-most populous state after California) to the U.S. population every decade.

²⁰ Op. Cit. Footnote #5. NRCS. 2020. *Summary Report: 2017 National Resources Inventory*.

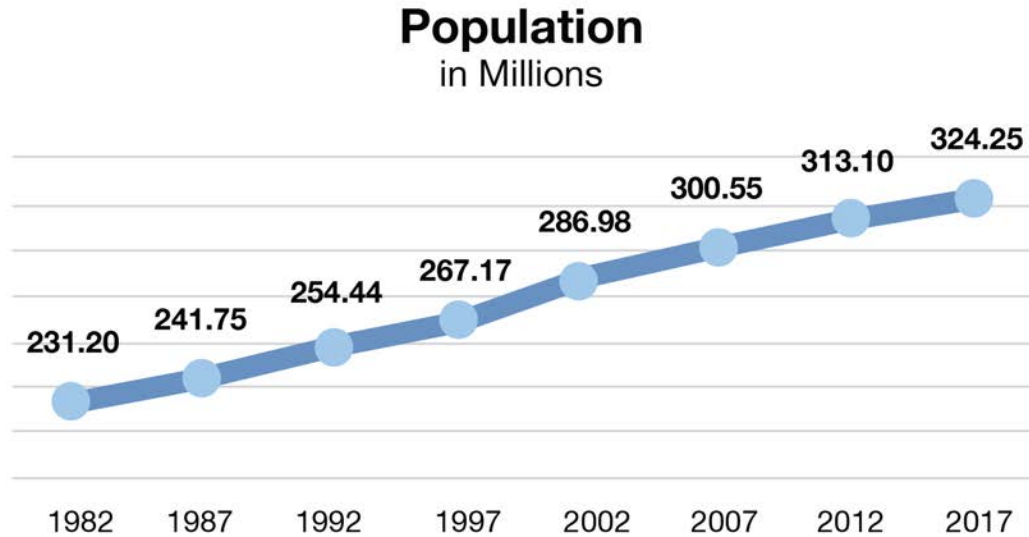


Figure 7. U.S. Population Growth from 1982 to 2017

Source: 2017 National Resources Inventory, Summary Report, p. 2-7 (Footnote #6).

Figure 8 is a satellite image depicting Arizona, showing the glow of lights in Phoenix and Tucson. The brightest patch of course is the vast Phoenix metro area. **Figure 8** is a small section of **Figure 9**, which is a composite nighttime satellite image of the United States as a whole. Viewing this image, it is easy to understand why astronomers say that residents of the United States east of the Mississippi River may live out their entire lives without ever once seeing the Milky Way, the galaxy in which we reside. This is due to the combination of the glow and glare from artificial lighting (light pollution) that envelops urbanized areas and the air pollution that the traffic, factories, and power plants associated with these areas often generate. In contrast, Arizona's dark and dry skies at night, away from its urban areas, and its higher elevations in many places are a blessing for astronomers and amateur stargazers who want to see, know, and appreciate man's place in the universe.



**Figure 8. Satellite Image of Arizona at Night,
Showing the Prominent Glow of Phoenix and Tucson**



Figure 9. Composite Satellite Image of the United States at Night

To the ecologically uninformed, the satellite view could suggest that with all those dark areas on the map, there must be plenty of room for tens -- even hundreds -- of millions additional residents. But most of these dark areas on the map represent: 1) mountains too steep, high, or cold, and deserts too dry or hot to support an urban population, or 2) lands already fully engaged in providing food, fiber, and forestry products (as well as minerals, hydroelectricity, and what ecologists call “ecosystem services” like watershed protection) to the current population. The remaining land in the unlit dark areas is what is left for nature that is vulnerable to development to accommodate an expanding U.S. population.

In 2009, an international coalition of scientists and conservationists formed an organization called Nature Needs Half with the goal of protecting half the landmass of the planet for nature. The scientists believe that it is necessary to ensure the functioning of the Earth’s life support systems. With that in mind, another look at the photo of America’s night lights raises additional questions. Those small dots are not security lamps on a solitary farm. Rather each dot is a town or city. And those are just the lights. Far more of the country is developed than is revealed at night, for example the expansive ground transportation network of millions of miles of highways, interstates, and paved and unpaved roads that crisscross rural areas. - What are the chances of the United States protecting half its land for nature if its population continues to grow, - especially at the present rate?



Figure 10. Cactuses reach up toward the Milky Way galaxy in the empty heart of the Arizona desert, far from the “Madding Crowd” and the encroaching glare of big city lights visible from many miles away

Urban expansion, of course, is not merely an American or a North American phenomenon; it is a global one. And globally, urban expansion is also driven by population growth, among other factors, but unsurprisingly, population’s role in driving expansion and sprawl varies from continent to continent, region to region, and country to country. For example, population growth contributes to urban expansion more in North America than in Europe,²¹ which has very low rates of population growth compared to Canada and the United States. Likewise, urban population growth is more closely related to urban expansion in Africa and India (both of which still experience rapid to very rapid population growth), than in China, where population growth is slowing and GDP growth is a greater factor in urban expansion.²²

Across the world, scholars and planners widely regard population growth as one of the most important factors driving “land take” and urban land expansion, along with income growth (higher GDP per capita), increased transport accessibility, weak or inadequate planning, and subsidies encouraging land consumption and automobile use.²³

Recognition by scholars that population growth is a major (albeit not the only) driver of urban land expansion and sprawl is sharply at odds with the way the news media and anti-sprawl activists in the United States have tended to portray the causes of sprawl. The news media and

²¹ Karen C. Seto, Michail Fragkias, Burak Güneralp, Michael K. Reilly. A Meta-Analysis of Global Urban Land Expansion. 2011. *PLoS One*. Vol. 6, Issue 8, August.

²² Ibid.

²³ Alice Colsaet, Yann Laurans, and Harold Levrel. What drives land take and urban land expansion? A systematic review. *Land Use Policy*. 79 (2018): 339-349.

anti-sprawl activists have chosen to accept that rapid, unending U.S. population growth on the order of 20 to 30 or more million new residents per decade is a given and a fait accompli in the name of “human progress”; they have shown no intent of questioning or challenging it.

Thus, since they want to convince Americans that something can still be done to halt or slow sprawl substantially in spite of never-ending U.S. population growth, these actors tend to downplay or minimize population’s importance as a causal factor in sprawl. In their efforts to publicize sprawl to the American public and enlist support for anti-sprawl measures – e.g., “smart growth” policies, higher residential densities, multifamily housing (apartments and condominiums), mixed land uses and zoning, and infill that eliminates existing urban open space (such as golf courses) – they reserve their criticism for “low-density sprawl,” essentially giving a pass to other new development on the urban periphery, as long as it is not low-density, even though it still permanently devours rural land and open space.

1.3 Threatened Species and Habitats

A biome is a large, naturally-occurring community of flora and fauna consisting of a dominant habitat, e.g., forest, grassland, or desert. Arizona boasts a number of diverse biomes (**Figure 11**).

Within the landscapes threatened by sprawl are found some of our most critical natural habitats. According to the World Wildlife Fund, habitat loss poses the single greatest threat to endangered species around the world. The United States is home to over 1,600 endangered or threatened animal and plant species and subspecies that are seriously harmed by ever-encroaching development.

In the context of Arizona’s Sonoran Desert, a schoolteachers’ guide explains the process that steals habitats and puts species at risk:

As the human population increases, cities, farms, ranches, factories, and shopping malls grow larger and expand into the wilderness including the Sonoran Desert. This leaves less habitat for animals and plants. Many of them cannot survive in other places. Their populations drop, and they become in danger of extinction.²⁴

Endangered species, subspecies, or populations are those rare plants or animals that, if recent trends continue, will likely become extinct within the foreseeable future, barring heroic measures to save them. Threatened species or subspecies may become endangered within the foreseeable future. Arizona habitats support flora and fauna, some of which have become imperiled in the state (in danger of “extirpation” or elimination over part of their overall range) but enjoy healthy populations elsewhere in their range, and others of which are threatened or

²⁴ Desert Museum. “Endangered and Threatened Species of the Sonoran Desert Region.” Desert Discovery Class Teacher Information ©2000, revised 2008 ASDM

endangered over large parts of their overall range, throughout their entire U.S. range, or are imperiled on a global scale (that is, they have no healthy populations anywhere).

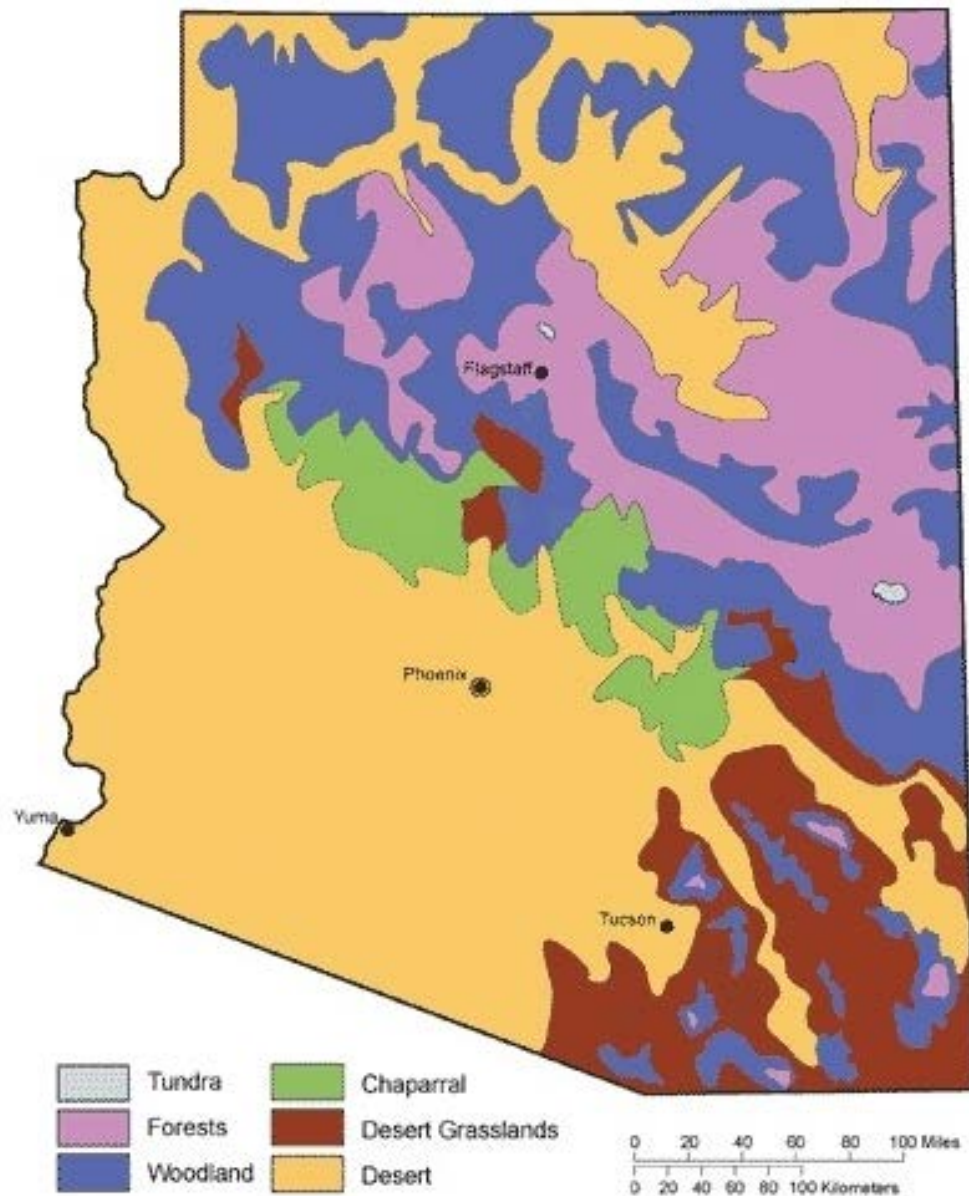


Figure 11. Biomes in Arizona

By far the greatest amount of habitat-destroying sprawl in Arizona to date has taken place in the desert biomes around Phoenix and Tucson (**Figure 12**).

The forests, woodlands, and chaparral biomes that predominate in the northern half of the state that includes the city of Flagstaff and Grand Canyon National Park have thus far been less subject to sprawl. While the mile-deep Grand Canyon – carved by the Colorado River over seven million years of geologic history and revealing rocks such as the Vishnu Schist more than a billion years old at the bottom – is a world-renowned treasure, a spectacular national phenomenon, part of what gives it the mystique and grandeur it possesses is its very isolation from human elements and landscape clutter. This is what lends it a sense of remoteness and geologic timelessness, and it would be a tragedy if this were to be compromised in the future because of population growth, development, and sprawl. Views of the Grand Canyon from the South Rim are already marred at times by air pollution blown east from Los Angeles.



Figure 12. Saguaro Cactus in the Sonoran Desert (Desert Biome) of Southern Arizona



Figure 13. Rugged landscape near Sedona (between Phoenix and Flagstaff), on the edge of the chaparral and the desert grasslands biomes

Here we highlight just a representative few of the endangered species of fauna found in Arizona.

The **Colorado pikeminnow** (*Ptychocheilus lucius*) is a federally endangered fish that occurs in Arizona (**Figure 14**). It is North America's largest minnow, and large specimens once reached six feet in length and almost 100 pounds in weight.²⁵ They were once so abundant that farmers would spear them with pitchforks in irrigation ditches and use them to fertilize crops. The Colorado pikeminnow depended on free-flowing passage up and down the Colorado River and tributaries to migrate from their home ranges to spawning beds, migrations that sometimes exceeded 200 miles.²⁶



Figure 14. Colorado Pikeminnow (*Ptychocheilus lucius*)

²⁵ Ibid. Footnote #21.

²⁶ U.S. Fish and Wildlife Service. Fish and Aquatic Conservation. Colorado Pikeminnow. Accessed online 12/30/19 at: https://www.fws.gov/fisheries/fishmigration/colorado_pikeminnow.html.

Today the Colorado pikeminnow has almost been extirpated in Arizona, and large adult fish have become rare. Aquatic habitat alteration is the main cause of the pikeminnow's demise. Dams were constructed on the Colorado River to generate electricity, supply water for farms and growing cities, and to control floods. These dams changed the timing and volume of river flows and the temperature of the water, as well as interfering with migration to and from spawning beds.

For many ages before the dams, pikeminnows spawned in late spring and early summer. After spring flooding receded, water levels would drop and water temperatures rise. These conditions were cues for the pikeminnows to reproduce. However, once dams were constructed, water levels remained higher and temperature stayed cooler in the spring and summer. With their reproductive cues muted or eliminated, pikeminnows stopped reproducing like before and their populations declined as a result.

Another problem for the Colorado pikeminnow was the introduction of the largemouth bass, a popular sportfish from the eastern United States. Largemouth bass thrived in their new habitat along the Colorado River, competed with pikeminnows for food and living space, and ate Colorado pikeminnow eggs and young.

The **Yuma clapper rail** (*Rallus longirostris yumanensis*) is a federally endangered sub-species of clapper rail (*R. longirostris*). It is a marsh bird with long legs and a short tail, about the size of a chicken (**Figure 15**), with a historical range that included Arizona and California.²⁷



Figure 15. Yuma Clapper Rail

Threats to its continued survival in Arizona include aquatic and riparian (streamside) habitat destruction, primarily from stream channelization and drying and flooding of marshes. These result from water flow management on the lower Colorado River. Additional threats include contaminants from agricultural tailwaters (the return flow of water draining from irrigated fields back to watercourses) and invasive, exotic vegetation.²⁸

²⁷ U.S. Fish and Wildlife Service. [ECOS Environmental Conservation Online System](https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=B00P). Yuma clapper rail (*Rallus longirostris yumanensis*). <https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=B00P>.

²⁸ U.S. Fish and Wildlife Service. 2014. Nevada Fish & Wildlife Office: Yuma Clapper Rail (*Rallus longirostris yumanensis*). Last updated April 16, 2014. Accessed online 12/31/19 at: https://www.fws.gov/nevada/protected_species/birds/species/yucr.html.

The **Southwestern Willow Flycatcher** (*Empidonax traillii extimus*) (**Figure 16**) is a federally-endangered “neotropical migrant” songbird, meaning that it breeds in North America and migrates southward to wintering grounds in Latin America. Flycatchers are insectivores (insect eaters) and this sub-species of flycatcher forages in dense riparian vegetation, catching insects in flight, hovering to glean them from foliage, and occasionally capturing them on the ground.²⁹ It breeds in relatively dense riparian tree and shrub communities alongside rivers, streams, lakes, reservoirs, swamps, and other wetlands including lakes and reservoirs, building a small open cup nest in a fork or on a horizontal branch of a shrub or small tree in dense foliage.³⁰

Historically, the Southwestern Willow Flycatcher nested in native willows, seepwillow, boxelder, buttonbush, and cottonwood. While it still nests in native vegetation, it must also use thickets now dominated by non-native, invasive species such as tamarisk and Russian olive, or in mixed native non-native stands.

Figure 16. Southwestern Willow Flycatcher

This sub-species has declined because of removal, thinning, or loss of riparian vegetation. Water diversions and groundwater pumping (which alter riparian vegetation), overstocking or other mismanagement of livestock, and recreational development have also played a part in its demise, as has cowbird parasitism.³¹



²⁹ U.S. Fish and Wildlife Service. Nevada Fish & Wildlife Office: Southwestern Willow Flycatcher (*Empidonax traillii extimus*). Last updated April 16, 2014.

³⁰ U.S. Geological Survey. 2008. Southwestern Willow Flycatcher Breeding Site and Territory Summary—2007. Available online at: <https://pubs.usgs.gov/of/2008/1303/>.

³¹ Op. Cit. Footnote #29.

The **ocelot** (*Leopardus pardalis*) is a small, wild feline that has been listed as endangered since 1982.³² Adult ocelots are about twice the size of housecats. Their coats come in a wide variety of patterns with unique markings (**Figure 17**). They are territorial, solitary, and nocturnal, hunting at night and sleeping in trees and brush during the day.³³

Figure 17. Young Ocelot

Their range extends from South America through Central America and Mexico into southern Arizona (**Figure 18**), where they can occur in desert, desert grassland, and woodland habitats. Ocelots are considered opportunistic carnivores, feeding on a variety of small mammals, birds, reptiles, amphibians, and even fish and shellfish.³⁴ While not endangered in Latin America, the United States is on the very northern edge of their range, and the status of the species is precarious.

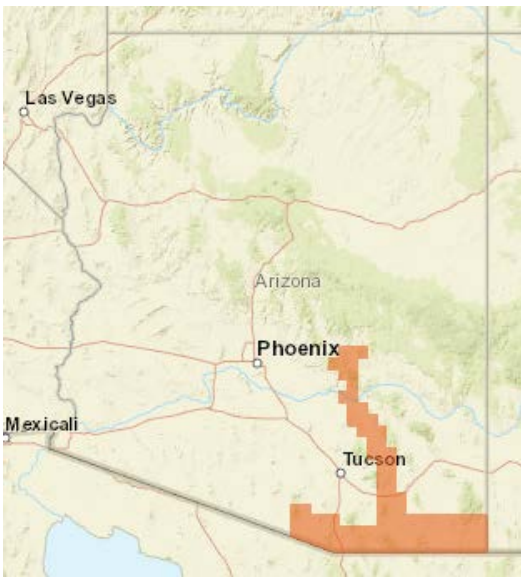


Figure 18. Range of the Ocelot in Arizona

³² U.S. Fish and Wildlife Service. 1982. Endangered and Threatened Wildlife and Plants; Endangered Status for U.S. Population of the Ocelot. Final rule. *Federal Register*. Vol. 47, No. 140. Available online at: https://ecos.fws.gov/docs/federal_register/fr609.pdf.

³³ Alina Bradford. 2016. Facts about Ocelots. *LiveScience*. Accessed online on 12/31/19 at: <https://www.livescience.com/55072-ocelot-facts.html>.

³⁴ International Society for Endangered Cats Canada. Ocelot. Accessed online 12/31/19 at: <http://wildcatconservation.org/wild-cats/south-america/ocelot/>

Of course, imperiled species in Arizona merely represent the tip of the iceberg, or the biosphere in a microcosm: globally, biological diversity is under assault from the explosive expansion of the “human enterprise”, that is, the sum total of all human activities, across the entire surface of the Earth. A group of researchers from the University of Queensland in Australia, the Wildlife Conservation Society in New York, and other institutions used a comprehensive dataset on the “human footprint,” computing the cumulative impact of human activities on the Earth’s surface. They reported in early 2020 that a staggering 20,529 terrestrial vertebrate species are facing intense pressure from humanity. Out of that number, about 85 percent have had half or more their range exposed to human pressure, according to the study, published in the journal *Global Ecology and Conservation*.³⁵

1.4 Stability of Ecosystems and the Biosphere

In 2017, Arizona’s population of just over seven million sprawled across an area of 3,280 square miles (2,098,900 acres) of developed land, according to the NRCS and its NRI. Much of this developed land was not occupied by residential areas per se, but by the widespread artificial structures, facilities, and infrastructure needed to support modern, high-consumption human settlements. The average land consumption per person (per capita) in 2017 in Arizona was 0.3 acre. That is, on average, each Arizona resident accounted for almost a third of an acre of developed land. This area, which is almost 14,000 square feet, is much larger (5 or 10 times) than the size (square footage) of the typical American and Arizona dwelling.

For every three residents in Arizona then, almost one acre (0.9 acre) has been converted from open space – both natural habitat and agricultural land – to pavement, a wide variety of manmade structures, and artificial landscaping.

This 0.3-acre/resident metric does not include relatively unpopulated rural lands – farmlands (cropland, pasture, and rangeland), forests, reservoirs, mines – that furnish crucial raw materials and products used by every resident, namely food, fiber, fuels, water, energy, metals, and minerals. Nor does it include the bioproductive (photosynthesizing) forestlands needed to absorb each resident’s carbon dioxide (CO₂) emissions from fossil fuel combustion to produce electricity and propel our vehicles.

All of these ecologically productive lands not covered with pavement and buildings, but used directly and indirectly by each and every state resident (and all human consumers), contribute to each average Arizonan’s ecological footprint (EF). This entails a much larger amount of land than that delineated by the NRI as developed land, approximately 50 times as much in fact, or 15.8 global acres per Arizona resident, according to the Global Footprint Network

³⁵ O’Byrne et al. 2020. Intense human pressure is widespread across terrestrial vertebrate ranges. *Global Ecology and Conservation*. Vol. 21. March 2020. Available online at: <https://www.sciencedirect.com/science/article/pii/S235198941930887X?via%3Dihub>.

(GFN).³⁶ According to GFN, the biocapacity in Arizona is a mere 1.1 global acres per person, because so much of the state is ecologically unproductive desert and desert grassland (with relatively low photosynthetic output, net primary production, and standing biomass). Thus, Arizona has an ecological deficit of 14.7 global hectares per person. In essence, the state’s human population survives ecologically only by importing carrying capacity from other geological times (e.g., the fossil fuels) and geographic places (e.g., food imports).

Globally, human civilization as a whole is also already well into overshoot of planetary carrying capacity, according to EF analysis conducted by the GFN. **Figure 19** illustrates that it would take the biocapacity of approximately 1.7 Planet Earths to provide sustainably) for the aggregate resource consumption of some 7.8 billion human consumers on the planet.³⁷

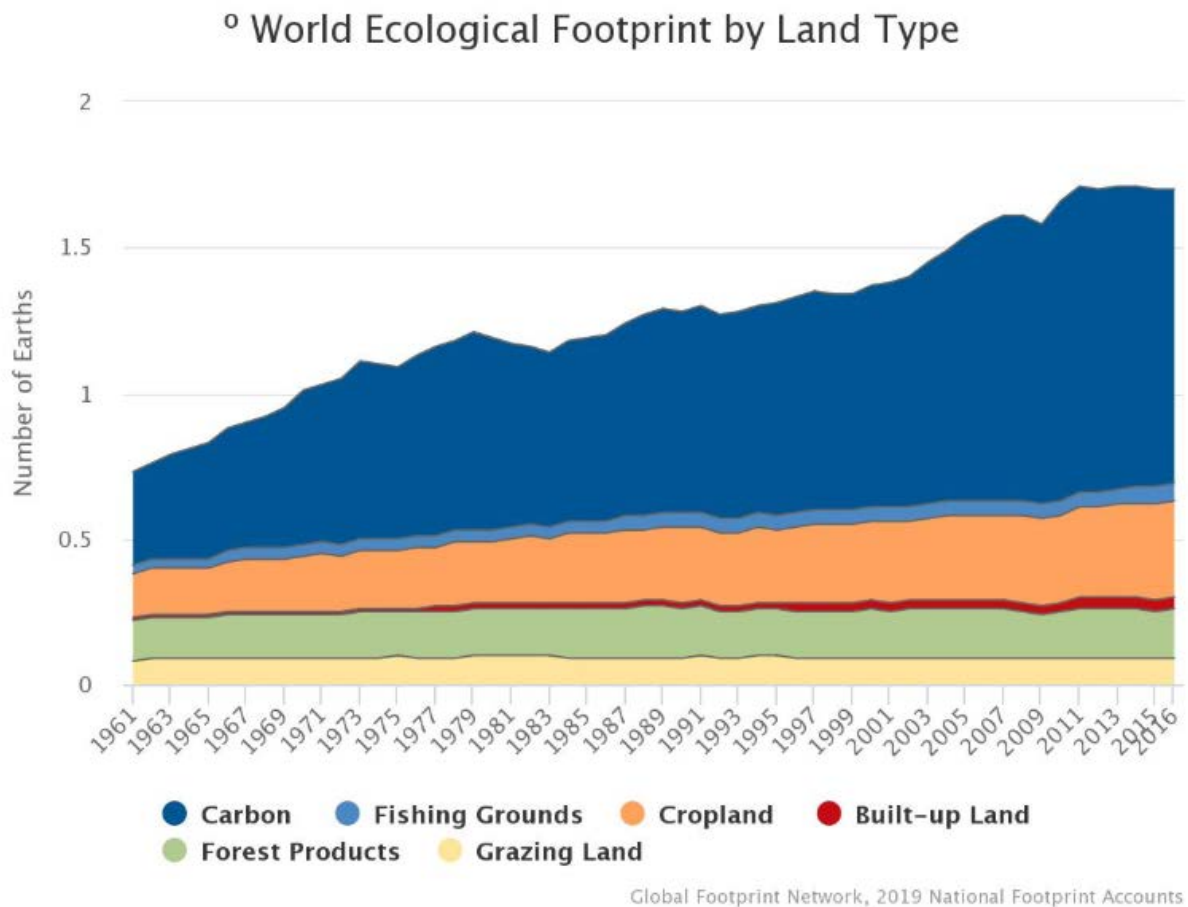


Figure 19. World Ecological Footprint in 2019 by Land Type

³⁶ Global Footprint Network. 2015. State of the States Report. Accessed on 1-4-20 at: <https://www.footprintnetwork.org/2015/07/14/states/>

³⁷ Global Footprint Network. 2019. Data/Methodology. <https://www.footprintnetwork.org/resources/data/>

The elimination of forest, grassland, desert, and wetland habitat from sprawl not only threatens native species, but has serious human health, safety, and economic consequences as well. Wild habitats and ecosystems perform “ecological services.” For example, wetlands (including vegetated riparian areas alongside watercourses) are important filters that clean pollutants out of our water. Wetlands can also moderate the devastating effects of floods by acting as natural buffers and sponges, soaking up and storing floodwaters. According to the Environmental Protection Agency, nearly two-thirds of all fish we Americans consume spend some portion of their lives in wetlands, which often serve as “nurseries” for juveniles. Continuing to pave over our nation’s breadbasket and valuable habitats with unrelenting sprawl entails serious long-term economic and human health and safety costs that we simply cannot afford.

In addition, sprawl in the United States is more than a domestic environmental or quality-of-life issue; it also has global implications. The relentless and accelerating disappearance of natural habitats dominated by communities of wild plants and animals (ecosystems), replaced by biologically impoverished artificial habitats – often “monocultures” – dominated by human structures and communities, contributes cumulatively to what may become a “state shift” or “tipping point” in Earth’s biosphere. This would be an uncontrolled, sudden switch to a less desirable condition in which the biosphere’s ability to sustain us and other species would be severely compromised. A 2012 paper in the prestigious British scientific journal *Nature* reviews the evidence that: “...such planetary scale critical transitions have occurred previously in the biosphere, albeit rarely, and that humans are now forcing another such transition, with the potential to transform Earth rapidly and irreversibly into a state unknown in human experience.”³⁸

Documented declines or collapses in insect, bird, and vertebrate populations in recent decades as a result of the ever-increasing human appropriation of the biosphere’s habitats, spaces, energy flows, and water are a sign that human civilization may be surpassing certain “planetary boundaries.”³⁹ Nine such boundaries have been identified and quantified, and we have already exceeded four of them: climate change, nitrate pollution, phosphorus pollution, and species extinction. A massive extinction of species is now underway and accelerating – the sixth in the history of life on Earth, and the first caused entirely by a single species: *Homo sapiens*.⁴⁰

³⁸ Barnosky, A.D. et al. 2012. “Approaching a state shift in Earth’s biosphere.” *Nature*, Vol. 486, 7 June.

³⁹ Rockstrom, J., Steffen, W., Noone, K. et al. 2009. Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society*, 14(2): 32; Steffen, W., Richardson, K., Rockström, J. et al. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, 347(6223).

⁴⁰ Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). 2019, Media Release: Nature’s Dangerous Decline ‘Unprecedented’; Species Extinction Rates ‘Accelerating’. Retrieved 1-5-2020 at: <https://ipbes.net/news/Media-Release-Global-Assessment>.

Biodiversity scholars have predicted that the world could lose up to half or two-thirds of its species of wild flora and fauna by 2100, if not sooner.⁴¹ In North America, scientists estimate that the number of birds has dwindled by approximately 30 percent since 1970. About three billion fewer birds now grace our skies, lawns, forests, prairies, deserts, and wetlands than just half a century ago. The number of breeding birds in the United States and Canada was estimated at 10 billion in 1970. Today that number has plunged to approximately 7.1 billion.⁴²

1.5 Water Issues in Arizona

Further squeezing the sustainability of Arizona's flora and fauna is the intense competition for water that comes from the state's growing human population and its demands for water.

In general, there are two types of freshwater sources: groundwater and surface water. In Arizona, most water is supplied by surface water sources: 38 percent from the Colorado River, 18 percent from in-state streams and rivers (such as the Verde and Salt), and three percent from high-quality treated wastewater, that is, reclaimed water or effluent.⁴³ Forty-one percent of Arizona's water is pumped from groundwater sources or aquifers (porous, water-bearing rock formations) beneath the ground surface.

Under Arizona's landmark 1980 Groundwater Management Act, the state has regulated groundwater use in five geographic regions called Active Management Areas (AMAs):⁴⁴ Prescott, Phoenix, Pinal, Tucson, and Santa Cruz. Within the AMAs, rules govern how municipalities, industry, agriculture, and individual citizens can use groundwater. More than 75 percent of the Arizona population lives within one of the AMAs. The Groundwater Management Act mandated conservation and efficiency in all water use sectors, which has led to declining per capita water use in Arizona in recent decades.

However, outside of the AMAs, there are few restrictions on using groundwater, and very little to deter large new users from extracting large volumes of groundwater, lowering the water table, and adversely affecting existing wells. In 2018, *The New York Times* reported that: "attracted by lax regulations, industrial agriculture has descended on a remote valley, depleting

⁴¹ Wilson, E.O. 2003. *The Future of Life*. New York: Vintage Books; Raven, P., Chase, J. & Pires, J. 2011. Introduction to special issue on biodiversity. *American Journal of Botany*, 98, 333-335; Chivian, E. & A. Bernstein, eds. 2008. *Sustaining Life: How Human Health Depends on Biodiversity*. Center for Health and the Global Environment. New York: Oxford University Press.

⁴² Kenneth V. Rosenberg et al. 2019. Decline of the North American Avifauna. *Science*, 04 Oct 2019, Vol. 366, Issue 6461, pp. 120-124. DOI: 10.1126/science.aaw1313; Carl Zimmer. 2019. Birds Are Vanishing From North America. *New York Times*. Available online at: <https://www.nytimes.com/2019/09/19/science/bird-populations-america-canada.html>.

⁴³ Haley Paul. 2018. 10 Things You Should Know About Arizona's Groundwater Management Act. Accessed online March 4, 2020 at: <https://www.audubon.org/news/10-things-you-should-know-about-arizonas-groundwater-management-act>

⁴⁴ Ibid.

its aquifer – leaving many residents with no water at all.”⁴⁵ Some residents of the valley in question – Sulphur Springs Valley – had no recourse but to move, after their well pumps and spigots started delivering more sand than water.

Dr. Jay Famiglietti, director of the Global Institute for Water Security at the University of Saskatchewan in Saskatoon, Canada, and formerly a senior water scientist at NASA’s Jet Propulsion Laboratory in Pasadena, California, who studied aquifers using NASA’s Gravity Recovery and Climate Experiment (GRACE) satellites, told *The New York Times*: “While we are so busy worrying about the water that we can see, the water that we can’t see, the groundwater, is quietly disappearing.” This is a worldwide problem that is actually at its most severe in densely populated Asia and the Middle East.

According to the 2014 National Climate Assessment conducted by experts in 13 agencies of the federal government,⁴⁶ in this century, the American Southwest will be subjected to declines in snowpacks and streamflows, leading to “decreasing surface water supply reliability for cities, agriculture, and ecosystems.” Freshwater aquatic ecosystems are expected to be especially hard-hit (**Figure 20**).



Figure 20. Caked mud alongside a drying watercourse in the American Southwest

⁴⁵ Noah Gallagher Shannon. 2018. The Water Wars of Arizona. *The New York Times*. Retrieved online March 4, 2020 at: <https://www.nytimes.com/2018/07/19/magazine/the-water-wars-of-arizona.html>.

⁴⁶ National Climate Assessment. 2014. Available online at: <https://nca2014.globalchange.gov/report>.

Scientists believe that anthropogenic warming (climate change) is contributing to an emerging “megadrought” in Arizona and the rest of the American Southwest: “Global warming has pushed what would have been a moderate drought in southwestern North America into megadrought territory”.⁴⁷ In a recent study reported in the journal *Science*, the authors used a combination of hydrological modeling and tree-ring reconstruction to demonstrate that the years from 2000 to 2018 were the driest 19-year period since the late 1500s. They believe it may be the start of a “more extreme trend toward megadrought as global warming continues.”

According to researcher Alexandra Tempus, writing in *FairWarning*:

Nowhere is the collision between water scarcity and population growth more evident than in Buckeye, Arizona, a Phoenix suburb that was the fastest-growing large city in the country from 2017 to 2018.

Right now, it is home to about 74,000 people, but it has enough land area to eventually be bigger than Phoenix [population of 5 million in 2020].

Buckeye uses 11,800 acre-feet of water per year, said the city’s hydrologist Ron Whittler. But based on estimates of population growth, the city council anticipates that it will need 200,000 acre-feet annually.⁴⁸

Buckeye relies mostly on groundwater for its municipal water supply. The director of the Buckeye Water Resources Department estimates that the city has enough water to accommodate population growth for the next two decades, but emphasizes the need to promote water conservation. About 70 percent of its water is used for outdoor landscaping and 30 percent indoors, and the Water Department is encouraging xeriscaping, the use of native vegetation in landscaping adapted to little rainfall.

Ensuring adequate water for the city by limiting future growth and development is not under consideration.

A 2020 report in the *Phoenix New Times* lists five key water supply issues facing Arizonans at this time.⁴⁹

⁴⁷ A. Park Williams et al. 2020. Large contribution from anthropogenic warming to an emerging North American megadrought. *Science*. Vol. 368, Issue 6488, pp. 314-318. 17 April. Available online at: <https://science.sciencemag.org/content/368/6488/314>.

⁴⁸ Alexandra Tempus. 2020. Thirsty Future for American West, as “Megadrought” Grips Some of the Fastest-Growing U.S. Cities. *FairWarning*. Accessed online May 10, 2020 at: <https://www.fairwarning.org/2020/05/megadrought-american-west/>.

⁴⁹ Elizabeth Whitman. 2020. What’s on Tap for Arizona Water in 2020? Five Issues to Watch. *Phoenix New Times*. January 14. Accessed online on February 20, 2020 at: <https://www.phoenixnewtimes.com/news/water-drought-arizona-southwest-farmers-groundwater-cap-mead-2020-11423832>

1. **Groundwater Sustainability** – In 2019, the Arizona Department of Water Resources⁵⁰ updated its groundwater model and found that rapidly-growing Pinal County, situated between Phoenix and Tucson, lacked sufficient groundwater to meet the projected demands of the county's planned residential subdivisions totaling over 139,000 homes (and at least twice as many new residents) over the coming decades. The projected shortfall exceeds eight million acre-feet.⁵¹ (An acre-foot is equal to 325,851 gallons of water, equivalent to one acre of water a foot deep, or about half an Olympic-sized swimming pool; the average household in Phoenix uses approximately one-third of an acre-foot annually.) This predicted gap between groundwater supply and expected demand may well inhibit future development in the Pinal AMA, both agricultural and residential.

2. **Cutbacks in Arizona's Colorado River Allocation** – Lake Mead (**Figure 21**), 112 miles long on the Colorado River between Arizona and Nevada, is the largest of 15 reservoirs on the mainstem of the river, and one of hundreds on the Colorado and its tributaries. It is also the largest man-made reservoir in the United States by volume (capacity). Lake Mead supplies water to some 20 million residents of Arizona, Nevada, California, and Mexico, as well as to large areas of farmland.⁵²

When construction of the Hoover Dam, which impounds Lake Mead, was completed in 1935, the reservoir initially had a capacity of 32.4 million acre-feet, but accumulation of sediments on its bottom since its impoundment 85 years ago has reduced its capacity by 11 percent, down to 28.9 million acre-feet. However, because of the decades-long Southwestern drought, as well as increased water demand, as of 2019, Lake Mead contained only about 10.4 million acre-feet, about 36 percent of full capacity. Lake Mead now appears shrunken or shriveled (**Figure 21**).

⁵⁰ Arizona Department of Water Resources. No date. ADWR Developed Groundwater Models. Retrieved at: <https://new.azwater.gov/hydrology/groundwater-modeling/adwr-models>.

⁵¹ Ian James. 2019. In Pinal, groundwater insufficient to meet long-term projected demands, officials say. *The Republic / azcentral.com*. October 12. Accessed online February 20, 2020 at: <https://www.azcentral.com/story/news/local/arizona-environment/2019/10/12/long-term-projections-show-insufficient-groundwater-pinal-county/3948754002/>; Dustin Gardiner. 2019. 'A recipe for disaster': Pinal County might not have enough water for 139,000 planned homes. *The Republic / azcentral.com*. March 5. Accessed online February 20, 2020 at: <https://www.azcentral.com/story/news/local/arizona-environment/2019/02/28/drought-contingency-plan-pinal-county-colorado-river-lake-mead-arizona-water-shortage-groundwater/2915799002/>.

⁵² Gary Wockner. 2015. This Is What Epic Drought Looks Like: Lake Mead Hits Historic Low. *Ecowatch*. Accessed online March 5, 2020 at: <https://www.ecowatch.com/this-is-what-epic-drought-looks-like-lake-mead-hits-historic-low-1882034680.html>.



Figure 21. Lake Mead in July 2019, when the water level was just below 40% of full capacity

The reservoir entered so-called Tier 0 under the Drought Contingency Plan (DCP), a seven-state plan specifying tiers of cutbacks to each state dependent on the capacity of the Colorado River's reservoirs. Thus, the Central Arizona Project (CAP) must leave 192,000 acre-feet in Lake Mead in 2020 that it otherwise would have been allowed to withdraw. CAP operates the canal conveying Colorado River to central Arizona, and its users are the first to lose Colorado River water during periods of shortage.⁵³

The 192,000 acre-feet per year reduction in Lake Mead withdrawals comprises 12 percent of CAP's normal annual supply from the Colorado River.⁵⁴ For the time being, CAP's customers will lose access to the water they were using for underground water storage, banking, and replenishment. Agricultural uses will be reduced by approximately 15 percent in 2020.

CAP emphasizes that these cuts, while not insignificant, are essentially equivalent to the volume of Colorado River water it has been voluntarily leaving in Lake Mead since

⁵³ Op cit. Reference #44.

⁵⁴ Central Arizona Project. 2020. Lake Mead Ends 2019 above 1090' – but 2020 still brings Tier Zero declaration. Web post by Chuck Cullom, Colorado River Programs Manager. Accessed March 7, 2020 at: <https://www.cap-az.com/public/blog/1157-lake-mead-ends-2019-above-1090-but-2020-still-brings-tier-zero-declaration>.

2015 as part of its Lake Mead Conservation Program. However, while those earlier contributions were voluntary, under the DCP, they are now compulsory.⁵⁵

Climate projections indicate that these currently reduced flows in the Colorado River – and reduced water availability for the 20 million humans dependent on these waters – are probably not an aberration but rather the start of a trend that is likely to continue through the remainder of this century and beyond.⁵⁶ Most of the water in the Colorado originates as snowfall in the Rocky Mountains. That snow accumulates during the winter months, a natural water bank that disburses its savings gradually, over months, as snowmelt enters streams and rivers in the late spring and summer months.

However, since 2000, the Colorado Basin has been mired in a long-term drought that appears to be aggravated by climate change. Tree ring data show that the ongoing drought is the most severe one in the last 1,250 years. Snowfall in this century to date has been marginal. Moreover, with warmer temperatures, more of the precipitation falls to the ground as rain, which quickly runs off instead of being stored as snow piling up on mountain slopes and valleys. Water authorities are concerned about the growing shortage of water from this juxtaposition of decreasing supply and soaring demand (over-allocation).⁵⁷

Climatologist Jonathan Overpeck of the University of Michigan has said that declines in annual Colorado River flows could reach 20 to 50 percent or even more by the end of the century.⁵⁸

3. **Investigating New Sources of Water for Arizona** -- Sarah Porter, director of the Kyl Center for Water Policy at Arizona State University, argues that it is not yet necessary to desalinate ocean water or brackish groundwater or to recycle wastewater (“toilet to tap”) to accommodate ongoing and future population growth in the state. “There’s still quite a bit of give in the system. There are less-expensive options,” she told *Phoenix New Times* staff writer Elizabeth Whitman.⁵⁹ Indeed, reverse osmosis desalination is expensive both in dollar and energy terms, costing approximately double the price of

⁵⁵ Ibid.

⁵⁶ Benjamin Cook, Toby Ault, and Jason Smerdon. 2015. Unprecedented 21st century drought risk in the American Southwest and Central Plains. *Science Advances*. American Association for the Advancement of Science (AAAS). Accessed March 9, 2020 at: <https://advances.sciencemag.org/content/1/1/e1400082>.

⁵⁷ Jim Robbins. 2019. As the Colorado River runs dry: A five-part climate change story. *Bulletin of the Atomic Scientists*. February. Accessed online March 9, 2020 at: <https://thebulletin.org/2019/02/as-the-colorado-river-runs-dry-a-five-part-climate-change-story/#>.

⁵⁸ Ibid.

⁵⁹ Op Cit. Footnote #44.

freshwater from conventional surface water or groundwater sources.⁶⁰ Environmentally safe disposal of concentrated brine which is left over from the desalination process is another key issue.⁶¹

In late 2019, the City of Scottsdale received a permit (the first of its kind in Arizona) to serve reclaimed municipal wastewater (sewage), treated to drinking-water standards, at its facility. The Arizona Department of Environmental Quality will issue permits on a case-by-case basis and is working to clarify treatment requirements for water treatment plant managers.⁶² Next door in California, wastewater recycling is well underway, although primarily for non-potable uses such as landscaping, irrigation, and industrial cooling.⁶³ In Orange County, California, the Groundwater Replenishment System (GWRS) is the largest water purification system in the world for indirect potable reuse. The GWRS uses highly treated wastewater that would have been discharged into the Pacific Ocean and purifies it using a three-step advanced treatment process including microfiltration, reverse osmosis, and ultraviolet light with hydrogen peroxide to obtain potable water that meets or exceeds drinking water standards.⁶⁴

Arizona water policymakers have begun to discuss both desalination and municipal wastewater recycling as options for the new future. Because of the lengthy pipeline that would be involved, as well as the desalination process itself, desalinating seawater from the Pacific Ocean, New River, or the Sea of Cortez (Gulf of California) would be much more expensive than in-state options involving conventional surface and groundwater and water conservation/efficiency. Nevertheless, a binational study of desalination in the Sea of Cortez with Mexico is ongoing,⁶⁵ and the Governor's Augmentation,

⁶⁰ Brian Bienkowski. 2015. Desalination is an expensive energy hog, but improvements are on the way. Public Radio International (PRI). May 15. Retrieved online March 17, 2010 at:

<https://www.pri.org/stories/2015-05-15/desalination-expensive-energy-hog-improvements-are-way>.

⁶¹ Hydrofinitly. Why Desalination Is Not the Answer to the World's Water Issues. Accessed online March 17, 2020 at: <https://www.hydrofinitly.com/blog/why-desalination-is-not-the-answer-to-the-worlds-water-issues>; Texas Water Development Board. Seawater FAQs. Accessed online March 17, 2020 at:

<https://www.twdb.texas.gov/innovativewater/desal/faqseawater.asp>.

⁶² Elizabeth Whitman. 2019. So Fresh, So Clean: How Scottsdale Wants to Purify Your Ideas on Recycled Water. July 30. *Phoenix New Times*. <https://www.phoenixnewtimes.com/news/flushing-up-is-recycled-water-the-future-of-water-in-arizona-11333357>.

⁶³ California Association of Sanitation Agencies. 2020. Water Recycling. Accessed online March 17, 2020 at: <https://casaweb.org/renewable-resources/water-recycling/>.

⁶⁴ Orange County Water District. GWRS – new water you can count on. Available online at: <https://www.ocwd.com/gwrs/>.

⁶⁵ Central Arizona Project. 2018. Report on a Binational Study of Desalination Opportunities in the Sea of Cortez Region Consistent with Minute 323. Retrieved online March 18, 2020 at: http://www.cap-az.com/documents/meetings/2018-08-02/1708-11.0_FINAL_Info%20Brief_%20Binational%20Desalination%20Study%20Sea%20of%20Cortez.pdf.

Innovation and Conservation Council is studying options for sustainable water supplies for Arizona that includes desalination.⁶⁶

4. **Competing for Colorado River Water** – Late in 2019, the town of Queen Creek, southwest of Phoenix, attempted to purchase water from an investment company that owned property near the Colorado River. Residents of nearby La Paz, Mohave, and Yuma counties that abut the river are adamantly opposed to any such purchase and transfer, because they would like to use that same water to stimulate their own growth and they fear setting a precedent.⁶⁷
5. **Water Rights** – General stream adjudications determine who has the rights to use water in a river system. Arizona has two general stream adjudications, for the Little Colorado River system and the Gila River system, and there are thousands of claimants and water users vying for this water – almost 15,000 for the Little Colorado and over 80,000 for the Gila River.⁶⁸ The Arizona Department of Water Resources provides crucial technical staff support for these adjudications.

According to the Arizona Department of Water Resources, agriculture consumes about 74 percent of the water in the state, municipalities another 20 percent, and industry just one percent.⁶⁹ In an arid, hot state like Arizona, many crops would not survive without irrigation. Indeed, about one third of farmland in Arizona is irrigated. In 2018, almost a million (945,570) acres of farmland were under irrigation in Arizona, compared to 8.4 million acres in California, 2.5 million in Colorado, and 694,000 in Nevada. In spite of this much smaller irrigated acreage, Arizona per acre water use (4.7 acre-feet) in 2018 was much higher than that of adjacent states – California (2.9 acre-feet per acre), Colorado (1.6 acre-feet), Nevada (2.8 acre-feet), and New Mexico and Utah (2.0 acre-feet).⁷⁰

⁶⁶Arizona Department of Water Resources. 2019. Governor's Augmentation, Innovation and Conservation Council. Accessed online March 18, 2020 at: <https://new.azwater.gov/gwaicc>.

⁶⁷ Bret Jaspers. 2019. Monday Is Deadline to Comment on Cibola Valley-Queen Creek Water Transfer. KJZZ. December 16. Retrieved online March 18, 2020 at: <https://kjzz.org/content/1355131/monday-deadline-comment-cibola-valley-queen-creek-water-transfer>.

⁶⁸ Judicial Branch of Arizona, Maricopa County. Overview of General Stream Adjudications. <http://www.superiorcourt.maricopa.gov/SuperiorCourt/GeneralStreamAdjudication/faq.asp#>.

⁶⁹ Andrew Nicla. 2019. "Does Arizona really use less water now than it did in 1957?" Azcentral.com. Retrieved online May 10, 2020 at: <https://www.azcentral.com/story/news/local/arizona-environment/2019/02/12/arizona-water-usage-state-uses-less-now-than-1957/2806899002/>.

⁷⁰ Jerd Smith. 2020. Colorado's farm water use exceeds national average, despite effort to conserve. Water Education Colorado. Accessed online March 19, 2020 at: <https://www.watereducationcolorado.org/fresh-water-news/report-colorados-farm-water-use-exceeds-national-average-despite-efforts-to-conserve/>; U.S. Department of Agriculture National Agricultural Statistics Service. 2019. *2017 Census of Agriculture*. 2018 Irrigation and Water Management Survey. Volume 3, Special Studies. Part One. Available online at:

Transferring water rights from agriculture to municipalities, higher population density development, and xeriscaping are all among the ideas under consideration by the state's politicians and water policy experts as to how Arizona should meet its increasing future water needs or demands. Supporting endless population growth goes unquestioned by those in authority.

Arizona's citizenry, in contrast, think much more broadly about how to resolve these critical growth-related issues, as revealed in a April 2020 survey conducted by Pulse Opinion Research for this study and NumbersUSA.⁷¹ Several of those questions pertained to water resources policy as it relates to population growth in Arizona.

5. Arizona cities compete for scarce water with the agriculture industry which relies on irrigation for most of its nearly million acres of cropland. Should water used to cultivate crops be diverted to support additional population growth?

19% Yes
55% No
26% Not sure

Arizona Residents Speak Out on Sprawl

“Where are they getting all that water for the sprawl?”

I moved from Michigan to attend graduate college at ASU way back in 1977. Back then one could travel from one side of the Phoenix metro to the other in a short amount of time despite the fact there were only two intersecting interstate highways...

I have subsequently moved over the years first to suburbs then progressively out of the Phoenix metro area. I now live in Flagstaff...in the Coconino National Forest area...since 2010 after a 7 year stint teaching on the Navajo reservation.

I recent drove to the Phoenix metro area....I was astounded as to the numerous freeways that girdle the Phoenix metro valley now....I thought my travel along the 101 west bypass would never end. I passed the football stadium and a lot of neighbor-hoods and shopping centers that I had no idea about this sprawl so far west...

My question is where are they getting all that water for the sprawl? I know about the CAP [Central Arizona Project] and their efforts to store water underground over the years but still so many new communities are sprouting up along all these new freeways. The Phoenix I once knew is no more.

-- Arizona resident John Persichilli

https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/Farm_and_Ranch_Irrigation_Survey/fris.pdf.

⁷¹ Pulse Opinion Research. Op cit. Footnote #6.

6. Arizona is an arid state with limited water in already depleted streams and aquifers. Is it more important for the remaining water to be used to support wildlife habitat, fish and water birds or is it more important to use the remaining water to support the needs of farms and a growing urban population?

- 47% More important for remaining water to be used to support wildlife habitat, fish and water birds
- 39% More important to use remaining water for farms and growing urban population
- 14% Not sure

7. Arizona faces decisions about how to provide sufficient water for urban needs if the state adds another 3 million people by 2050. In order to accommodate this additional population is it better to divert the water from the state's remaining surface water and aquifers, divert the water from agriculture, build a pipeline across Mexico and California to transport desalinated Pacific Ocean water, or is it better to not add another 3 million residents?

- 10% It is better to divert the water from the state's remaining surface water and aquifers
- 7% It is better to divert the water from agriculture
- 31% It is better to build a pipeline across Mexico and California to transport desalinated Pacific Ocean water
- 44% It is better not to add another 3 million residents
- 8% Not sure

For all three questions, at least a plurality of voters indicated a preference for keeping enough water available in streams for use by wildlife. In question #5, a majority of Arizonans opposed diverting water from agriculture in the state to accommodate additional population growth. In question #6, Arizonans were more likely by 47-39% to think that it was more important to keep remaining water resources in aquatic habitats to support the needs of wildlife than to support further population growth in Arizona. And in question #7, more Arizonans responded that they thought the best approach to meeting future water needs in the state is by not adding another 3 million residents by 2050 instead of diverting additional water from remaining surface waters and aquifers or agriculture, or by constructing a pipeline across Mexico or California to convey desalinated Pacific Ocean water.

1.6 Rejuvenating the Human Spirit: Physiological and Psychological Benefits of Open Space

Open space, parks, green spaces, natural areas – including wetlands, riparian corridors, farmland, deserts, rivers, lakes, the ocean, fields and forests – provide demonstrable mental and physical health benefits, as does exposure to animals. Contact with nature, or even just viewing images and videos of nature and non-human creatures, have proven to be preventative measures that can actually lower health care costs and reduce the need for health interventions. Exploring or just gazing upon natural areas – such as a mountain, lake, swamp, or austere desert next to a city – gives human beings a sense of perspective, continuity in a changing

world, spiritual renewal, well-being, and a feeling of harmony with the world around us. The presence of open space within and adjacent to our urban areas (**Figure 22**) – and the assurance that this open space will outlast us – serve to counterbalance the stress and strain of modern life. Direct or indirect interaction with other living creatures that inhabit that open space and share the planet with us also gives humans a sense of well-being. “Watching nature programs makes you happier new research reveals,” proclaims a 2017 BBC headline.⁷² “Animals are able to reduce stress and anxiety in humans,” commented another researcher.⁷³



Figure 22. Hikers on popular Piestewa Peak in the Phoenix-Mesa Urbanized Area

Contact with nature and open space provides both physiological and psychological benefits. Research on the physiological benefits of open space has centered on how direct or indirect (vicarious) experience with vegetated and/or natural landscapes reduces stress, and anxiety.⁷⁴ A series of studies spanning nearly 20 years in the seventies and eighties linked photo simulations of natural settings to reduced stress levels as measured by heart rate and brain waves. One study revealed that subjects experienced more “wakeful relaxation” in response to slides showing vegetation only and vegetation with water

compared to urban scenes without vegetation. These findings were corroborated by attitude measures which indicated lower levels of fear and sadness when experimental subjects observed nature-related slides, as opposed to urban slides.⁷⁵ In studies of hospital patients, recovery was faster, there were fewer negative evaluations in patient reports, and there was

⁷² BBC Media Centre. 2017. Watching nature programs makes you happier new research reveals. Available online at: <https://www.bbc.co.uk/mediacentre/worldwide/2017/rhp>.

⁷³ “Study: Quokkas can be good for your health.” 2020. Available online at: <https://www.firststopsingapore.com/en/study-quokkas-can-be-good-for-your-health/>.

⁷⁴ Rubenstein, N.R. The Psychological Value of Open Space. Chapter 4 in *The Benefits of Open Space*. The Great Swamp Watershed Association. 1997. Available on the World Wide Web at: <http://www.greatswamp.org/publications/rubinstein.htm>.

⁷⁵ Ulrich, R. 1979. Visual landscapes and psychological well-being. *Landscape Research*, 4(1): 17-23.

less use of anesthetic medication among post-surgery patients with views of exterior greenery than among control group patients with views of buildings.⁷⁶

In other research, breast cancer survivors who engaged in personally enjoyable and nature-related "restorative activities" showed dramatic effects on their cognitive process and quality of life.⁷⁷ At the end of three months, the experimental group showed significant improvements in attention and self-reported quality of life measures; they had begun a variety of new projects. Control group members, meanwhile, who had been given no advice regarding nature exposure activities, continued with deficits in measures of attention, had started no new projects, and had lower scores on quality-of-life measures. This research underscored that difference between nature as an amenity and nature as a human need. As one reviewer of the study observed:

"People often say that they like nature; yet they often fail to recognize that they need it...Nature is not merely 'nice.' It is not just a matter of improving one's mood, rather it is a vital ingredient in healthy human functioning."⁷⁸

As one book affirms about the important distinction between nature as amenity and nature as need:

"Viewed as an amenity, nature may be readily replaced by some greater technological achievement. Viewed as an essential bond between humans and other living things, the natural environment has no substitutes."⁷⁹

While there are many anecdotal reports linking the natural environment or open space to everything from increased self-esteem to stress reduction, there are few studies that track long-term longitudinal effects on changed attitudes and behavior. It is difficult to characterize and quantify the long-term, intangible manner in which lives are modified; however, it is easy to acquire narrative accounts about the effect of a favorite overlook, trail, or patch of woods on one's psyche. One of the best known of such testimonials is from pioneering naturalist-conservationist John Muir:

⁷⁶ Ulrich, R. 1983. Aesthetic and affective response to natural environment. Chapter 3 in I. Altman, & J. F. Wohlwill (Eds.), *Human Behavior and Environment: Volume 6* (pp. 85-126). New York: Plenum Press; Ulrich, R. 1984. Views through a window may influence recovery from surgery. *Science*, 224, 420-421.

⁷⁷ Cimprich, B. E. 1990. Attentional fatigue and restoration in individuals with cancer. Unpublished Doctoral Dissertation, University of Michigan.

⁷⁸ Kaplan, S. (1992). The Restorative Environment: Nature and human experience. In D. Relf (ed.), *The Role of horticulture in human well-being and social development: A National Symposium* [Proceedings of Conference Held 19-21 April 1990, Arlington, VA] (pp. 134-142). Portland, OR: Timber Press.

⁷⁹ Kaplan, R., & Kaplan, S. (1989). *The Experience of nature: A Psychological perspective*. New York: Cambridge University Press.

“Climb the mountains and get their good tidings. Nature's peace will flow into you as sunshine flows into trees. The winds will blow their own freshness into you, and the storms their energy, while cares will drop away from you like the leaves of Autumn.”⁸⁰

Natural settings are unparalleled in their ability to furnish solitude, privacy, and tranquility. They also have “existence value,” that is, there is value to knowing that they are simply *there* and to the very idea that we *could* get away into them, if we so chose; this is a value in and of itself, which provides for a psychological “time-out” and a sense of wellbeing.

The 2020 national survey⁸¹ mentioned above of Americans found most of them at least superficially recognizing the value of non-developed open spaces for their emotional wellbeing.

7. Do you feel an emotional or spiritual uplift from time spent in natural areas like woodlands, wetlands, and grasslands?

73% - Yes
16% - No
11% - Not sure

A majority of Americans also indicated to pollsters that they want to have easy access to natural areas near where they live.

8. How important is it that you can get to natural areas fairly quickly from where you live?

45% - Very important
40% - Somewhat important
10% - Not very important
2% - Not important at all
3% - Not sure

Arizonans feel “the call of the wild” even more strongly than other Americans. In our April 2020 survey of 1,000 likely Arizona voters, fully 90% responded that it was “very or somewhat important” to spend time in natural areas close to where they live:

9. How important is it that you can easily spend time in natural areas near where you live?

57% Very important
33% Somewhat important
6% Not very important
1% Not at all important
2% Not sure

⁸⁰ John Muir. *The Mountains of California*. First published in 1894.

⁸¹ Pulse Opinion Research, 2020; Appendix G to this study.

As would be expected from these poll results, Arizonans are lovers and users of the outdoors and are justifiably proud of their state's spectacular landscapes. On an evening in Phoenix in 2003, one of the authors (Kolankiewicz), in town for an environmental conference, decided to take the short but scenic hike up 2,610 ft. Squaw Peak, since renamed Piستewa Peak (**Figure 23**), in tribute to the fallen U.S. Army soldier Lori Piستewa.⁸² He was stunned at the full parking lot and literally hundreds of hikers encountered on the trail to the summit, in spite of the lingering heat and occasional rattlesnake.

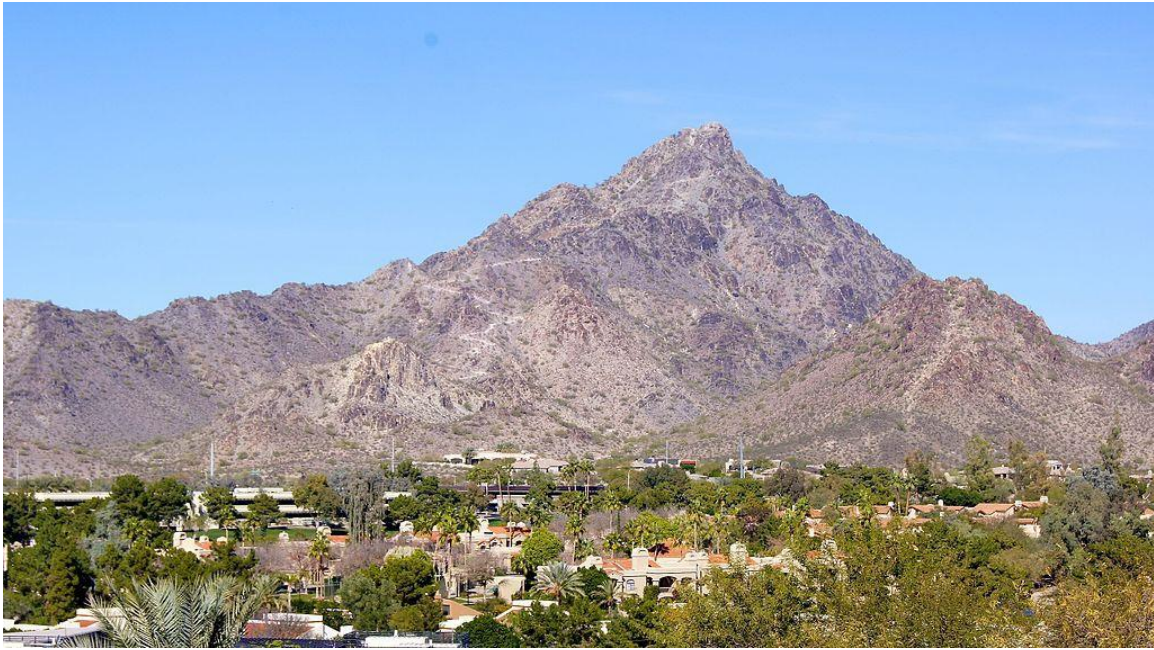


Figure 23. Piستewa Peak, with trail visible, rising above Phoenix

⁸² Lori Ann Piستewa, born in 1979 in Tuba City, Arizona, was half Hopi Indian and half Mexican American. In March 2003, she became the first Native American female in history to die in combat while serving in the U.S. armed forces. She was killed at the age of 23 when her Humvee was struck by an enemy rocket-propelled grenade in an ambush during the U.S. invasion of Iraq.

First published in 1921 by the Arizona Highway Department (now the Arizona Department of Transportation), the glossy magazine *Arizona Highways* (**Figure 24**) features travelogues and artistic photographs depicting the glorious scenery, landscapes, habitats, historic sites, and settlements of the Grand Canyon State.



Figure 24. *Arizona Highways* magazine

Arizona Highways developed a reputation for documenting the indigenous American Indian peoples of Arizona and the Southwest more generally, in particular the Navajo, Hopi, and Apache who are native to the state. In the late 1930s, future U.S. Senator and presidential candidate Barry Goldwater first came to public attention when *Arizona Highways* published his photographs of American Indian life and Arizona scenery.⁸³

1.7 Americans and Arizonans Love Their Open Space

While not garnering the media attention it once did, the topic of urban sprawl remains a major concern to many American citizens. According to the Land Trust Alliance, voters still care deeply about conserving our remaining natural land, approving over 80% of land conservation measures on the ballot around the country in November 2012.⁸⁴ The 46 measures passed nationally in 2012 provided a total of \$767 million to protect and improve water quality,

⁸³ Arizona Highways. *Wikipedia*. Accessed online 1-10-2020 at:

https://en.wikipedia.org/wiki/Arizona_Highways.

⁸⁴ Land Trust Alliance. 2012. Voters Approve 81% of Land Conservation Ballot Measures. Available at: <http://www.landtrustalliance.org/policy/public-funding/voters-enthusiastically-approve-new-spending-on-conservation-nationwide>.

acquire new parks and open space, and conserve working farms and ranches. Many of the referenda won by landslides – 27 measures passed with at least 65% of the vote.

National and regional non-governmental land conservancies such as The Nature Conservancy, the Trust for Public Land, Tampa Bay Conservancy, Inc., and the North Florida Land Trust continue to garner substantial public support. In the November 2016 election alone, 25 land conservation ballot measures were voted on in 10 different states.⁸⁵

In 2018, the Trust for Public Land helped communities draft and campaign for 18 ballot measures on Election Day 2018. Voters approved all but one of the 18. In total, of some 61 ballot measures voted on nationwide in 2018, 52 passed, including two in Arizona. By a margin of 56 to 44 percent, Tucson voters approved \$24 million in bonds for parks and recreation (parks, trails, recreation, greenways), while voters in Mesa approved \$5.9 million for parks and recreation by the same margin.⁸⁶ Nationwide, on Election Day in 2019, voters approved 33 of 41 ballot measures, raising over \$900 million in funding for conservation. Overall, between 1988 and 2019, American voters passed 2,096 of 2,758 open space ballot measures (76 percent) they voted on.⁸⁷



**Figure 25. Stunning Sunset Over Monument Valley
on the Navajo Nation (Northeastern Arizona)**

⁸⁵ Trust for Public Land. 2016 conservation ballot measures. Accessed March 2017 at: <https://www.tpl.org/2016-conservation-ballot-measures#sm.0001r394ttayecqpw771offt5wflx>.

⁸⁶ Trust for Public Land. TPL LandVote Database. Retrieved online 1-13-2020 at: <https://tpl.quickbase.com/db/bbqna2qct?a=dbpage&pageID=8>.

⁸⁷ Ibid.

While these were not anti-sprawl measures per se, they do indicate that the American public cares deeply about preserving open space, and is willing to “put its money where its mouth is.”

In short, Americans still value our rural lands and natural habitats; oppose heavy traffic, gridlock, and longer commute times to work and to daily, weekly, and monthly open-space destinations; and dislike increased environmental degradation, greater economic costs, and higher taxes; all of which are part of the price tag of sprawling urban development.

As noted earlier, separate polling⁸⁸ in 2020 found that sizeable majorities of Arizonans and of Americans nationwide feel strongly about the need to protect farmland and natural habitats for themselves, for their fellow Americans, for posterity, and for the nation's wildlife. Large majorities also indicate it is important to have ready access to natural areas and open space and that they feel spiritually and emotionally rejuvenated by the time they spend in natural areas. In sum -, Arizonans love their wild and natural areas.



Figure 26. View of Deva, Brahma, and Zoroaster Temples as seen from Grand Canyon Lodge on North Rim of the Grand Canyon

National Park Service photo

⁸⁸ Op. cit. Footnote #7, Pulse Opinion Research. Also see Appendix H.

2. THE FACTORS IN SPRAWL AND HABITAT LOSS

Over the past few decades, dozens of diverse factors have been suggested as causes of America's relentless, unending sprawl, defined here as the expansion of urban land at the expense of rural land.

1. One factor is population growth.
2. All the other factors combine to increase per capita land consumption.

This study examines the relative importance of those two overall factors.

2.1 Sprawl Defined

The word "sprawl" is not a precise term. But we do indeed use the term "Overall Sprawl" in a precise way in this study – it is the amount of rural land lost to development.

Fortunately, it is easy to measure the amount of Overall Sprawl because of two distinct, painstaking processes conducted by two unrelated federal agencies: the U.S. Census Bureau (Census) and the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA). Using data from decennial censuses, Census has tabulated changes in the size and shape of the nation's Urbanized Areas (UAs) every 10 years for more than a half a century (since 1950), while the NRCS has estimated changes in the size and shape of America's Developed Lands (including outside Urbanized Areas) every five years or so for more than thirty years (since 1982).

Defining sprawl by the Census standards has some limitations that are discussed in Appendix D. But the UA delineations, coupled with the NRI surveys, are unequalled as uniform, quantitative, longitudinal measures of expanding urbanization – converting rural lands to urban lands – by cities and towns in all regions of the country.

2.2 Our Two Main Data Sources

This study relies on data from two federal agencies, the Census Bureau and the Department of Agriculture's NRCS.

The Census Bureau uses a rather complicated set of conditions to measure the spread of cities into surrounding rural land. Census defines the contiguous developed land of a central city and its suburbs as an "Urbanized Area."

During the period covered by this study, Arizona had nine Urbanized Areas: Avondale-Goodyear, Casa Grande, Flagstaff, Lake Havasu City, Phoenix-Mesa, Prescott Valley-Prescott, Sierra Vista, Tucson and Yuma.

The National Resources Inventories (NRI) data furnish a portrait that includes not only the cities but development in places outside of the boundaries of the Census Bureau's UAs. The NRCS gathers its NRI data by way of remote sensing (aircraft and satellite), on-the-ground surveys, and statistical techniques to derive estimates of changes in land use on the nation's non-federal lands. Built-up or developed lands are one of the categories of land use NRCS delineates.

Available NRI Developed Land estimates span an uninterrupted 35-year period from 1982-2012 in seven mostly 5-year intervals (1982-1987, 1987-1992, 1992-1997, 1997-2002, 2002-2007, 2007-2012, 2012-2017). These estimates quantify how much rural land was converted into developed or built-up land over these discrete time intervals, as well as over the 35-year time period in its entirety. Therefore, we are able to see how sprawl in Arizona has consistently impacted areas throughout Arizona over the last 35 years.

2.2.1 Census Bureau's Urbanized Areas

The U.S. Census Bureau classifies all geographic areas of the United States as either urban or rural. Urban places are those characterized by densely populated and developed land above a minimum population threshold; they include residential, commercial, industrial and other non-residential urban land uses.⁸⁹

The Census Bureau has been making these classifications for a long time: it first defined urban places in reports following the 1880 and 1890 censuses. It adopted the current minimum population threshold for urban areas of 2,500 a century ago back in the 1910 Census; any incorporated place that contained at least 2,500 people within its boundaries was designated as urban. All territories outside of these urban places, regardless of their population densities, were considered rural.⁹⁰

Beginning with the 1950 Census, urban areas with 50,000 or more residents were called Urbanized Areas.

And since the 2000 Census, urban areas with fewer than 50,000 residents but more than 2,500 have been designated as Urban Clusters. **Figure 27** is a map showing Arizona's Urbanized Areas and Urban Clusters.

⁸⁹ U.S. Census Bureau. 2013. 2010 Census Urban and Rural Classification and Urban Area Criteria. Accessed at: <http://www.census.gov/geo/reference/ua/urban-rural-2010.html>

⁹⁰ U.S. Census Bureau. 2010 Census Urban Area FAQs. Accessed at: <http://www.census.gov/geo/reference/ua/uafaq.html>.



Figure 27. Arizona’s Urbanized Areas in 2010

Source: <https://portal.azoah.com/oedf/documents/2017-EMS-0104-DHS/CA-151-2010%20Census%20Urban%20Areas%20by%20the%20Numbers.pdf>

The Census Bureau lists a number of revealing facts and figures about Arizona's urban areas in 2010:

- **69:** Total number of 2010 Census urban areas in Arizona, in two groups:
 - **9:** Number of Urbanized Areas (UAs) – containing 50,000 or more residents
 - **60:** Number of Urban Clusters (UCs) – with between 2,500 and 50,000 residents
- **89.8:** Percent of Arizona population living in an urban area
 - **80.1:** Percent living in within an Urbanized Area
 - **9.7:** Percent living within an Urban Cluster

A comparison with similar Census numbers for the entire nation shows that Arizona's population is more urban (89.8% vs. 80.7%) and also more likely to live in the big Urbanized Areas (80.1% vs. 71.2%) than the U.S. population as a whole.

- **3,573:** Total number of 2010 Census urban areas in the United States, in two groups:
 - **486:** Number of Urbanized Areas (UAs)
 - **3,087:** Number of Urban Clusters (UCs)
- **71.2:** Percent of U.S. population living within Urbanized Areas
- **80.7:** Percent of the U.S. population that is urban
- **16:** Number of UAs with populations of 2,500,000 or more
- **41:** Number of UAs with populations of 1,000,000 or more
- **179:** Number of UAs with populations of 200,000 or more
- **36:** Number of new UAs between 2000 and 2010
- **2,534** persons per square mile: Overall Urbanized Area population density in the U.S.

Between 2000 and 2010, the country's Urbanized Area population grew by 12.1%, in comparison with total U.S. population growth of 9.7% during the same period. (And this does not include additional population growth in more than 3,000 Urban Clusters.) In other words, America's urban areas grew at a faster pace than the country as a whole, continuing a demographic trend – a relative shift or migration of the population from rural to urban areas – that has been underway for more than a century. This trend is in evidence around the entire world.

2.2.2 Natural Resources Conservation Service's National Resources Inventory And Developed Lands

The National Resources Inventory (NRI) is based on rigorous scientific and survey protocols. It is the primary data source for this study of the loss of agricultural land and natural habitat in Arizona.

The U.S. Department of Agriculture's NRCS began developing the NRI in 1977 in response to several Congressional mandates. The first NRI published in 1982 used most of the survey methodology and protocols utilized by earlier inventories. However, the scope and sample size of the 1982 NRI were expanded to meet the demands of the Soil and Water Resources Conservation Act (RCA) of 1977, as well as to better address emerging issues like the

permanent loss of agricultural lands to nonagricultural uses, such as transportation, industry, commercial and residential land uses.⁹¹

The NRI covers the entire surface area (both land and water) of the United States, including all 50 states, Puerto Rico, the U.S. Virgin Islands, and certain Pacific Basin islands. The sample includes all land ownership categories, including federal lands (e.g., national parks, national wildlife refuges, national forests, Bureau of Land Management lands, military installations), although NRI data collection activities have historically focused on non-federal lands. Sampling is conducted on a county-by-county basis, using a stratified, two-stage, area sampling scheme. The two-stage sampling units are nominally square segments of land and points within these segments. The segments are typically half-mile-square parcels of land equal to 160-acre quarter-sections (a section is a square of territory one mile on each side, and comprising one square mile or 640 acres in area) in the Public Land Survey System, but there are a number of exceptions in the western and northeastern U.S. Three specific sample points are selected for most segments, although two are selected for 40-acre segments in irrigated portions of some western States, and some segments originally contained only one sample point.⁹²

The 1997 NRI sample contained about 300,000 sample segments and 800,000 sample points. Whereas the NRI was conducted every five years up to 1997, an annual or continuous approach was begun in 2000. Each year a subset of between 71,000 and 72,000 segments from the 1997 sample is selected for observation. The subset is selected using a “supplemented panel rotation” design, meaning that a “core panel” of about 40,000 segments is observed each year along with a different supplemental or rotation panel chosen for each year.

The NRI survey system uses points as the sampling units rather than farms or fields, because land use and land unit boundaries often change in some parts of the country. Utilizing points has allowed the survey process to generate a database with dozens of factors or data elements that are properly correlated over many years. Thus, analyses and inferences based on these data are using proper combinations of longitudinal data.⁹³

Data for the initial 1982 NRI were collected by thousands of field staff of the Soil Conservation Service (SCS – precursor agency to NRCS), whose efforts were supplemented by contractors and employees of other agencies working under SCS supervision. Data collection began in the spring of 1980 and ran for more than two years, finishing in the autumn of 1982. For the 1987 NRI, data were also collected by teams of trained personnel. Remote sensing techniques (via aircraft or satellite) were used to update 1982 conditions for about 30 percent of the sample

⁹¹ U.S. Department of Agriculture. 2009. *Summary Report: 2007 National Resources Inventory*, Natural Resources Conservation Service, Washington, DC, and Center for Survey Statistics and Methodology, Iowa State University, Ames, Iowa. 123 pages.

http://www.nrcs.usda.gov/technical/NRI/2007/2007_NRI_Summary.pdf.

⁹² Ibid.

⁹³ Ibid.

sites. Reliance upon remote sensing increased during the 1990s. Beginning in 2000, special high-resolution imagery was obtained for each NRI sample site.⁹⁴

In 2004, NRCS established Remote Sensing Laboratories (RSLs) in Greensboro, NC; Fort Worth, TX; and Portland, OR. These three labs were designed, equipped, and staffed to take advantage of modern geospatial technologies, enabling efficient collection and processing of NRI survey data. The RSLs are now staffed with permanent employees whose full-time job is NRI data collection and processing.⁹⁵

A number of quality control and quality assurance (QC/QA) processes are conducted by NRCS and contract staff as well as by the Statistical Unit and NRCS resource inventory specialists. Many of these QC/QA processes are embedded within the survey software developed by NRCS and the Statistical Unit. The QC/QA processes ensure that differences in the data over time reflect actual changes in resource conditions, rather than differences in the perspectives of two different data collectors, or changes in technologies and protocols.

One of the special features of the NRI is its genuine longitudinal nature, that is, its reliability and consistency - over time, so that users of this dataset can be confident that, for example, differences in the area of developed land shown for 2007 and 1997 accurately reflect true differences “on the ground” or in reality. Even though many operational features of the NRI survey program have evolved over the years, processes have been implemented to ensure that data contained within the 2007 NRI database are longitudinally consistent. Data collection protocols always include review and editing of historical data for the particular NRI sampling units being observed.⁹⁶

NRI’s broadest classification divides all U.S. territory into three categories: federal land, water areas, and non-federal land. Non-federal land is - divided into developed and rural. Rural lands are further subdivided into cropland, Conservation Reserve Program (CRP) land, pastureland, rangeland, forestland, and other rural land. In the present study we are concerned only with the data for developed land.

NRI’s category of developed land differs from that used by other federal data collection entities. While other studies and inventories emphasize characteristics of human populations (e.g., Census of Population) and housing units (e.g., American Housing Survey), for the NRI, the intent is to identify which lands have been permanently eliminated from the rural land base. The NRI Developed Land category includes: (a) large tracts of urban and built-up land; (b) small tracts of built-up land less than 10 acres in size; and (c) land outside of these built-up

⁹⁴ Ibid.

⁹⁵ Ibid.

⁹⁶ Ibid.

areas that is in a rural transportation corridor (roads, interstates, railroads, and associated rights-of-way).

2.3 Population Growth

A city or state’s population grows based on personal behavior – births and in-migration – and on local and national governmental actions and policies. Looking more closely, the net increase (or decrease) in population in any given time period (e.g., one year, one decade) is due to the number of births minus the number of deaths plus the number of in-migrants minus the number of out-migrants.

Figure 28 shows population growth in Arizona from 1915 to 2018. In 1915, there were just over one-quarter million residents in Arizona (263,000); a little over a century later (2018), this number had exploded by about 28 times to almost 7.2 million. The fact that this function is curving upward is suggestive of exponential growth for much of the period of record.

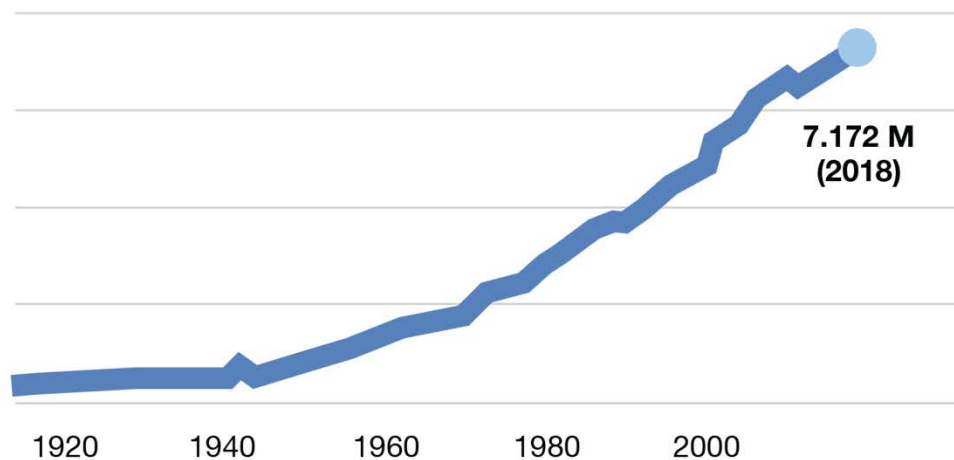


Figure 28. Population Growth in Arizona, 1915-2018

Nowadays, rapid growth in an urban area’s population is much more likely to be the result of enticing residents to relocate from elsewhere. Local and state governments can and do create many explicit incentives or subsidies that encourage people to move into a particular urban area. These include aggressive campaigns to persuade industries and corporations to move their factories, offices, headquarters, and jobs from another location, public subsidies for the infrastructure that supports businesses, tax breaks, expansion of water service and sewage lines into new areas, new housing developments and new residents, and general public relations that increase the attractiveness and “business friendliness” of a city to outsiders and the business community. Even without trying, a city can attract new residents just by maintaining amenities, good schools, low crime rates, pleasant parks, and a high quality of life, especially if the nation’s population is growing significantly, as continues to be the case today.

2.3.1 Population Growth in Arizona Counties

Arizona has 15 counties (shown on the map in **Figure 29**). When naming them and to assist the reader, this report will often include in parentheses the name of the Urbanized Area that is in the county. For example: Coconino Co. (Flagstaff UA).



Figure 29. Arizona's Counties

Eight of the 15 counties have an Urbanized Area. During the period of this study, Maricopa County had two: the Phoenix--Mesa UA and the Avondale--Goodyear UA.

Table 4 shows the population change in all 15 Arizona counties from 1982 to 2017. On average during those 35 years, these 15 counties grew by 144 percent; that was an annual compound (exponential) rate of 2.6 percent. Fourteen of 15 counties grew in population and only one declined slightly.

Table 4. Population Growth in Arizona Counties – 1982 to 2017

County	Population in 1982	Population in 2017	% growth
Apache	52,152	71,545	37%
Cochise (Sierra Vista UA)	88,373	124,864	41%
Coconino (Flagstaff UA)	79,156	141,001	78%
Gila	38,924	53,578	38%
Graham	23,830	37,481	57%
Greenlee	11,747	9,443	-20%
La Paz	12,692	20,706	63%
Maricopa (Phoenix--Mesa UA & Avondale-- Goodyear UA)	1,611,847	4,327,184	168%
Mohave (Lake Havasu City UA)	62,539	207,017	231%
Navajo	66,910	109,079	63%
Pima (Tucson UA)	568,004	1,026,391	81%
Pinal (Casa Grande UA)	96,802	431,564	346%
Santa Cruz	21,689	46,566	115%
Yavapai (Prescott Valley--Prescott UA)	74,009	228,082	208%
Yuma (Yuma UA)	81,186	209,507	158%
All Arizona Counties	2,889,860	7,044,008	144%

These charts cover a period that starts in 1982 when the first federal NRI results were published, and ends in 2017, the year of the last available data at the time of this report.

Unsurprisingly, Maricopa County (including Phoenix-Mesa) added the most people, over 2.7 million. Pinal Co. (Casa Grande) and Mohave Co. (Lake Havasu City) grew by the highest percentages, 346% and 231% respectively. Overall, the state's population grew from 2.9 million to more than 7 million, more than doubling in size, adding more than four million additional residents.

Table 5 shows the more recent sub-period from 2002 to 2017. The aggregate population of Arizona's 15 counties increased by 31 percent during these 15 years, at an annual compound (exponential) rate of 1.6 percent.

All 15 counties increased in population. While the rate of annual percentage increase (1.8%) in this most recent period was lower than the average annual percentage increase over the entire 35-year period of record (2.6%) for NRI developed land data, the difference in the annual increment (average number of people added yearly to Arizona's population) between the longer period, and the shorter, more recent period did not differ by all that much: 118,690 added per year between 1982 and 2017, versus 109,850 added per year between 2002 and 2017.

Table 5. RECENT Population Growth in Arizona Counties – 2002 to 2017

County	Population in 2002	Population in 2017	% growth
Apache	67,319	71,545	6%
Cochise (Sierra Vista UA)	119,847	124,864	74%
Coconino (Flagstaff UA)	121,308	141,001	16%
Gila	51,478	53,578	4%
Graham	33,224	37,481	13%
Greenlee	7,831	9,443	21%
La Paz	19,464	20,706	6%
Maricopa (Phoenix--Mesa UA & Avondale-- Goodyear UA)	3,255,388	4,327,184	33%
Mohave (Lake Havasu City UA)	166,155	207,017	25%
Navajo	100,123	109,079	9%
Pima (Tucson UA)	874,267	1,026,391	17%
Pinal (Casa Grande UA)	197,082	431,564	119%
Santa Cruz	40,009	46,566	16%
Yavapai (Prescott Valley--Prescott UA)	177,362	228,082	29%
Yuma (Yuma UA)	165,398	209,507	27%
All Arizona Counties	5,396,255	7,044,008	31%

2.3.2 Sources of Arizona's Population Growth

In one form of analysis, all of Arizona's population growth can be measured in two sources:

- Natural Increase: births in the state minus deaths in the state.
- Net migration: number of people who moved into the state minus those who moved out of the state

Figure 30 shows that births outnumbering deaths were responsible for only 34% of Arizona's recent population growth from 2000 to 2015. This includes births to and deaths of both those born in the United States and those born in other countries.

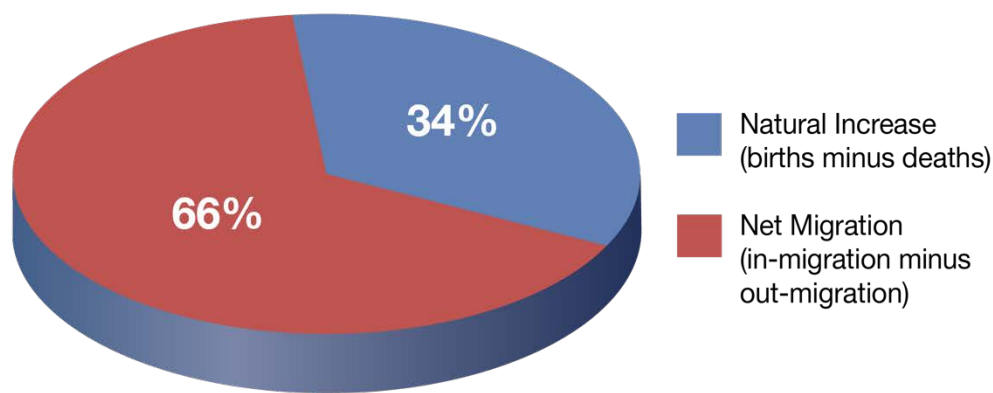


Figure 30. Sources of RECENT Population Growth in Arizona, 2000 to 2015⁹⁷

The majority (66%) of Arizona's population expansion was due to people moving into the state while significantly fewer moved out during that period. The in-migration counts people who moved to Arizona directly from abroad and people (both U.S.-born and foreign-born) who moved into Arizona from other states.

Because neighboring California has experienced so many negative quality-of-life developments stemming from its own massive population growth in recent decades, it has shed residents all across the West for decades and is the leading state contributor to Arizona's net in-migration.

All of the top eight sending states were in the West and Southwest, according to the Census Bureau in 2015 (**Table 6**).

⁹⁷ The University of Arizona, Eller College of Management, "Arizona Population and Vital Statistics," <https://www.azeconomy.org/arizona-population/>, accessed May 23, 2020; Tom Rex, "Migration to and From Arizona: A Report from the Office of the University Economist, Arizona State University, W.P. Carey School of Business, May 2016.

Table 6. Top Ten Sources of Domestic (Non-Foreign) Migrants to Arizona in 2015

Rank	State
1	California
2	Texas
3	Washington
4	Oregon
5	Colorado
6	New Mexico
7	Nevada
8	Utah
9	Florida
10	New York

Source: U.S. Census Bureau

Another way to measure a state's population growth is to divide all growth between these two sources:

- growth related to international migration
- all other growth that is not related to international migration

Figure 31 shows that 44% of Arizona's recent population growth is due directly and indirectly to immigration from foreign countries. This is based on the increase in the number of foreign-born residents and their U.S.-born children in Arizona, whether they came directly from another country or through another state. Because births to foreign immigrants would not have happened in Arizona if not for the foreign migration, those births are counted in growth related to international migration.

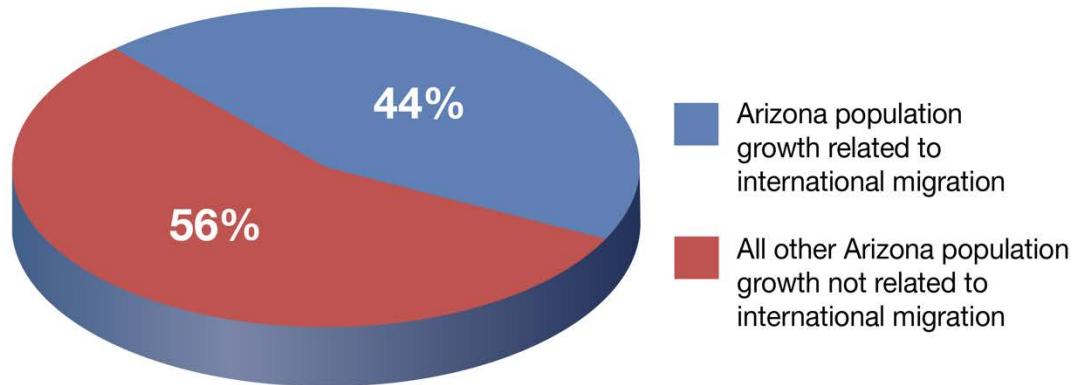


Figure 31. Percentage of RECENT Arizona Population Growth Due Directly and Indirectly to Foreign Immigration, 2000 to 2015

The data for **Figure 31** come from the U.S. Census Bureau, American Community Survey, and analysis by Steven A. Camarota, Director of Research, Center for Immigration Studies.⁹⁸

2.4 Per Capita Land Consumption

Per capita land consumption statistics are a useful way to understand the combined power of numerous land use and consumption choices that can lead to urban sprawl. See Appendices B and C for how this statistic is calculated.

When Census Bureau data show that per capita land consumption was 0.16 acre in 2017 in Maricopa County, it means that it takes approximately one-sixth of an acre to provide the average resident with space for housing, work, retail (**Figure 32**), transportation, education, religious assembly, government, recreation, utilities, and all other urban needs.

⁹⁸ Camarota, S. 2020. Analysis of U.S. Census Bureau, Current Population Survey. Center for Immigration Studies. Note that U.S.-born children of immigrants are automatically granted U.S. citizenship regardless of the status of their parents. In order to more accurately measure the effect that immigration has on U.S. population growth, it is necessary to include children born in the U.S. to immigrants. For examples, see U.S. Census Bureau, “A Changing Nation: Population Projections under Alternative Migration Scenarios,” Report Number P25-1146, February 2020, <https://www.census.gov/library/publications/-2020/demo/p25-1146.html>; Pew Research Center, “Modern Immigration Wave Brings 59 Million to U.S., Driving Population Growth and Change Through 2065,” September 25, 2015, <https://www.pewresearch.org/hispanic/2015/09/28/modern-immigration-wave-brings-59-million-to-u-s-driving-population-growth-and-change-through-2065/>; Center for Immigration Studies, “Projecting the Impact of Immigration on the U.S. Population,” February 4, 2019, <https://cis.org/Report/Projecting-Impact-Immigration-US-Population>.

Looked at another way, the per capita land consumption of a county is determined by dividing all the developed acreage by the total number of residents. The lower the per capita consumption number, the more efficiently the population is using the land for urban purposes.



Figure 32. Tri City Mall in Mesa (Phoenix--Mesa UA)

By Osiris7 - Own work, CC BY-SA 3.0,

<https://commons.wikimedia.org/w/index.php?curid=16354930>

2.4.1 Per Capita Developed Land Consumption in Arizona Counties

Table 7 shows the change in per capita developed land use in Arizona’s 15 counties from 1982 to 2017. About half the counties showed an increase, which means residents and their officials were using land less efficiently in 2017 than in 1982. And about half the counties showed a decrease in per capita land consumption, which means residents were living, working, and shopping at higher density. In the state as a whole, overall land consumption per capita (developed acres/person) decreased by 12 percent during this 35-year period.

Table 7. Per Capita Developed Land Consumption in Arizona Counties – 1982 and 2017

County	Per Capita Land Consumption – 1982 (acre)	Per Capita Land Consumption -2017 (acre)	% Change in Per Capita Land Consumption, 1982-2017
Apache	1.30	1.54	18%
Cochise (Sierra Vista UA)	0.79	1.01	28%
Coconino	0.61	0.59	-3%

(Flagstaff UA)			
Gila	0.42	0.52	23%
Graham	0.73	0.98	35%
Greenlee	0.23	0.46	98%
La Paz	0.86	1.40	63%
Maricopa (Phoenix--Mesa UA & Avondale-- Goodyear UA)	0.16	0.16	-4%
Mohave (Lake Havasu City UA)	0.80	0.76	-5%
Navajo	1.48	1.25	-16%
Pima (Tucson UA)	0.35	0.31	-14%
Pinal (Casa Grande UA)	0.55	0.42	-24%
Santa Cruz	1.11	0.91	-18%
Yavapai (Prescott Valley--Prescott UA)	0.52	0.40	-23%
Yuma (Yuma UA)	0.24	0.39	65%
All Arizona Counties	0.34	0.30	-12%

At a minimum, the per capita land consumption figure reflects the combined outcome of all the following individual and institutional choices and factors:

- Development
 - Consumer preferences for size and type of housing and yards
 - Developer preferences for constructing housing, offices and retail facilities
 - Governmental subsidies that encourage land consumption, and fees and taxes that discourage consumption
 - Quality of urban planning and zoning
 - Level of affluence
 - Size of the entire built-up urbanized land area comprised of non-residential land uses, such as industrial, institutional, government, commercial, etc.
 -

- Transportation
 - Governmental subsidies and programs for highways, streets and mass transit
 - Consumer preferences favoring the mobility and flexibility offered by using private vehicles rather than public transit
 - Price of gasoline (cheap gas encourages sprawl)
- Quality of existing communities and ability to retain residents
 - Quality of schools
 - Reality and perceptions concerning crime and personal safety
 - Ethnic and cultural tensions or harmony
 - Quality of government leadership
 - Job opportunities
 - Levels of pollution
 - Quality of parks, other public facilities and infrastructure
- Number of people per household
 - Marriage rate and average age for marriage
 - Divorce rate
 - Recent fertility rate
 - Level of independence of young adults
 - Level of affluence enabling single people to live separately



Figure 33.
Picacho Peak
rises to 3,374 ft.
elevation near
Casa Grande in
Pinal County

In **Table 8**, we review changes in the latter part of the 1982-2017 period. Between 2002 and 2017, per capita land consumption for the entire state declined slightly from 0.32 acre to 0.30 acre – an 8% reduction.

In comparison with the longer period when eight of the 15 counties had declines in per capita land consumption, six counties had declines in the recent 15-year period.

Table 8. Per Capita Developed Land Consumption in Arizona Counties – 2002 and 2017

County	Per Capita Land Consumption – 2002 (acre)	Per Capita Land Consumption -2017 (acre)	% Change in Per Capita Land Consumption, 2002-2017
Apache	1.38	1.54	12%
Cochise (Sierra Vista UA)	0.92	1.01	9%
Coconino (Flagstaff UA)	0.58	0.59	2%
Gila	0.47	0.52	11%
Graham	0.88	0.98	12%
Greenlee	0.52	0.46	-13%
La Paz	1.40	1.40	0%
Maricopa (Phoenix--Mesa UA & Avondale--Goodyear UA)	0.17	0.16	-7%
Mohave (Lake Havasu City UA)	0.70	0.76	8%
Navajo	1.22	1.25	2%
Pima (Tucson UA)	0.34	0.31	-10%
Pinal (Cas Grande UA)	0.68	0.42	-39%
Santa Cruz	0.98	0.91	-7%
Yavapai (Prescott Valley--Prescott UA)	0.41	0.40	-2%
Yuma (Yuma UA)	0.31	0.39	27%
All Arizona Counties	0.32	0.30	-8%

Table 9 compares change in population to change in per capita land consumption in Arizona counties from 1982 to 2017. On average, across these 35 years, all Arizona counties increased in population by 144 percent, while their per capita land consumption actually decreased by 12 percent. While one of the two factors that drive urban sprawl grew in prominence, the other contracted, at least in aggregate for the state as a whole (when all counties are aggregated or added together). It should be noted, however, that per capita developed land consumption did actually increase in eight of the 15 Arizona counties, more than half of them.

Table 9. Population Growth vs. Growth in Per Capita Developed Land Consumption in Arizona Counties, 1982-2017

County	% POPULATION GROWTH, 1982-2017	% GROWTH IN PER CAPITA LAND CONSUMPTION, 1982-2017
Apache	37%	18%
Cochise (Sierra Vista UA)	41%	28%
Coconino (Flagstaff UA)	78%	-3%
Gila	38%	23%
Graham	57%	35%
Greenlee	-20%	98%
La Paz	63%	63%
Maricopa (Phoenix--Mesa UA & Avondale-- Goodyear UA)	168%	-4%
Mohave (Lake Havasu City UA)	231%	-5%
Navajo	63%	-16%
Pima (Tucson UA)	81%	-14%
Pinal (Caa Grande UA)	346%	-24%
Santa Cruz	115%	-18%
Yavapai (Prescott Valley--Prescott UA)	208%	-23%
Yuma (Yuma UA)	158%	65%
All Arizona Counties	144%	-12%

Table 10 compares recent change in population to change in per capita land consumption in Arizona counties from 2002 to 2017. On average, across these 15 years, all Arizona counties increased in population by 31 percent, while their per capita land consumption actually decreased by eight percent. In the same pattern as for the longer 1982 to 2017 time period, one of the two factors (population growth) that drive urban sprawl grew in prominence while

the other (per capita land consumption) contracted, at least when aggregated at the statewide level. It should be noted, however, that per capita developed land consumption did actually increase in seven of the 15 Arizona counties, or about half of them. However, the counties without increases or with declines had the larger population, which resulted in the statewide average reflecting the eight percent per capita decline.

Table 10. RECENT Population Growth vs. Recent Growth in Per Capita Developed Land Consumption in Arizona Counties, 2002-2017

County	% POPULATION GROWTH, 2002-2017	% GROWTH IN PER CAPITA LAND CONSUMPTION, 2002-2017
Apache	6%	12%
Cochise (Sierra Vista UA)	74%	9%
Coconino (Flagstaff UA)	16%	2%
Gila	4%	11%
Graham	13%	12%
Greenlee	21%	-13%
La Paz	6%	0%
Maricopa (Phoenix--Mesa UA & Avondale-- Goodyear UA)	33%	-7%
Mohave (Lake Havasu City UA)	25%	8%
Navajo	9%	2%
Pima (Tucson UA)	17%	-10%
Pinal (Casa Grande UA)	119%	-39%
Santa Cruz	16%	-7%
Yavapai (Prescott Valley--Prescott UA)	29%	-2%
Yuma (Yuma UA)	27%	27%
All Arizona Counties	31%	-8%

2.5 Measuring Overall Sprawl (Loss of Habitat and Farmland)

Using the National Resources Inventory (Developed Land) data, along with county-by-county Census Bureau population estimates for 1982, 2002, and 2017, we were able to measure the increase in the overall amount of developed land in each Arizona county, along with what fraction or percentage of that sprawl could be attributed to population growth and what portion was a result of an increase in per capita land use.

The NRI provided the estimates, county by county, on how many acres of rural land had been converted into developed land in 5-year increments (and a three-year final increment) within their 35-year time span.



Figure 34. Classic Arizona landscape

Arizona Residents Speak Out on Sprawl

“It would be a shame to see urban sprawl destroy the beauty we all share and the habitats of the animals that we all enjoy.”

We moved from Wisconsin to Arizona in 2005 and settled in Gold Canyon. In 2012 we moved to Apache Junction. We have always enjoyed the out-of-doors and especially seeing the wild animals such as the coyotes, javelina, deer, bobcats, roadrunners, etc. In the short time we have been in Arizona we have noticed that we hardly ever see the number of wild animals that we once enjoyed.

If Arizona continues to grow and develop in the upcoming years as it has in the past, it will only drive the wildlife up into the higher elevations and we will have lost a very special part of Arizona. We will become a concrete state of buildings and highways.

I think Arizona has done a good job of keeping up-to-date with building highways to accommodate the increase of vehicles. Yes, it does get congested with the influx of 'snowbirds'. However, the 'snowbirds' bring in a tremendous amount of money to the state and many businesses would not survive without their presence.

My main concern is the ability to continue to survive as urban sprawl and the population continues to grow. Water is in limited supply and it appears that many of our lakes and water sources are continuing to be depleted. What happens if it reaches the point where we have to limit water usage, like they did in California for a period of time.

Arizona is a beautiful state and very diverse in its topography. It would be a shame to see urban sprawl destroy the beauty we all share and destroy the habitats of all the animals that we all enjoy.

-- Arizona resident Barbara Brook

3. FINDINGS

This study focuses on the loss of previously undeveloped, or rural, land that includes cropland, pastureland, rangeland, forest, and other natural habitat and open space in the state of Arizona.

At its most basic level, there are three possible reasons for an increase in the area of developed or urbanized land: 1) each individual, on average, is consuming more developed land; 2) there are more people consuming the land; or 3) a combination of both factors is working together to create sprawl. This study attempts to quantify the relative roles of the two fundamental factors behind sprawl: rising per capita land consumption (that is, declining population density) and population growth.

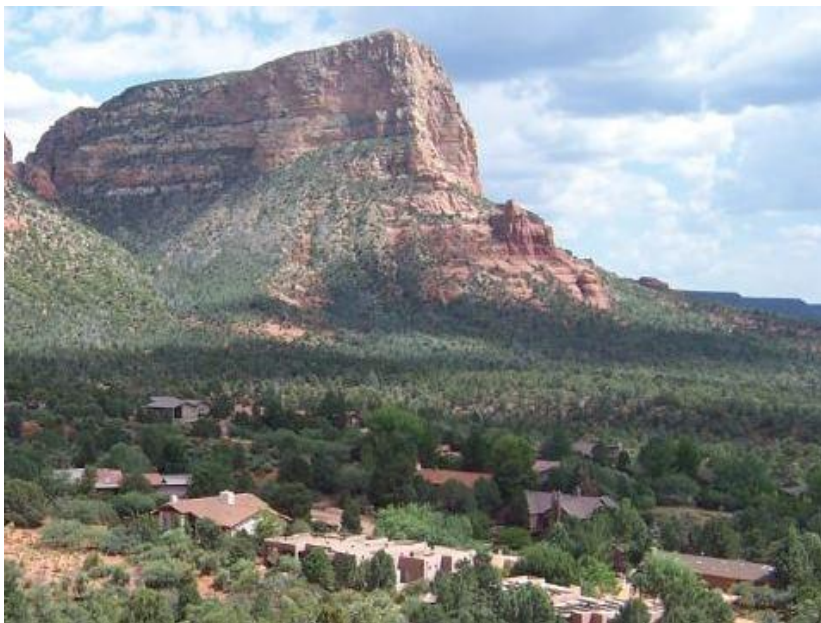


Figure 35. Houses and subdivisions encroach further and further into Arizona’s natural habitats

3.1 Arizona Urbanized Areas and Developed Areas

3.1.1 Per Capita Sprawl and Overall Sprawl

Many respected environmental organizations and urban planners contend that implementing Smart Growth, New Urbanism, and LEED⁹⁹ building strategies into our new and existing cities is the best way to rein in sprawl in our cities. However, this is based on the premise that it is only or primarily our land-use choices that cause sprawl in Arizona. As our multiple studies

⁹⁹ LEED stands for Leadership in Energy & Environmental Design. According to the U.S. Green Building Council, LEED “is transforming the way we think about how our buildings and communities are designed, constructed, maintained and operated across the globe. Comprehensive and flexible, LEED is a green building tool that addresses the entire building lifecycle recognizing best-in-class building strategies.” <http://www.usgbc.org/leed>

over the past two decades demonstrate conclusively, Per Capita Sprawl by itself could not explain Overall Sprawl in the great majority of America's urbanized or developed areas.

Arizona is no exception. By comparing the percentage growth of per capita land consumption (Per Capita Sprawl) with the percentage growth of Overall Sprawl in the nine Urbanized Areas in Arizona from 2000 to 2010 in **Figure 36**, we find that the Per Capita Sprawl percentage is much smaller than the Overall Sprawl percentage: 6 percent versus 34 percent. This is not to denigrate Smart Growth, New Urbanism, and the LEED program, but to recognize their limitations when they don't also focus on the role of population growth. These multi-faceted, multi-jurisdictional approaches have indeed slowed the pace at which sprawl is transforming the countryside into pavement and buildings over the last decade. Given incessant population growth, however, they are capable only of slowing sprawl, not stopping it.

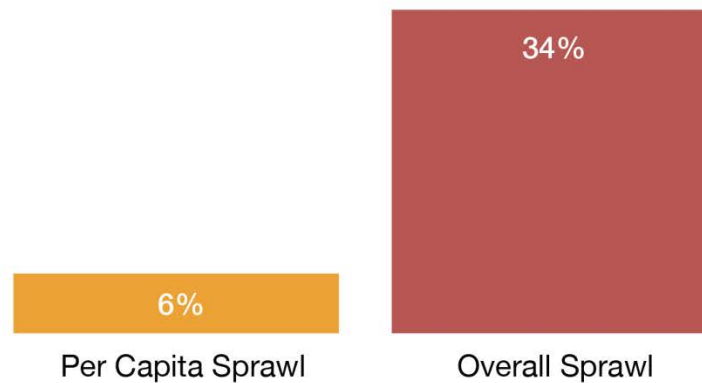


Figure 36. Recent Per Capita Sprawl vs. Overall Sprawl in Arizona UAs, 2000-2010

Note: Per Capita Sprawl is % growth in per capita urbanized land consumption and Overall Sprawl is % growth in urbanized land area.

Table 11 compares the percentages of Per Capita Sprawl and Overall Sprawl from 2000 to 2010 in all nine UAs in the state of Arizona. In all cases but one (an anomaly), Per Capita Sprawl is only a small fraction of Overall Sprawl. Per Capita Sprawl was non-existent (negative) in the smaller four of the nine UAs, but positive in the two largest UAs – Phoenix-Mesa and Tucson, though still much smaller than Overall Sprawl.

**Table 11. RECENT Per Capita Sprawl vs. Overall Sprawl
Arizona Urbanized Areas – 2000 to 2010**

Urbanized Area	% Change in Per Capita Land Consumption, 2000-2010 (PER CAPITA SPRAWL)	% Change in Overall Land Consumption, 2000-2010 (OVERALL SPRAWL)
Avondale--Goodyear	3%	199%
Casa Grande	-21%	36%
Flagstaff	-15%	7%
Lake Havasu City	-12%	10%
Phoenix--Mesa	15%	43%
Prescott Valley--Prescott	-4%	31%
Sierra Vista ¹	-66%	-62%
Tucson	4%	21%
Yuma	10%	57%
All Arizona UAs	6%	34%

¹See Appendix D (“Anomalies – Urbanized Areas with Populations that Grew But Areas that Supposedly Shrank”)

Even the best Smart Growth, New Urbanism, and LEED strategies are able to engineer only so much population density. As long as the population is still growing, the land area taken up by Arizona cities will almost certainly continue to grow.

Turning to Arizona’s counties, from 1982 to 2017, the area of Developed Land (Overall Sprawl) more than doubled, increasing by 114 percent. However, per capita land consumption – Per Capita Sprawl in **Figure 37** – actually decreased by 12 percent during these 35 years. This means that at an aggregate statewide level, combining all counties into one dataset, people did not consume more developed land on average, they consumed less. Per Capita Sprawl did not contribute substantially to urban sprawl in Arizona’s counties. **Table 12** displays these data county by county.

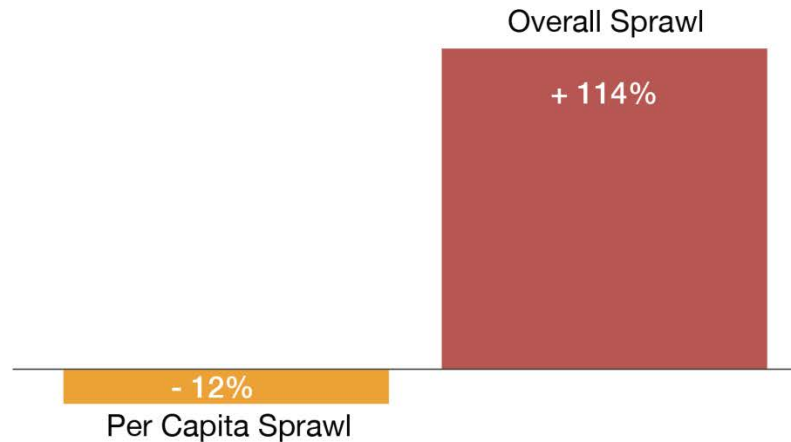


Figure 37. Per Capita Sprawl vs. Overall Sprawl in Arizona Counties, 1982-2017

Note: Per Capita Sprawl is % growth in per capita developed land consumption and Overall Sprawl is % growth in developed land area.

**Table 12. Per Capita Sprawl vs. Overall Sprawl
Arizona Counties – 1982 to 2017**

County	% Change in Per Capita Land Consumption, 1982-2017 (PER CAPITA SPRAWL)	% Change in Overall Land Consumption, 1982-2017 (OVERALL SPRAWL)
Apache	18%	62%
Cochise (Sierra Vista UA)	28%	81%
Coconino (Flagstaff UA)	-3%	72%
Gila	23%	69%
Graham	35%	112%
Greenlee	98%	59%
La Paz	63%	165%
Maricopa (Phoenix--Mesa UA & Avondale--Goodyear UA)	-4%	157%
Mohave (Lake Havasu City UA)	-5%	214%
Navajo	-16%	38%
Pima (Tucson UA)	-14%	56%

Pinal (Casa Grande UA)	-24%	238%
Santa Cruz	-18%	77%
Yavapai (Prescott Valley--Prescott UA)	-23%	137%
Yuma (Yuma UA)	65%	326%
All Arizona Counties	-12%	114%

Figure 38 and **Table 13** display the same data for the most recent 2002 to 2017 period. During these 13 years, Per Capita Sprawl decreased by three percent while Overall Sprawl (total area of Developed Land in all Arizona counties) increased by 20 percent.

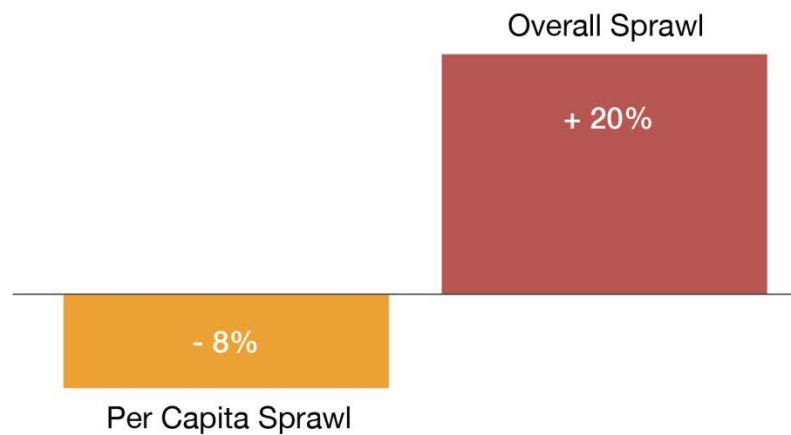


Figure 38. RECENT Per Capita Sprawl vs. Overall Sprawl in Arizona Counties, 2002-2017

Note: Per Capita Sprawl is % growth in per capita developed land consumption and Overall Sprawl is % growth in developed land area.

**Table 13. RECENT Per Capita Sprawl vs. Overall Sprawl
Arizona Counties – 2002 to 2017**

County	% Change in Per Capita Land Consumption, 2002-2017 (PER CAPITA SPRAWL)	% Change in Overall Land Consumption, 2002-2017 (OVERALL SPRAWL)
Apache	12%	19%
Cochise (Sierra Vista UA)	9%	14%
Coconino (Flagstaff UA)	2%	19%
Gila	11%	16%
Graham	12%	26%
Greenlee	-13%	5%
La Paz	0%	6%
Maricopa (Phoenix--Mesa UA & Avondale-- Goodyear UA)	-7%	23%
Mohave (Lake Havasu City UA)	8%	35%
Navajo	2%	11%
Pima (Tucson UA)	-10%	6%
Pinal (Casa Grande UA)	-39%	33%
Santa Cruz	-7%	8%
Yavapai (Prescott Valley--Prescott UA)	-2%	26%
Yuma (Yuma UA)	27%	60%
All Arizona Counties	-8%	20%

3.1.2 Per Capita Sprawl versus Population Growth

Because Overall Sprawl is explained by the combination of population change and per capita urbanized land or developed land consumption change, we can learn much about their relative roles by simply lining up those percentages side by side.

Figure 39 aggregates the nine UAs in Arizona and finds that their average population change from 2000 to 2010 was 27 percent while their per capita land change was six percent. Thus, we can see that the rate of population growth was a much larger factor than the rate of per capita land consumption growth in urban sprawl in Arizona from 2000 to 2010.

Figures 40 and 41 make the same comparison for county Developed Land area that **Figure 39** does for Urbanized Areas. Even a cursory examination of **Figures 39, 40, and 41** shows not only that Per Capita Sprawl cannot account for much of Overall Sprawl, but that for both UAs between 2000 and 2010 and county Developed Land areas between 1982 and 2015, it does not appear to be nearly as significant a factor in generating sprawl as Population Growth is. Subsequent sections will explore this finding further by apportioning responsibility for sprawl in cities and counties between Population Growth and Per Capita Sprawl by using another methodology.

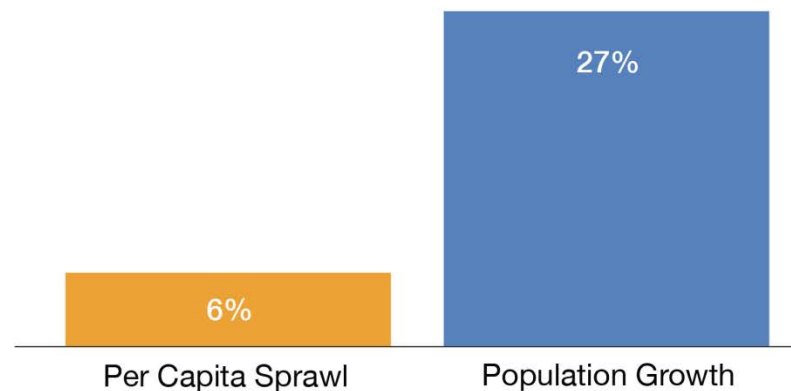


Figure 39. RECENT Per Capita Sprawl vs. Population Growth in Nine Arizona UAs, 2000-2010

Description: When comparing the growth rates of the two factors behind Overall Sprawl we find that population growth was much greater than per growth in capita land consumption from 2000 to 2010.

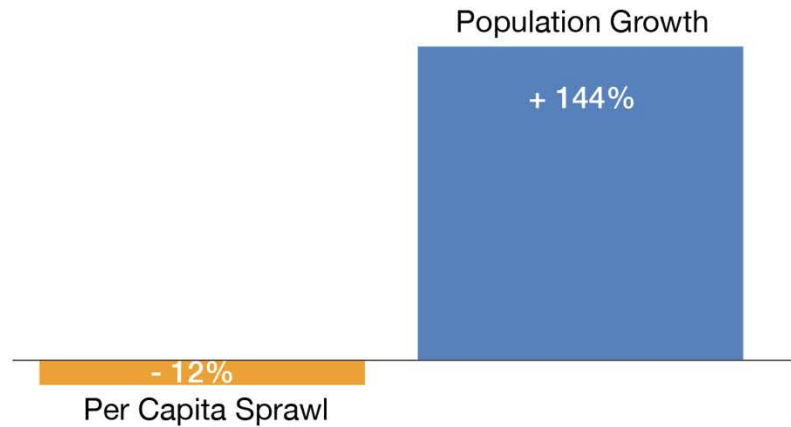


Figure 40. Long-term Per Capita Sprawl vs. Population Growth in Arizona Counties, 1982-2017

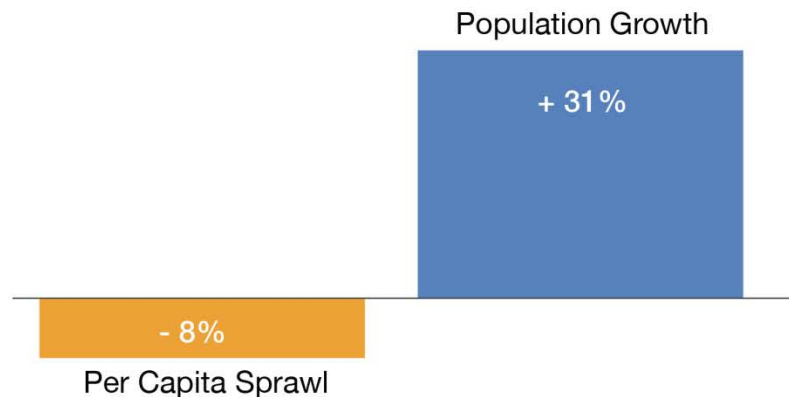


Figure 41. RECENT Per Capita Sprawl vs. Population Growth in Arizona Counties, 2002-2017

Since our primary concern is the ongoing loss of rural lands – agricultural lands, natural habitats, and other open space – to development and sprawl, it is worth seeing how much of this loss is related to Per Capita Sprawl and how much to Population Growth.

The findings of the current updated study broadly reinforce one of the conclusions of our original sprawl studies two decades ago – that when investigating the causes of sprawl, and presenting findings, it is best to avoid absolutes or categorical statements. Unlike some who have looked into the sprawl phenomenon, we attribute sprawl neither to population growth exclusively nor to declining density exclusively, that is, to increasing per capita land consumption. Once again, our findings clearly indicate that both factors are involved and important, although it is evident that, in Arizona especially, the population growth factor substantially outweighs the Per Capita Sprawl factor in importance.

Figure 42 compares the rates of sprawl when Arizona counties are divided into three groups based on the rate of population growth from 2002-2017. The three groups are <10% population growth, 10 to 25%, and >25%. On average, counties that added more population clearly sprawled over greater land areas. Those that had population growth under 10 percent sprawled on average by 12 percent (increased their area of Developed Land by that amount on average). Those counties whose populations grew from 10 to 25 percent experienced sprawl of 17 percent, and those with populations that increased by more than 25 percent sprawled by 36 percent on average.

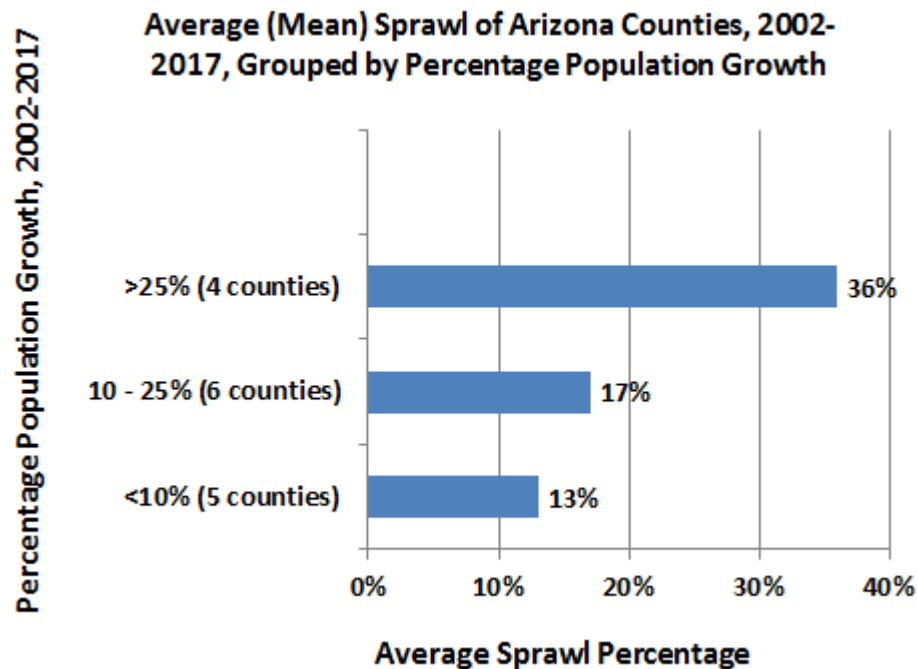


Figure 42. Arizona Counties with More Population Growth Experienced More Sprawl

Figure 43 displays the results of another grouping that once again demonstrates population growth's preminent role in driving sprawl in Arizona. This figure highlights the amount of population growth in the top five sprawling counties versus the bottom five sprawling counties.

The five counties in Arizona with the most sprawl (82 square miles on average) between 2002 and 2017 averaged population growth of approximately 288,400. In contrast, the five counties with the least amount of sprawl (just five square miles on average) averaged about 3,150 population growth during the same 15 years. This comparison shows dramatically how closely sprawl is linked with population growth.

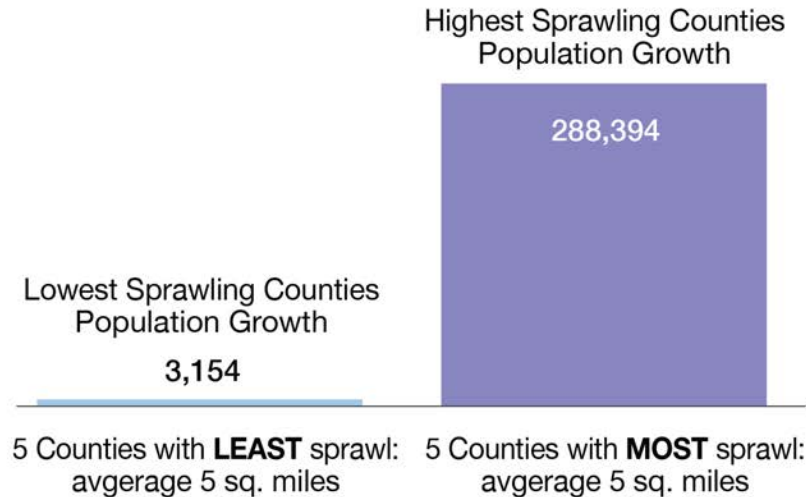


Figure 43. Average Population Growth in Arizona in Highest Five Sprawling Counties versus Lowest Five Sprawling Counties, 2002-2017

Note: 5 Arizona counties that sprawled the least between 2002 and 2017, averaging just 5 square miles, had average population growth of 3,154. In contrast, those 5 counties that sprawled the most between 2002 and 2017, averaging 82 square miles of sprawl during these 15 years, grew by an average (mean) of 288,394 residents during the period.

3.1.3 Relative Weight of Sprawl Factors in Arizona Urbanized Areas

To better understand and quantify the respective roles of population growth and per capita land consumption in generating Overall Sprawl, we can use a more mathematically sophisticated method that is sometimes used to apportion consumption of natural resources between two or more factors. Physicist John Holdren, Ph.D., former Director of the White House Office of Science and Technology Policy and former president of the American Association for the Advancement of Science (AAAS), developed and applied this methodology in a scientific paper evaluating how much of the increase in energy consumption in the United States in recent decades was due to population growth, and how much to increasing per capita energy consumption.¹⁰⁰ This “Holdren method” can be applied to virtually any type of resource in which use of the resource in question is increasing over time, and the number of resource

¹⁰⁰ John P. Holdren. 1991. “Population and the Energy Problem.” *Population and Environment*, Vol. 12, No. 3, Spring 1991. Prior to being Director of the White House Office of Science and Technology Policy in the Obama Administration between 2009 and 2017, Holdren was Teresa and John Heinz Professor of Environmental Policy and Director of the Program on Science, Technology, and Public Policy at Harvard University’s Kennedy School of Government, as well as Professor of Environmental Science and Public Policy in the Department of Earth and Planetary Sciences at that university. Trained in aeronautics/astronautics and plasma physics at MIT and Stanford, he co-founded and for 23 years co-led the campus-wide interdisciplinary graduate degree program in energy and resources at the University of California, Berkeley. On April 12, 2000 he was awarded the Tyler Prize for Environmental Achievement at the University of Southern California, which administers the award. The Tyler Prize is the premier international award honoring achievements in environmental science, energy, and medical discoveries.

consumers is changing, the amount of the resource being used by each consumer on average is changing, or both.

This study, as have our other studies over the past two decades, applies this method to sprawl. Rural, undeveloped land is thus the resource in question. As in the case of looking at energy consumption, the issue here is how much of the increased total consumption of rural land (Overall Sprawl) is related to the increase in per capita land consumption (Per Capita Sprawl) and how much is related to the increase in the number of land consumers (Population Growth).

Table 14 applies the Holdren method to all nine Urbanized Areas in Arizona. In the case of Tucson, for example, 19 percent of its Overall Sprawl was related to, or explained by, increases in per capita land consumption, and 81 percent was related to its population growth over the past decade.

Table 14. Sources of RECENT Sprawl in Arizona Urbanized Areas, 2000-2010

Urbanized Area	Total Sprawl 2000 to 2010 (square miles)	% of Total Sprawl Related to POPULATION GROWTH	% of Total Sprawl Related to GROWTH IN PER CAPITA LAND CONSUMPTION
Avondale--Goodyear	58.5	97%	3%
Casa Grande	5.9	100%	0%
Flagstaff	2.4	100%	0%
Lake Havasu City	2.7	100%	0%
Phoenix--Mesa	347.6	61%	39%
Prescott Valley--Prescott	12.2	100%	0%
Sierra Vista	-50.2	N/A	N/A
Tucson	62.1	81%	19%
Yuma	21.3	79%	21%
Total Sprawl	462.4	81%	19%
Weighted Average*	462.4	78%	22%

*Each UA's contribution to aggregate total weighted by relative amount of its sprawl and % sprawl due to population constrained to between 0-100%.

Table 14 shows how much of the sprawl in Arizona towns and cities is related to population growth and how much is related to growth in per capita land consumption (declining population density). Depending on the mathematical method used, in the state as a whole, between 78 to 81 percent, or about four-fifths, of the sprawl in Arizona's Urbanized Areas is related to population growth. In **Figure 44**, we use the smaller of these two amounts to estimate conservatively that 78 percent, over three-quarters, of the sprawl in Arizona's towns and cities between 2000 and 2010 was associated with population growth, not declining population density (what we call Per Capita Sprawl).

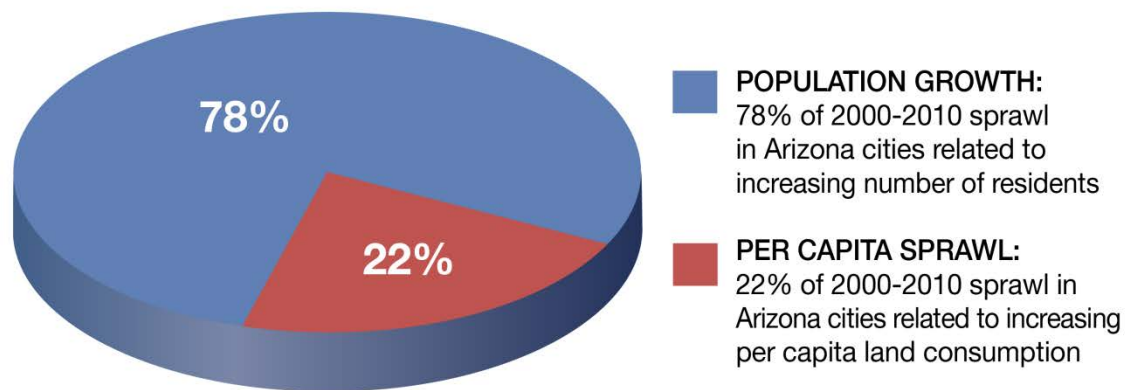


Figure 44. Percentages of RECENT Sprawl Related to Population Growth and Per Capita Sprawl in Arizona Urbanized Areas

Source: U.S. Census Bureau, 2000-2010 urbanized land area delineations

Description: Approximately 22 percent of the sprawl in Arizona's town and cities was related to increasing per capita land consumption. Approximately 78 percent of the sprawl was related to population growth.

Given this apportionment or breakdown, opponents of sprawl in Arizona should know that 78 percent of the sprawl problem is the inability to stabilize the state's population. In contrast, only 22 percent of the problem is the inability to stabilize per capita land use within urban development in the state. **Figure 44** displays the relative magnitude of these factors on a pie chart.

Between 2000 and 2010, the nine UAs in Arizona sprawled across and consumed an additional 462 square miles of land in aggregate. **Figure 45** shows that population growth in Arizona UAs was responsible for about 3.5 times as much loss of rural land as Per Capita sprawl or rising land consumption per capita: 360 square miles vs. 102 square miles.

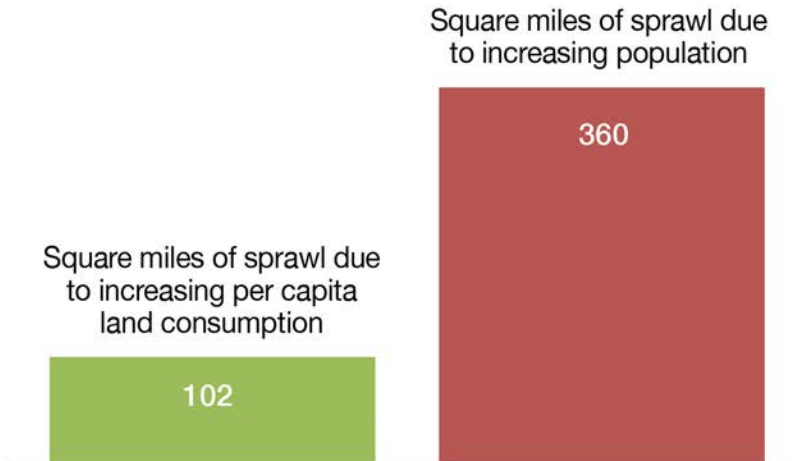


Figure 45. Rural Land Lost to RECENT Per Capita Sprawl vs. Population Growth in 9 Arizona UAs, 2000-2010

3.1.4 Relative Weight of Sprawl Factors in Arizona Developed Areas

Recall that the Census Bureau’s Urbanized Areas and the Natural Resources Conservation Service’s Developed Areas in the National Resources Inventory (NRI) are measured in two totally different manners, with different methodologies for collecting data on urban areas versus rural areas, and two completely distinct ways of defining the two land uses. Thus, quantifying sprawl using these two very different databases would not be expected to generate identical results, and indeed, our calculations do not. However, they produce fairly similar results, which is a sign of the robustness of our findings and an indication of their probable veracity.

From 2002 to 2017, an overlapping but different time frame than the Census Bureau’s most recent decade (2000 to 2010), the analysis of NRI Developed Land data for Arizona counties shows that population growth accounted for 84 percent of sprawl in the state (**Table 15** and **Figure 46**). This compares to 78 percent for the Census Bureau’s UA’s from 2000 to 2010.

Table 15. Sources of RECENT Sprawl in Arizona Counties, 2002-2017

Urbanized Area	Total Sprawl 2002 to 2017 (square miles)	% of Total Sprawl Related to POPULATION GROWTH	% of Total Sprawl Related to GROWTH IN PER CAPITA LAND CONSUMPTION
Apache	27.0	36%	64%
Cochise (Sierra Vista UA)	23.9	32%	68%
Coconino (Flagstaff UA)	20.8	86%	14%
Gila	5.9	27%	73%
Graham	11.9	52%	48%
Greenlee	0.3	100%	0%
La Paz	2.7	100%	0%
Maricopa (Phoenix--Mesa UA & Avondale-- Goodyear UA)	199.8	100%	0%
Mohave (Lake Havasu City UA)	63.6	74%	26%
Navajo	21.4	81%	19%
Pima (Tucson UA)	26.7	100%	0%
Pinal (Casa Grande UA)	70.3	100%	0%
Santa Cruz	5.0	100%	0%
Yavapai (Prescott Valley--Prescott UA)	28.9	100%	0%
Yuma (Yuma UA)	48.4	50%	50%
Total Sprawl	556.7	100%	0%
Weighted Average*	556.7	84%	16%

*Each county's contribution to aggregate total weighted by relative amount of its sprawl and % sprawl due to population constrained to between 0-100%.

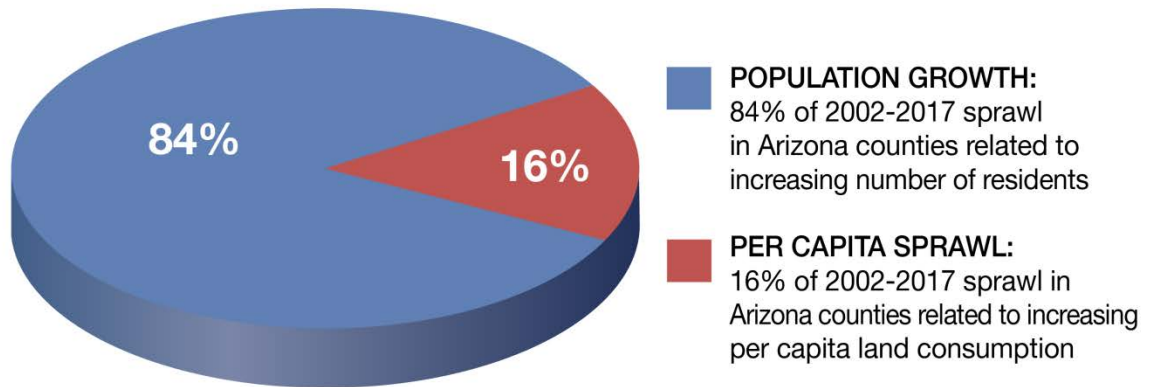


Figure 46. RECENT Sprawl Factors (Increasing Population and Increasing Per Capita Land Consumption) in all Arizona Counties, 2002-2017

Sources: Analysis of developed land estimates from NRCS National Resources Inventory, 2017; population estimates for 2002 and 2017 for each Arizona county from official Arizona population estimates.

Description: Approximately 16 percent of the sprawl in Arizona’s counties was related to increasing per capita land consumption. Approximately 84 percent of the sprawl was related to population growth.

Unlike the Census Bureau data, the NRCS survey encompasses development such as weekend cottages and second homes that are built by city residents far enough into the country that they don’t get included in the data on expanding Urbanized Areas (because they don’t have permanent residential populations). The NRI includes them in the “Small Built-up Areas” category. The NRI survey also captures all the rural land that succumbs to the development of recreational areas, resorts, roads, manufacturing, parking areas, and sprawling towns under 50,000 residents. Finally, on a national scale, the NRI category of Developed Land called “Rural Transportation” accounted for 19 percent (22.3 million acres) of all developed land in 2017.

Between 2002 and 2017, Arizona counties sprawled across and consumed an additional 557 square miles of land in aggregate. Figure 47 shows that population growth in Arizona counties was responsible for more than four times as much loss of rural land as Per Capita Sprawl or rising land consumption per capita: 468 square miles vs. 89 square miles.

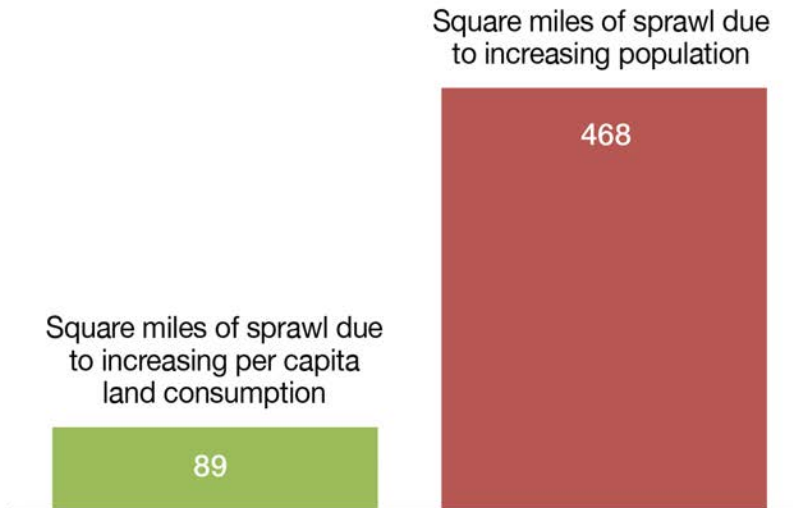


Figure 47. RECENT Rural Land Lost to Per Capita Sprawl vs. Population Growth in Arizona Counties, 2002-2017

Examining the entire period of record of NRI Developed Land data – from 1982 to 2017 – shows that population growth accounted for an even higher share of overall sprawl in Arizona counties: 93 percent (Table 16 and Figure 48).

Table 16. Sources of Sprawl in Arizona Counties, 1982-2017

Urbanized Area	Total Sprawl 1982 to 2017 (square miles)	% of Total Sprawl Related to POPULATION GROWTH	% of Total Sprawl Related to GROWTH IN PER CAPITA LAND CONSUMPTION
Apache	66	65%	35%
Cochise (Sierra Vista UA)	88	58%	42%
Coconino (Flagstaff UA)	55	100%	0%
Gila	18	61%	39%
Graham	30	60%	40%
Greenlee	3	0%	100%
La Paz	28	50%	50%

Maricopa (Phoenix--Mesa UA & Avondale-- Goodyear UA)	648	100%	0%
Mohave (Lake Havasu City UA)	168	100%	0%
Navajo	58	100%	0%
Pima (Tucson UA)	175	100%	0%
Pinal (Casa Grande UA)	198	100%	0%
Santa Cruz	29	100%	0%
Yavapai (Prescott Valley--Prescott UA)	82	100%	0%
Yuma (Yuma UA)	98	65%	35%
Total Sprawl	1,744	117%	0%
Weighted Average*	1,744	93%	7%

*Each county's contribution to aggregate total weighted by relative amount of its sprawl and % sprawl due to population constrained to between 0-100%.

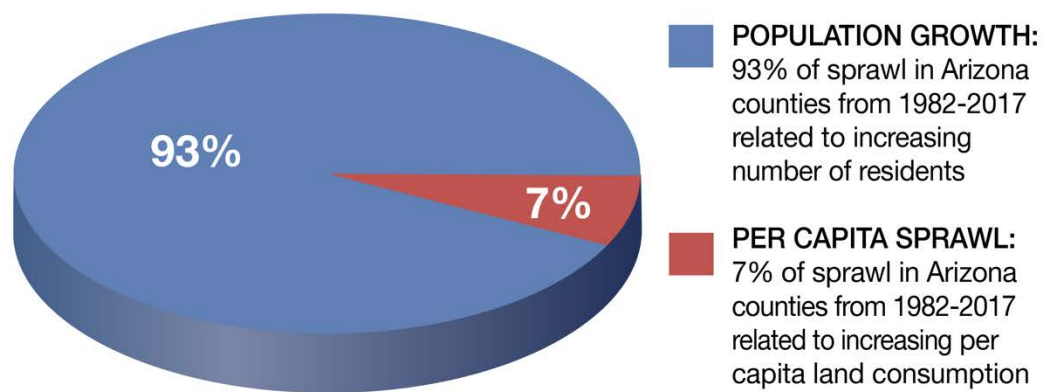


Figure 48. Sprawl Factors (Increasing Population and Increasing Per Capita Land Consumption) in all Arizona Counties, 1982-2017

Between 1982 and 2017, development in Arizona counties sprawled across and devoured an additional 1,744 square miles of rural land and open space in total. **Figure 49** shows that population growth in Arizona counties was responsible for more than ten times as much loss of rural land as Per Capita Sprawl or rising land consumption per capita: 1,613 square miles vs. 131 square miles.

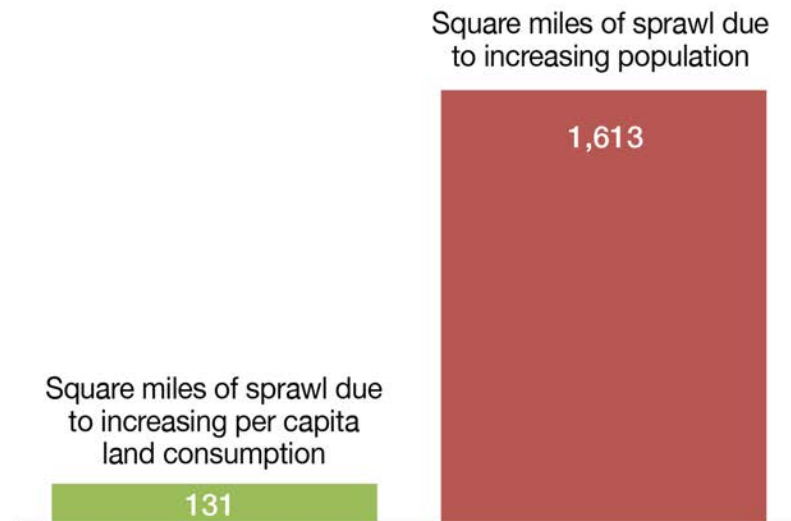


Figure 49. Rural Land Lost to Per Capita Sprawl vs. Population Growth in Arizona Counties, 1982-2017

3.2 Arizona Compared to Other States

It is interesting to compare the relative amounts and causes of sprawl in Arizona and other states using the NRI data on Developed Land. Here we do so for the entire NRI time period, from 1982 to 2017. This covers the complete three-decade-plus period of NRCS NRI land use data.

Figure 50 shows that across the entire 35-year time span between 1982 and 2017, about two-thirds (68%) of all open space developed in the United States was associated with population growth and about one-third of all open space developed (32 percent) was associated with increasing per capita land consumption or Per Capita Sprawl.

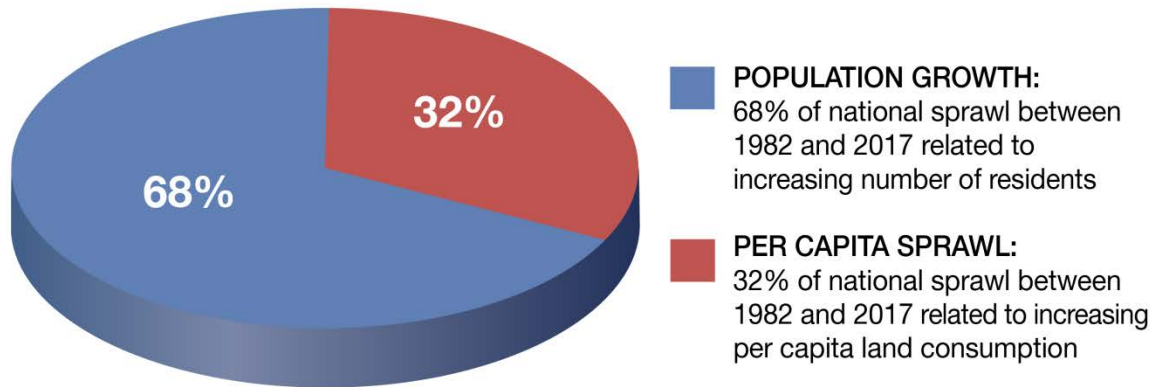


Figure 50. Sources of Sprawl in 48 Contiguous States, 1982-2017

Sources: National Resources Inventory, 1982-2017: population estimates for 1982 and 2017 for each state from U.S. Census Bureau population estimates.

During the same time period, 93 percent of Arizona’s sprawl was related to population growth. Therefore, it is evident that a higher share of Arizona’s Overall Sprawl was associated with population growth than was the case nationally, 93% versus 68%. Another way of looking at this is that all of the factors – both intended and unintended – affecting Arizona’s residential and overall population density succeeded in raising the population density in newly and previously developed areas, thereby reducing the rate of sprawl. Yet this also raises the percentage of the reduced amount of sprawl that does occur which is attributable to population growth.

3.3 Scatter Plots of Population Growth and Sprawl

Another useful way to examine the relationships between the factors in sprawl is by using scatter plot analysis. **Figure 51** is a scatter plot for Arizona that examines the relationship between each county’s population in 2015 on the x-axis (horizontal axis) and the area of developed land (i.e., cumulative total sprawl) on the y-axis (vertical axis). The scatter plot has a “best fit” line that shows the linear relationship between the data points.

The left-to-right, upward-sloping “best fit” line for **Figure 51** indicates that there is a positive relationship between population size and overall cumulative area of developed land (Overall Sprawl). Counties with larger populations are also those where more land has been developed cumulatively over time to accommodate the diverse land use needs of that population, which encompass far more than residential land for housing only. Perhaps these results are unsurprising, but if population size and sprawl were unrelated, as some have always maintained, the trend line would be flat or negative (sloping downward toward the right instead of upward). While this scatter plot alone does not prove that population causes sprawl, it does strongly suggest and reinforce the hypothesis that the two are closely correlated.

Figure 51. Scatter Plot of Population Size vs. Cumulative Overall Sprawl in 15 Arizona Counties, 2017

Sources: Census Bureau 2017 population estimates and National Resources Inventory (2017)

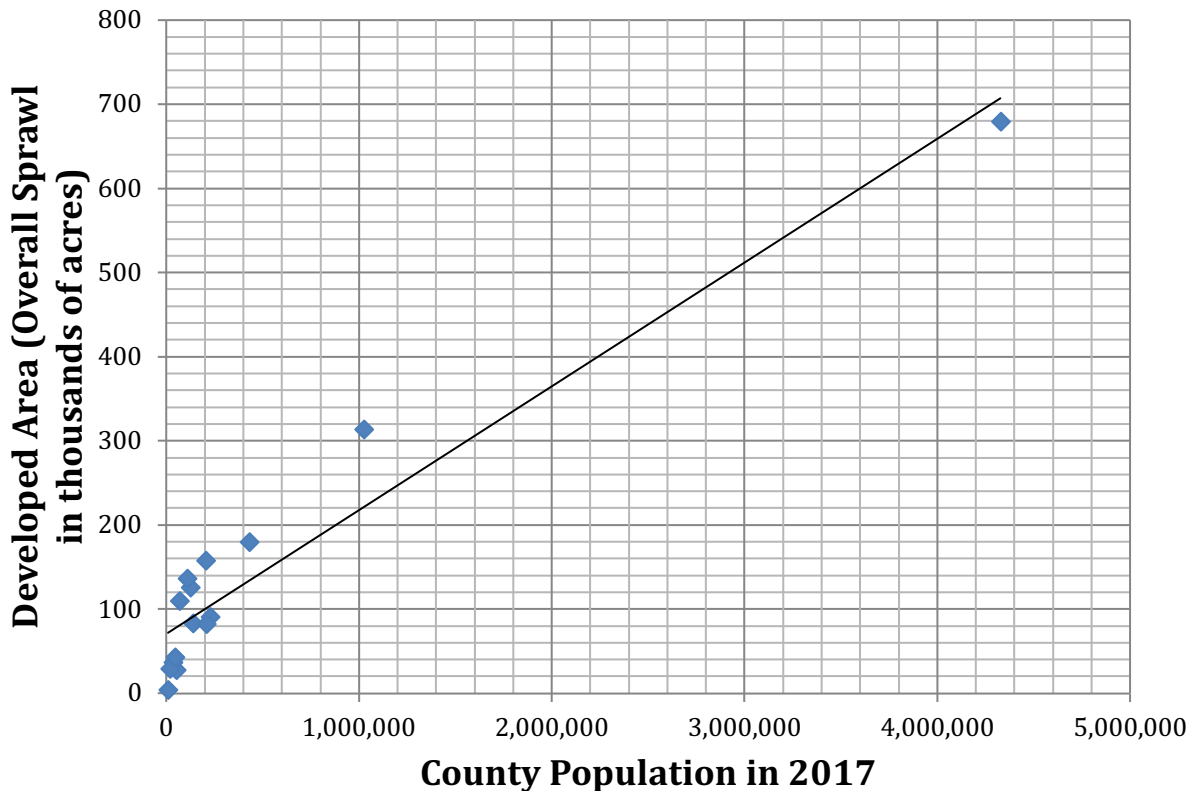


Figure 52 is a scatter plot of the change in population (growth) from 2002 to 2017 and the change or increment in the area of developed land (Overall Sprawl) in those 15 years. As in **Figure 51**, the scatter plot in **Figure 52** has a “best fit” line that shows the linear relationship between the data points.

Once again, the left-to-right, upward-trending “best fit” line for **Figure 52** indicates that there is a positive relationship between population increase and Overall Sprawl. Counties with more population growth in this period tended to be those where more land is being developed, and not just with housing (residential land use), but with all the various urban land uses and infrastructure required to meet the demands of a modern, high-consumption population.

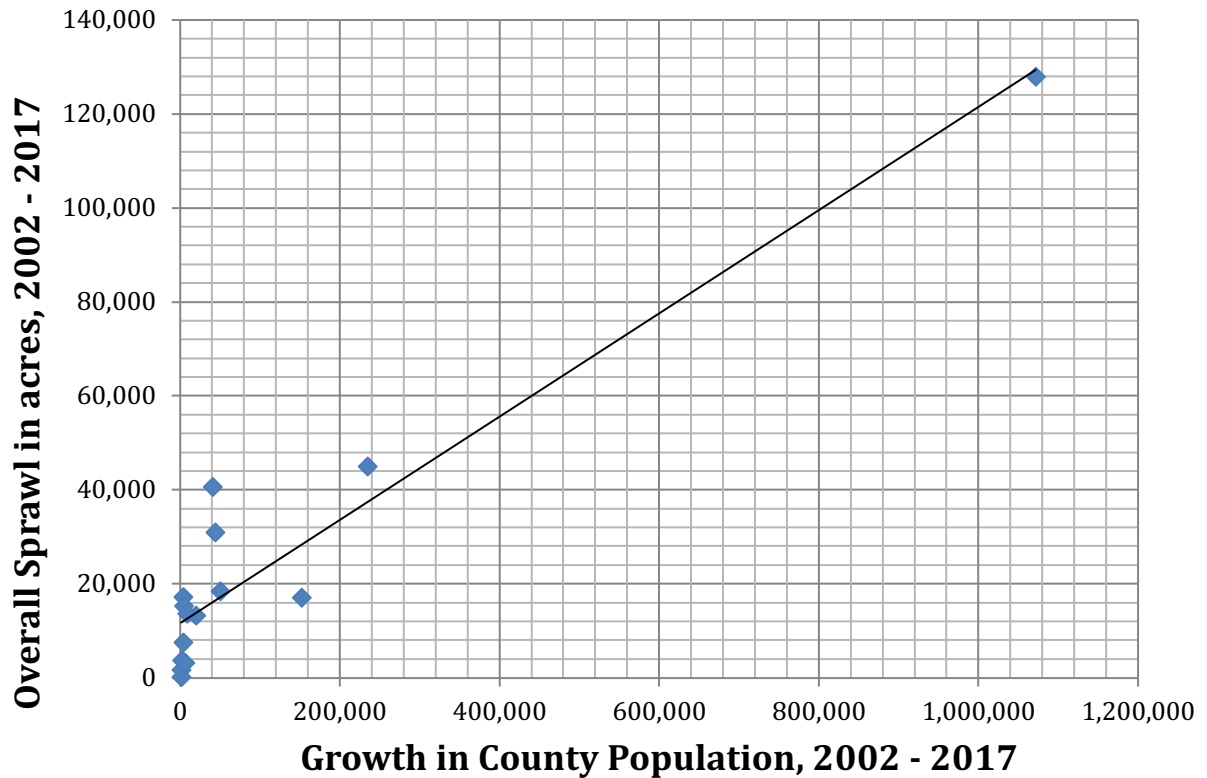


Figure 52. Scatter Plot of RECENT Growth in Population vs. Growth in Developed Land (Overall Sprawl) in Arizona Counties, 2002 to 2017

Sources: Census Bureau population estimates and National Resources Inventory (2002 and 2017)

3.4 Trends

From 2000 to 2010 the most significant factor contributing to Overall Sprawl in the United States was the addition of more than 17 million new residents to our nation's Urbanized Areas, and the additional nine million residents who settled elsewhere. Per Capita Sprawl was halted in 192 of our cities and was responsible for less than 30% of Overall Sprawl in Urbanized Areas during the same period of study.

Likewise, in Arizona, the addition of almost 1.1 million new residents to Urbanized Areas between 2000 and 2010 was responsible for approximately 78 percent of sprawl in the Grand Canyon State.

At the national level, NRCS data on sprawl in the contiguous 48 states from 2002-2017 were also broadly consistent with our findings for the cities. From 2002-2017 population growth was the most important factor in the loss of non-federal rural land, accounting for approximately 84 percent of new development. The ten states experiencing the most sprawl by percentage, 19% on average (Nevada, Utah, Texas, Delaware, **Arizona**, Mississippi,

Oklahoma, Florida, Idaho, Arkansas) had populations that grew on average more than three times (23% vs. 7%) as fast as the ten least sprawling states by percentage, 6% on average (South Dakota, Connecticut, Nebraska, Kansas, New Jersey, New York, Massachusetts, Iowa, Rhode Island, Oregon) (**Figure 53**).

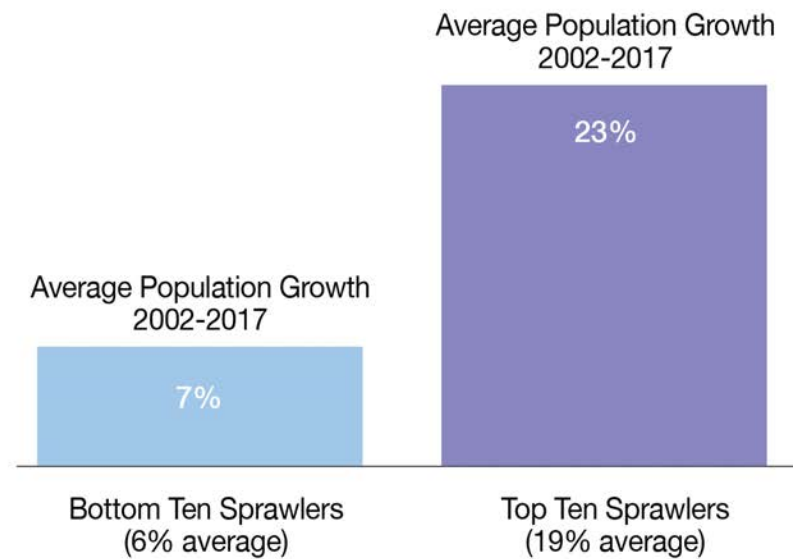


Figure 53. Comparison of RECENT Population Growth between High and Low Sprawling States, 2002 - 2017

Description: The populations of ten states experiencing the most sprawl by percentage between 2002 and 2017 (Nevada, Utah, Texas, Delaware, **Arizona**, Mississippi, Oklahoma, Florida, Idaho, Arkansas), grew on average more than three times faster than the ten least sprawling states (South Dakota, Connecticut, Nebraska, Kansas, New Jersey, New York, Massachusetts, Iowa, Rhode Island, Oregon)

Figure 54 visualizes the same data and the same 2002-2017 time period from a different perspective.

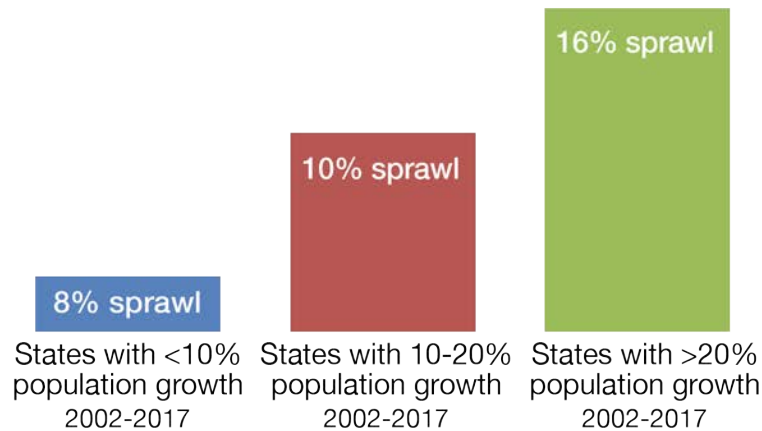


Figure 54. Comparison of RECENT Overall Sprawl in Slow-Population-Growth vs. Fast-Population-Growth States, 2002 - 2017

Those states that experienced less population growth (measured by percentage) from 2002 to 2017 also experienced proportionately less urban sprawl; the percentage increase in their area of developed land was smaller.

The 22 states that underwent less than 10 percent population growth in the 15 years between 2002 and 2017 averaged 8 percent increase in developed land area, or what we term Overall Sprawl. The 15 states whose populations increased between 10 percent and 20 percent averaged 10 percent Overall Sprawl. Meanwhile, the states whose populations expanded by 20 percent or more experienced 16 percent Overall Sprawl on average.

Table 17 ranks the states according to their sprawl rate from 2002 to 2017, from highest to lowest, by percentage. **Table 17** also includes the entire 35-year, 1982-2017 period of record, so that for each state, the percent sprawl and ranking are provided for the entire extended period of study. Arizona is in fifth place in the most recent 2002-2017 time period and second place for the overall 1982-2017 time period. Out of all 48 states, only Arizona's neighbor Nevada has sprawled faster, on average, in both the recent period and the overall period.

Table 17. Sprawl in 48 States, Ranked by Percentage

Ranking (by percentage) 2002-2017	Overall Sprawl (percentage), 2002-2017	State	Overall Sprawl (percentage), 1982-2017	Ranking (by Percentage) 1982-2017
1	27.0%	Nevada	152.8%	1
2	25.9%	Utah	96.5%	7
3	21.3%	Texas	80.3%	14

4	21.0%	Delaware	86.8%	11
5	20.4%	Arizona	113.6%	2
6	14.5%	Mississippi	66.6%	18
7	14.2%	Oklahoma	48.8%	31
8	13.9%	Florida	99.0%	6
9	13.7%	Idaho	66.5%	19
10	13.4%	Arkansas	54.3%	28
11	13.1%	Louisiana	61.7%	21
12	12.9%	Georgia	112.4%	3
13	12.9%	South Carolina	100.1%	5
14	12.5%	Virginia	75.9%	16
15	12.2%	Tennessee	91.6%	8
16	12.2%	New Mexico	90.8%	9
17	12.0%	North Carolina	108.4%	4
18	11.7%	Alabama	78.9%	15
19	11.6%	Colorado	64.2%	20
20	11.3%	Maine	73.9%	17
21	10.2%	Kentucky	89.4%	10
22	10.0%	Montana	31.2%	41
23	9.7%	New Hampshire	83.6%	12
24	9.5%	Vermont	54.4%	27
25	9.3%	Indiana	43.1%	34
26	9.2%	California	53.4%	29
27	9.1%	Wisconsin	40.7%	36
28	8.7%	Maryland	57.6%	25
29	8.7%	North Dakota	16.4%	47
30	8.4%	Missouri	39.3%	37
31	8.4%	Wyoming	30.0%	42
32	8.0%	Ohio	48.3%	32

33	7.9%	Washington	57.1%	26
34	7.7%	Illinois	32.4%	40
35	7.6%	West Virginia	83.0%	13
36	7.6%	Pennsylvania	61.6%	22
37	7.4%	Minnesota	42.5%	35
38	6.9%	Michigan	50.2%	30
39	6.8%	Oregon	45.1%	33
40	6.8%	Rhode Island	37.0%	38
41	6.6%	Iowa	19.7%	46
42	6.2%	Massachusetts	59.7%	23
43	6.0%	New York	37.0%	39
44	5.5%	New Jersey	58.3%	24
45	5.1%	Kansas	23.1%	44
46	5.0%	Nebraska	15.8%	48
47	4.6%	Connecticut	28.9%	43
48	3.5%	South Dakota	19.8%	45

Sources: 2017 NRCS National Resources Inventory; U.S. Census Bureau

It is interesting to compare the sprawl amounts in the various states for the more recent (2002-2017) and longer (1982-2017) periods, especially for those states that differ markedly between the two periods. For example, Oklahoma was in 7th place from 2002 to 2017 but 31st place from 1982 to 2017, perhaps as a result of the boom in hydraulic fracturing (hydro-fracking) for petroleum in this century. Similarly, North Dakota moved from 47th (next-to-last) place in its sprawl during the overall period (1982-2017) to 29th place for the more recent 2002 to 2017 period, likely an outcome of land development related to the Bakken Formation oil boom. Even in the “post-industrial” 21st century, various places – especially natural resource hinterlands – often experience “boom and bust and boom again” economic prosperity cycles related to waxing and waning waves of extraction of raw materials and non-renewable natural resources.

Overall, at a national level, two main temporal trends are evident in both the Census Bureau's UA data set and the NRI's Developed Land data set. The first trend, supported primarily by the NRI data, is that Overall Sprawl may have peaked in the late 1990s but continued into the late 2000s at a very high rate which still exceeded that experienced in the 1980s and early 1990s. The second temporal trend is that the role of the population growth factor has increased markedly over time, from approximately half (50%) in the 1970-1990 period to roughly 70-90% in the 2000s and 2010s. The Census Bureau and NRCS data, obtained in such different manners, are remarkably consistent in this regard.

Sprawl trends in Arizona are broadly similar to those of the nation at large. According to **Table 3**, drawing on the 2017 NRI (published in 2020), the average daily rate of sprawl (conversion from rural to urban land) in Arizona in five-year periods from 1982 to 2017 was as follows:

- 1982-1987: 85 acres/day
- 1987-1992: 51 acres/day
- 1992-1997: 52 acres/day
- 1997-2002: 228 acres/day
- 2002-2007: 110 acres/day
- 2007-2012: 59 acres/day
- 2012-2017: 26 acres/day

The sprawl average during this 3-decade period was 87 acres per day, or about 3.6 acres of open space devoured every hour. The sprawl rate peaked from 1997 to 2002. In the most recent period for which NRI data are available (2012 to 2017), the rate of sprawl had plunged to a mere 26 acres/day from 228 acres/day from 1997 to 2002. It should be remembered that in the 2012 to 2017 period, Arizona and the nation were still emerging from the Great Recession, a crisis instigated by the subprime mortgage crisis, housing bubble, and unsustainable household debt. During the Great Recession, land development and sprawl were drastically curtailed around the United States.



Figure 55. Arizona Cactus and Evening Sky

Credit: Tim Gainor on Unsplash.com



Figure 56. Chapel of the Holy Cross near Sedona

Figure 57. Inner basin of the San Francisco Peaks, rising to 12,633 ft. north of Flagstaff



Figure 58. Coronado National Forest and Chiricahua Mountains in Southern Arizona

Credit: Zereshk, own work

4. CONCLUSIONS AND POLICY IMPLICATIONS

4.1 Conclusions

At both the state (Arizona) and national level, there exists a broad correlation between population size and sprawl: generally, the larger a city, county, or state’s population, the larger the land area it will sprawl across.

This is shown clearly in **Figure 59**, a simple scatter plot of the 48 contiguous states’ cumulative populations and developed land areas in 2017. The positive (upward tilting toward the right) slope of the best-fit line means that as a state’s population increases, the area of built-up, developed land increases as well. This obliterates the whimsical notion entertained by those prone to wishful thinking and fairy tales that there is an insignificant connection between population size or growth rates and environmental consequences.

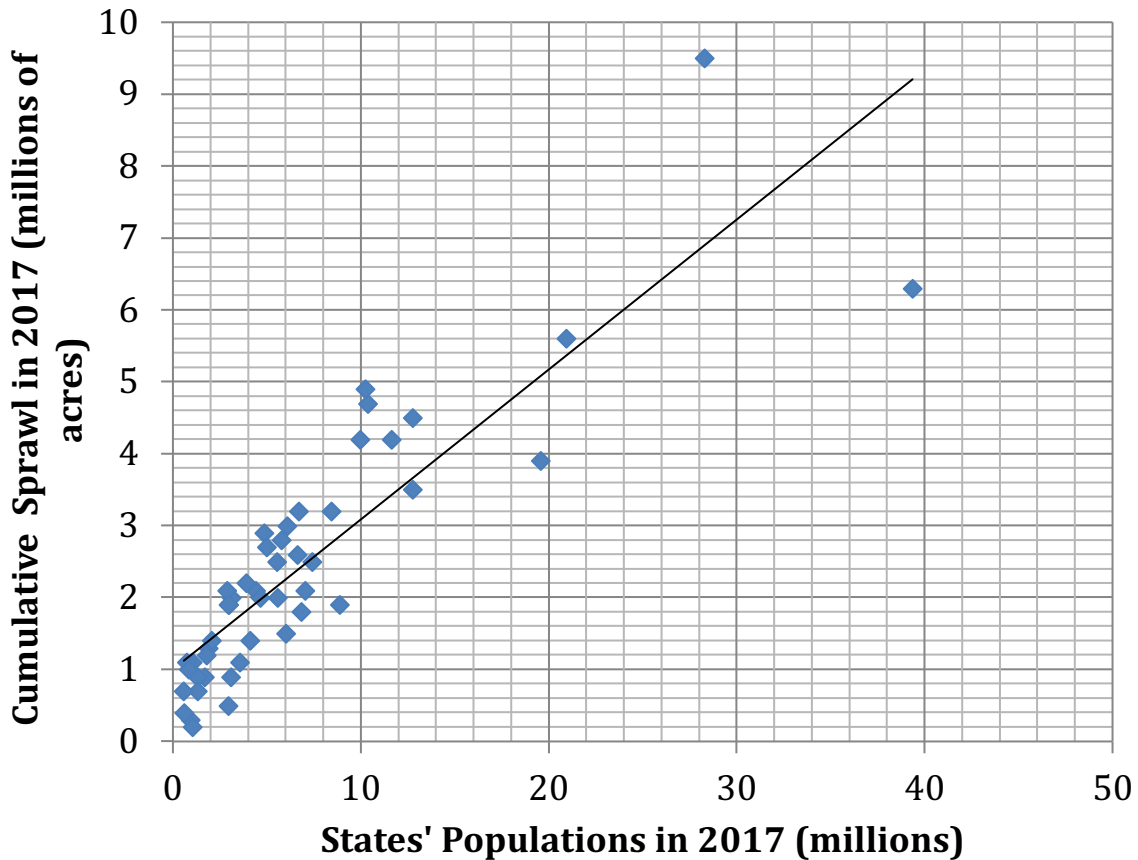


Figure 59. Cumulative Developed Land Area (Sprawl) Is a Function of Population Size
 Source: U.S. Census Bureau; NRCS, 2020. *Summary Report: 2017 National Resources Inventory*

Sprawl continues to devour rural land around Arizona cities at a rapid rate.

Although the pace of sprawl in Arizona may have peaked in the late 1990s and early 2000s, our most recent data for the past decade or so show that it continues to devour open space at a rate of almost 17,000 acres per year (26 square miles), or one square mile every two weeks. This comes out to an average of 46 acres per day. And in all likelihood, this rate has accelerated with the gradual waning of the Great Recession, though we don't yet have the data to confirm this hypothesis. Even at this reduced rate, sprawl would continue to convert an additional 170,000 acres (260 square miles) of Arizona's valuable rural lands, open space, agricultural land and wildlife habitat into pavement and buildings every decade. By 2050, more than half a million additional acres of Arizona's rural lands will have been paved or built over with subdivisions; hotels; industrial, office and theme parks; schools; and commercial strips, a great and permanent loss to Arizona's agricultural lands, wildlife habitat, natural heritage, quality of life, and environmental sustainability.

Smart growth efforts, higher gasoline prices, fiscal and budgetary constraints (limiting new road-building, for example), the increasing popularity of denser city living and its cultural amenities, and the recession-inducing mortgage meltdown in 2008 may have all played roles in slowing Arizona's rate of sprawl late in the first decade of this century. The extent to which any of these and still other unforeseen factors and events – such as the coronavirus (COVID-19) pandemic of 2020 – may affect the rate of sprawl in the coming decades is unknown and unpredictable. It may well be that concerns about high density residential living in the face of disease pandemics could increase sprawl pressures by shifting the preference of consumers for lower-density suburban neighborhoods.

As an April 2020 article in *The New York Times* indicated:

“The pandemic has been particularly devastating to America's biggest cities, as the virus has found fertile ground in the density that is otherwise prized. And it comes as the country's major urban centers were already losing their appeal for many Americans, as skyrocketing rents and changes in the labor market have pushed the country's youngest adults to suburbs and smaller cities often far from the coasts.”¹⁰¹

The article quoted Brookings Institution demographer William Frey, who noted that even before the coronavirus pandemic, “millennials and older members of Generation Z were

¹⁰¹ Sabrina Tavernise and Sarah Mervosh. 2020. America's Biggest Cities Were Already Losing Their Allure. What Happens Next? *New York Times*. April 19. Accessed online on 4/22/2020 at: <https://www.nytimes.com/2020/04/19/us/coronavirus-moving-city-future.html>. The article also quoted Harvard University economics professor Ed Glaeser, author of *Triumph of the City*, who said: “It feels like it's back to smallpox, back to cholera. Cities were killing fields for centuries because of contagious disease.” Glaeser observed that the life expectancy of a baby born in a city in 1900 was seven years less than one born in a rural area, but that that gap had disappeared by the 1920s with advances in modern water supply and sewage systems.

already increasingly choosing smaller metro areas like Tucson, Ariz.; Raleigh, N.C.; and Columbus, Ohio.... Also growing were exurbs and newer suburbs outside large cities. ‘There was a dispersion from larger metros to smaller metros, from urban cores to suburbs and exurbs.’”

In any case, as more and more of Rural Arizona succumbs to development – chipped away and clogged with roads, vehicles, people, facilities and infrastructure – at some point it will not be possible to maintain rapid rates of sprawl simply because other critical land uses – e.g., high-value crop and pastureland; national and state parks, forests, and wildlife refuges; mines; watersheds and reservoir buffer zones; utility corridors; U.S. military bases and arsenals – will represent a larger and larger fraction of the remaining undeveloped land. Water scarcity and climate change (still hotter, drier temperatures) may also restrict dispersed, never-ending development in Arizona and force higher and higher densities, like them or not.

The role of population growth in driving sprawl in Arizona has remained consistently high over the last half century.

Since 1970, population growth has by conservative estimate accounted for approximately 70 to 90 percent of the sprawl in Arizona, depending on the city, county, and time period in question. There are exceptions to this rule of course, but they are just that, exceptions. During an earlier period (1970 to 1990), when in the nation as a whole, population growth accounted for roughly half of all sprawl, in Arizona, it was still responsible for a much higher percentage than this.

In this century, in the nation as a whole, the percentage of sprawl attributable to population growth has risen to approximately 70-90 percent, catching up with Arizona. But Arizona has remained consistently higher than the national average.

In the meantime, the role of increasing per capita land consumption (what we have referred to as “land use choices”) has fallen in the country as a whole, but it has always been a minor factor in Arizona’s sprawl.

In our 2014 study of national sprawl, *Vanishing Open Spaces*, using data from the same two federal agencies (U.S. Census Bureau and NRCS) and the same two long-term data gathering programs, during the decade just ended (2000-2010), population growth accounted for approximately 70-90% of sprawl on the national scale; declining density or increasing per capita land consumption accounted for about 10-30%. In other words, nationally, the relative role of the population growth factor has increased by about 20-40 percentage points (from 50 to 70-90) over the four-decade period from 1970 to 2010 that the study encompasses.

Efforts to concentrate and direct development into confined, denser areas are not sufficient to offset the pressures from population growth.

An important objective of Smart Growth is to preserve open space, farmland, natural beauty, wildlife habitat, and critical environmental areas by preventing declining population density. Thus, places where population density increases should be highlighted as success stories. Between 2000 and 2010 in Arizona, there were four out of six Urbanized Areas (i.e., two-thirds of all Arizona UAs) whose density increased – in other words, their per capita land consumption decreased. However, three out of four of these UAs still experienced appreciable sprawl.

Almost half of Arizona's counties (seven out of 15) experienced a decrease in developed land per capita between 1982 and 2017.

No Urbanized Area in Arizona has approached **Portland, Oregon** in the lengths it has gone to control sprawl, and perhaps no city in America better exemplifies the shortcomings and limitations of the Smart Growth approach as the Pacific Northwest's Emerald City.

Despite being lauded for its urban growth boundary (UGB), extensive light rail infrastructure, and high-density mixed-use developments, even Portland has been unable to contain its own sprawl. Between 2000 and 2010, the Portland UA decreased its per capita land consumption by five percent from 0.19 acre per person to 0.18 acre per person. (By comparison, the average per capita 2010 land consumption in Arizona Urbanized Areas was 0.22 acre/person, 22 percent higher than Portland.)

However, despite its modest gain in population density (reduction in per capita land consumption) over the decade, the Portland UA still sprawled outward an additional 50.4 square miles between 2000 and 2010. The addition of 266,760 people during the decade was more than enough to wipe out the increased population density and cause the urbanized area to swell by an additional 11 percent. While the UGB and other smart growth initiatives have certainly slowed the pace of sprawl in Portland, some contend that they have driven up real estate and housing prices within the city. This has led to spill-over sprawl in other nearby cities and along the scenic Willamette Valley as people seek sanctuary from higher home prices. Supporting this contention is the nearby city of Salem, Oregon, whose urbanized area population grew by 14 percent from 2000 to 2010, and which has quickly become the second largest city in Oregon.

Of the 192 Urbanized Areas in the United States which over the last decade experienced a decline in per capita land area, **Raleigh, North Carolina** is another instructive example of the limits of gradually shrinking the acreage afforded to each person in which to live, work, shop, play. Its per capita land consumption decreased by 0.003 acre. At the same time, the population grew by over 300,000 people, causing the Raleigh UA to become more densely populated. But despite Raleigh's drop in per capita acreage, its 63 percent increase in population caused it to expand by an additional 198.5 square miles in these 10 years.

The drop in per capita land consumption can be explained by the efforts of city planners to tame sprawl by directing development toward certain centers within the Urbanized Area. These were not enough to prevent the construction of new suburban neighborhoods, the development of retail centers, and the creation of roads and highways to connect these more intensely developed areas.

In Texas, the **Houston UA** reduced its per capita land use (increased its density) slightly from 0.2169 acre/person in 2000 to 0.2149 acre/person in 2010, a decrease of almost one percent. According to the conventional wisdom espoused by Smart Growthers, because density increased, by definition there was no sprawl on the Houston UA periphery from 2000 to 2010, yet the region still lost over 365 square miles of open space during this period.

In the first of our nationwide sprawl studies almost two decades ago, 18 of the 100 largest Urbanized Areas in the U.S. had reduced per capita land consumption, and during that time period all 18 of those Urbanized Areas still experienced Overall Sprawl. Between 2000 and 2010, 26 Urbanized Areas had a decline in their per capita land consumption, and 22 of those cities experienced Overall Sprawl. The four areas that did not sprawl saw a decrease in their total urbanized land area by an average of 18.5 square miles. While it is encouraging to see that some cities are stopping both their per capita and Overall Sprawl, 22 of the nation's major cities that stopped per capita growth still sprawled in an unsustainable manner. A stronger approach must be taken towards suppressing sprawl before our already dwindling rural lands disappear altogether.

Stabilized population alone does not prevent sprawl.

Throughout the country, many local officials see population growth as a driver of economic development and an indicator of the vibrancy of the locales they represent. This mentality is seen in the aggressive campaigns and taxpayer subsidies that local officials use to attract new residents. However, economic growth does not necessarily require growing populations and sprawling cities. According to a 2012 study by Eben Fodor and Associates, **cities experiencing rapid population growth had higher rates of unemployment** and were more affected by the 2007-2008 recession than were cities with slower growth rates.¹⁰²

This can be seen in urbanized areas like **Pittsburgh (Figure 60)**, which have benefited from a stabilized population in recent years. From 2000 to 2010, Pittsburgh experienced no population-induced sprawl and had a relatively low level of Overall Sprawl. One benefit Pittsburgh has seen from a stabilized population is that it had an unemployment level well below the national rate in 2009 after the Great Recession. Energized largely by strong gains in the education, healthcare, financial, and natural gas industries, Pittsburgh has been able to

¹⁰² Eben Fodor. 2012. Relationship Between Growth and Prosperity in the 100 Largest U.S. Metropolitan Areas. *Economic Development Quarterly*. Available at: <http://edq.sagepub.com/content/26/3/220>.

distance itself from both the image of the “smoky city” of steel mills and the image of the city of shut-down steel mills.

Pittsburgh has also been making headlines in the 2000s as one of the country’s most livable cities. In 2011 *The Economist* Intelligence Unit named it America's most livable city, and the 29th most livable city in the world. Despite having a stable population and diverse economy, the Pittsburgh Urbanized Area sprawled over an additional 52.8 square miles in the last decade. The reason was high levels of Per Capita Sprawl. One possible culprit could be that Pittsburgh has fewer people per household than the nationwide average. This means that the population of Pittsburgh requires more dwellings and more area for the same population size than do other American cities of comparable population size. Also, the decline of the steel industry left parts of the city abandoned as contaminated “brownfields”, driving residents to build outward into the suburbs. Cases like Pittsburgh highlight the necessity of a two-pronged approach to addressing overall sprawl: both population growth – undertaken primarily at a national level, not a local one – and per capita consumption sprawl.



Figure 60. Downtown Pittsburgh, Pennsylvania, at the confluence of the Monongahela (right) and Allegheny Rivers (left), which combine to form the Ohio River at The Point

Recognition by scholars that population growth is a major (though not the sole) driver of urban land expansion and sprawl is sharply at odds with the way most news media and anti-sprawl activists in the United States have tended to portray the causes of sprawl. The news media and anti-sprawl activists appear to have accepted that rapid, unending U.S. population growth on the order of 20 to 30 or more million new residents per decade is a given and a *fait accompli*.

Thus, since they want to convince Americans that something can still be done to halt or slow sprawl substantially in spite of never-ending U.S. population growth, they tend to downplay or minimize population’s importance as a causal factor in sprawl. In their efforts to publicize

sprawl to the American public and enlist support for anti-sprawl measures – e.g., “smart growth” policies, higher residential densities, multifamily housing (apartments and condominiums), mixed land uses and zoning, and infill that eliminates existing urban open space (such as golf courses) – they reserve their criticism for “low-density sprawl,” essentially giving a pass to other new development on the urban periphery, as long as it is not low-density, even though it still permanently devours rural land and open space.

If current population trends are allowed to continue, Arizona will experience vast amounts of sprawl over the next half century.

If current demographic trends in Arizona continue as projected by official state demographers at the Arizona Commerce Authority, and shown in **Figure 61**, Arizona’s population will surpass 10 million by the year 2050 and still be growing rapidly.

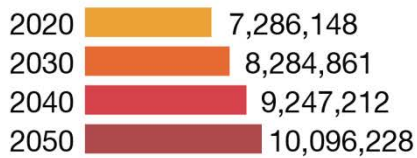


Figure 61. Arizona population projection from 2020 to 2050

Source: Arizona Commerce Authority at:

<https://www.azcommerce.com/oeo/population/population-projections/>

Combining these demographic trends and current sprawl development patterns, Arizonans can expect to see millions of additional acres of their state’s remaining open space converted to urbanized and developed lands in the coming decades. In 2017, the average Arizonan consumed or accounted for 0.31 acre (about one-third of an acre) of developed land. If the nearly three million additional Arizonans projected by 2050 continue to use land at the same rate as the average resident in 2012, almost one million acres (about 1,500 square miles) of additional open space – e.g., farmland, pastureland, ranchland, desert, forest, wildlife habitat – in the state will be converted from rural to developed land. Not many Arizonans, we believe, would hail this permanent loss of open space as constituting “progress.”

The year 2050 – the midpoint of this century – is just 30 years away. Today’s toddlers will have started careers and families of their own.

We can extend the official state projections out to 2060 and to 2100 – well within the lifetimes of today’s toddlers – by assuming a continuation of the growth rate used in the latest decade (2040 to 2050). **Table 18** shows how large Arizona’s population would grow from 7.3 million in 2020 :

Table 18. Arizona’s Population Growth Projected to 2060 and 2100

	2060	2100
Low Projection	9,369,252	11,041,626
Medium Projection	10,931,488	15,034,900
High Projection	12,627,953	20,097,356

The low, medium, and high projections for 2060 and 2100 are depicted graphically in **Figure 62**.

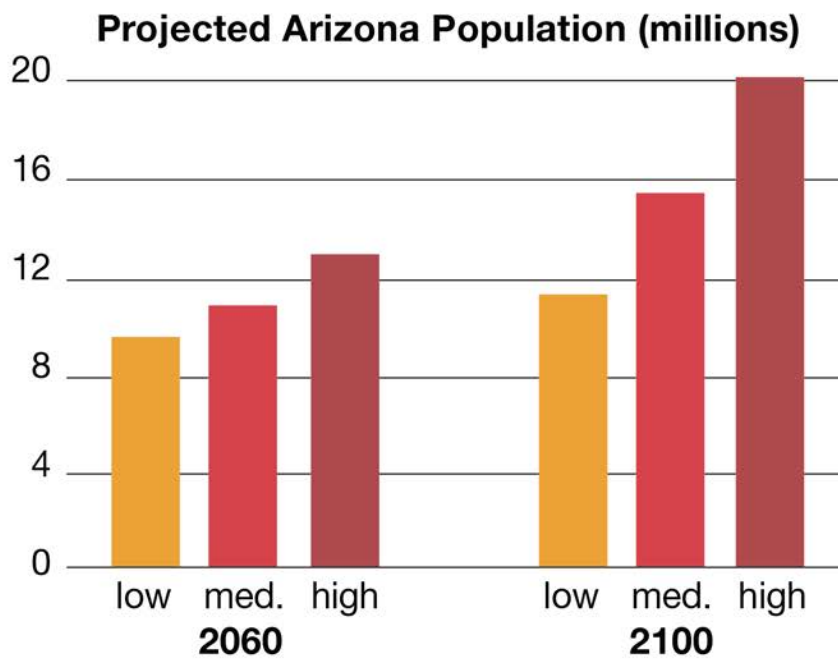


Figure 62. Arizona’s Population Projections to 2060 and 2100 under Low, Medium, and High Assumptions

4.2 Policy Implications

Recommendations in this section are those of the authors and not necessarily of the publisher, NumbersUSA Education & Research Foundation.

In order for Arizona policy makers to reduce the negative impacts of sprawl and over-development, they must adopt a two-pronged approach. Building on the findings of our original studies in 2000 and 2001, and using the same analysis of U.S. Census Bureau and U.S. National Resource Conservation Service data, this study provides further evidence of the necessity for such a strategy to combat sprawl effectively in Arizona. Furthermore, this study found that the role of population growth in contributing to Overall Sprawl has persisted in Arizona from the 1970s to the present. These findings further reinforce the need for robust measures that both reduce wasteful over-consumption of our land and resources as well as others that address the large population growth that persists in our country as a whole and in Arizona in particular.

While the findings of this study directly challenge the assumptions of many Smart Growth and New Urbanism advocates that population growth plays only a small role in Overall Sprawl, they do not discount the necessity for smarter urban planning that reduces per capita land consumption. The results of this study suggest that in Arizona about a fourth or less of recent sprawl was caused by a complicated array of zoning laws, infrastructure subsidies, and complex socioeconomic forces. Efforts to make cities and communities more space-efficient and livable are certainly needed, but they largely ignore the main concern that sprawl is eating away at the remaining undeveloped lands of Arizona.

Following the logic of this study's findings it isn't hard to conclude that even the most aggressive and well-intentioned policies promoting smarter growth, better urban planning, and higher residential densities cannot escape the immense population pressures facing many communities around the rapidly growing state of Arizona. Only Utah, Nevada, and Texas have exceeded Arizona's population growth rate in recent years.

As noted above, based on the results of our study, urban sprawl will engulf perhaps another million acres or 1,500 square miles of farmland, desert, and wildlife habitat in Arizona by 2050 if current population growth trends continue unabated.

4.2.1 Local Influence on Sprawl

Local policy makers sincere in trying to curb sprawl in Arizona cities have a number of policy actions and instruments at their disposal. While most local officials see population growth as an indicator of the vibrancy and vitality of their respective communities, there is little evidence to suggest that unfettered population growth is any of those things. Well-known sprawl critic and urban planner Eben Fodor, author of *Better Not Bigger*, challenged this very notion in his

2010 study “Relationship between Growth and Prosperity in 100 Largest U.S. Metropolitan Areas.”¹⁰³

Fodor’s study found that rapidly expanding metropolitan areas did not fare well in terms of standard economic indicators such as unemployment rates, per capita income, and poverty rates in comparison with slower growing metropolitan areas. Yet, despite this, local officials and city planners continue to offer subsidies and tax breaks to attract new residents, investment and development. Many times these subsidies are borne unfairly by existing residents, who see their property taxes rise and are saddled with paying the bill for sprawling highways, new schools, water and wastewater treatment, and energy grids ever farther from the urban core.

Many cities have overly complicated or restrictive zoning laws that drive up home prices. New immigrants and low income families are being priced out and diverted to the more affordable suburbs and Sunbelt cities. Sprawl in the Sunbelt is of particular concern because its growth puts added strain on already scarce water resources. In order for cities to properly address sprawl, taxpayer subsidies need to be eliminated and the true costs of development need to be borne by those developing the land. Additionally, as suggested by Harvard economist Edward Glaeser, author of *Triumph of the City*, the true social costs of activities such as driving should be paid for. More sensible planning policies and zoning ordinances can help curb sprawl and reduce the size of population booms in areas not suitably equipped to handle large populations.

The U.S. Environmental Protection Agency (EPA) has a website devoted to Smart Growth at: <https://www.epa.gov/smartgrowth>. It contains a number of practical resources for planners, activists, developers, and local officials to help promote smart growth, which EPA defines as: “a range of development and conservation strategies that help protect our health and natural environment and make our communities more attractive, economically stronger, and more socially diverse.”

The EPA Smart Growth website lists the ten (for consistency’s sake. In the next paragraph ‘The ten principles’ is used) principles of smart growth developed in 1996 by the Smart Growth Network, an alliance of environmental, affordable housing, real estate and development, historic preservation, public health, government, and similar groups. The ten principles of Smart Growth are:

- Mix land uses
- Take advantage of compact building design



¹⁰³ Eben Fodor. See footnote #102.

- Create a range of housing opportunities and choices
- Create walkable neighborhoods
- Foster distinctive, attractive communities with a strong sense of place
- Preserve open space, farmland, natural beauty, and critical environmental areas
- Strengthen and direct development toward existing communities
- Provide a variety of transportation choices
- Make development decisions predictable, fair, and cost effective
- Encourage community and stakeholder collaboration in development decisions

According to the NGO Smart Growth America and Tucson’s then-mayor, downtown Tucson has been undergoing a revival that embraces smart growth principles.¹⁰⁴ In 2013, then-mayor Jonathan Rothshield said that a 3.9-mile streetcar line called the Sun Link, connecting the University of Arizona, 4th Avenue Business District, Congress Avenue Shopping and Entertainment District and the Mercado District had served as a catalyst, “transformed our community and our downtown” (**Figure 63**). According to Rothshield, people and businesses were moving back to the downtown core after decades of departing it for the city’s expanding periphery. Between 2008 and 2013, nearly 50 new restaurants, cafes, and bars opened or expanded downtown. These businesses alone injected more than \$12 million in private investment capital into the area. Overall, during that period, 141 new businesses opened up downtown, attracting an estimated \$800 in total private and public investment.

In recent years, a growing pro-development citizens’ movement in urban centers has emerged and been making waves. This so-called YIMBY movement (for “Yes In My Backyard”, in explicit contrast to the NIMBY or “Not In My Backyard” movement) began in San Francisco in the early 2010s, fueled by millennials fed up with astronomical housing prices that effectively priced them out of living in the city. According to *The Guardian*, YIMBY advocates see themselves as progressive housing activists welcoming higher density and accompanying rents and mortgages affordable to the middle class, while their detractors denounce them as dupes for luxury developers, contributing to the gentrification of urban

¹⁰⁴ Craig Chester. 2013. Mayor Jonathan Rothshield on the revival of downtown Tucson, AZ. October 28. Smart Growth America: Making Neighborhoods Great Together. Accessed online April 26, 2020 at: <http://old.smartgrowthamerica.org/2013/10/28/mayor-jonathan-rothschild-on-the-revival-of-downtown-tucson-az/>

centers.¹⁰⁵ In San Francisco, NIMBYs have clashed with Hispanic organizations over housing developments proposed for the low-income, traditionally Hispanic Mission District.



Figure 63. Sun Link Streetcar in Downtown Tucson

Credit: City of Tucson

In the authors' view, in general, Smart Growth principles and strategies should be pursued for the sake of environmental sustainability and neighborhood livability in any case, regardless of the amount of population growth that is occurring. From the findings of this study however, as well as recent experience around the country, it is quite evident that Smart Growth alone will not stop urban sprawl from devouring the countryside. Physicist and famed population activist Dr. Albert Bartlett wrote that: "smart growth will destroy the environment, but it will do it in a sensitive way." The authors would express this idea somewhat differently: smart growth is necessary but not sufficient to save the environment and open spaces from incessant sprawl.

In early 2020, the coronavirus pandemic threw a curve ball into all of these long-term trends and emerging considerations, and proponents of higher urban densities have been put on the

¹⁰⁵ Erin McCormick. 2017. Rise of the yimbys: the angry millennials with a radical housing solution. *The Guardian*. October 2. Retrieved online April 26, 2020 at: <https://www.theguardian.com/cities/2017/oct/02/rise-of-the-yimbys-angry-millennials-radical-housing-solution>.

defensive. As the headline of an article in the *Los Angeles Times* expressed it: “Building dense cities was California’s cure for the housing crisis. Then came coronavirus.”¹⁰⁶

In our 2020 opinion survey of 1,000 likely Arizona voters, we asked what they thought of efforts to control sprawl by changing zoning and land use management to raise population densities in the state’s urban areas. A majority (51%) opposed increasing density as a way of accommodating further population growth while avoiding accompanying sprawl.

16. One way to handle continued population growth without losing as much natural habitat and farmland in Arizona is to change zoning and other regulations so that more residents live in apartments and condo buildings instead of single-family houses. Do you strongly favor, somewhat favor, somewhat oppose or strongly oppose this kind of change?

- 12% Strongly favor
- 26% Somewhat favor
- 27% Somewhat oppose
- 24% Strongly oppose
- 11% Not sure

4.2.2 National Influence of Population Growth

Beyond the short term, local Arizona officials supportive of growth control and management can hope only to slow population growth -- not stop it -- in their jurisdictions if the national population continues to increase by some 2-plus million additional residents each year. These 20-25 million additional Americans each decade will nearly all settle in some community, inevitably leading to additional sprawl as far and as long as the eye can see. Many of these added millions will choose to seek a home in Arizona, as indicated by the state’s official population projections shown in **Figure 61**.

In essence there are only three sources of national population growth: native fertility (in conjunction with slowly increasing life spans), immigration, and immigrant fertility. We know the following about their contribution to long-term growth:

- Native fertility: At approximately 1.7 births per woman, the total fertility rate (TFR) of the United States remains below the replacement level of 2.1 and has not been a source of long-term population growth in the U.S since 1971.
- Immigration: The sole source of long-term population growth in the United States is immigration, due both to new immigrants (arriving at about four times higher than the “replacement level” where immigration equals emigration) and to immigrants’ fertility,

¹⁰⁶ Liam Dillon. 2020. Building dense cities was California’s cure for the housing crisis. Then came coronavirus. *Los Angeles Times*. April 26. Accessed online April 26, 2020 at: <https://www.latimes.com/homeless-housing/story/2020-04-26/coronavirus-density-cities-urbanization-housing-climate-change>.

which despite declines during and since the “Great Recession” has remained above replacement level and above native fertility.

Thus, long-term population growth in the United States and Arizona is in the hands of federal policy makers. It is they who have increased the annual intake and settlement of immigrants from one-quarter million in the 1950s and 1960s to over a million since 1990, fluctuating between one million and nearly two million, once net illegal immigration is included. Until the numerical level of national immigration is addressed, even the best local plans and political commitment will be unable to stop sprawl. Any serious efforts to halt the loss of open space, farmland, and wildlife habitat in Arizona must include reducing the volume of population growth, which requires lowering the level of immigrants entering the country each year unless Americans and immigrants decide to move to a one-child per woman average.

A far more sustainable immigration level would be the approximately half-million a year recommended in 1995 by the bi-partisan U.S. Commission on Immigration Reform, established by President Clinton and chaired by former Democratic Congresswoman Barbara Jordan. That would move annual immigration back to around the level that was the norm as recently as the 1980s.

A poll of America’s likely voters conducted in May 2020 by Pulse Opinion Research found that reducing immigration was a popular policy choice among most when linked with the goal of slowing down U.S. population growth (see Appendix G for the full survey questions and results).

11. Over the rest of this century, would you prefer that the nation's population continue to grow toward 500 million, grow much more slowly, stay about the same as it is now at 331 million, or slowly become smaller?

- 17% Continue to grow toward 500 million
- 43% Grow much more slowly
- 22% Stay about the same at 331 million
- 10% Slowly become smaller
- 8% Not sure

GROUPINGS: 17% Continue to grow at present pace
75% Substantially slow, stop, or reverse growth

12. Census data shows that since 1970, annual immigration has tripled and is now the cause of nearly all long-term population growth. Should the federal government reduce annual immigration to slow down population growth, keep immigration and population growth at the current level, or increase annual immigration and population growth?

- 47% Reduce annual immigration to slow down population growth
- 33% Keep annual immigration and population growth at the current level
- 12% Increase annual immigration and population growth
- 8% Not sure

13. Currently the government allows one million legal immigrants each year. How many legal immigrants should the government allow each year -- two million or more, one million, a half-million, or 100,000 or less?

- 17% Two million or more
- 27% One million
- 21% Half a million
- 22% 100,000 or less
- 14% Not sure

GROUPINGS: 44% Keep same level or increase
43% Cut immigration at least in half

In our April 2020 survey of 1,000 likely Arizona voters, included as Appendix H, we inquired as to preferences about population size and growth rates in the state of Arizona. We also asked Arizonans about what immigration levels would be appropriate in view of immigration driving America’s and Arizona’s future population growth, and population growth driving sprawl in the state.

12. Arizona's population has more than doubled since 1980 and is on pace to increase by another third over the next three decades. Would you prefer that Arizona's population continue to double in size, that it grow much more slowly, that it stay about the same size, or that it become smaller?

- 8% You prefer that Arizona’s population continue to double
- 48% You prefer that Arizona’s population grow much more slowly
- 26% You prefer Arizona’s population remain the same
- 14% You prefer Arizona’s population become smaller
- 4% Not sure

Only 8% of respondents preferred that Arizona’s population continue to grow rapidly toward an eventual doubling in size, while 88% expressed a preference for much slower growth, a cessation of growth (population stabilization), or a smaller population altogether.

Respondents were then asked about the two sources of in-migration to Arizona – from other states and from foreign countries.

14. Census data show that new immigrants and births to immigrants have been equal to 44% of all Arizona population growth since the year 2000. Should the federal government reduce annual immigration to slow down Arizona’s population growth, keep immigration and population growth at the current level, or increase annual immigration and population growth?

- 44% Federal government should reduce annual immigration to slow down Arizona’s population growth
- 39% Federal government should keep immigration and population growth at the

current level
 9% Federal government should increase annual immigration and population growth
 8% Not sure

15. Currently the government allows one million legal immigrants each year. How many legal immigrants should the government allow each year -- two million or more, one million, a half-million, or 100,000 or less?

14% Two million or more	
24% One million	38% Don't cut immigration
21% Half a million	
26% 100,000 or less	48% Cut immigration
15% Not sure	

In question 14, Arizonans were about evenly divided between those who say the federal government should cut immigration to slow Arizona's population growth and those who believe in maintaining or increasing federal immigration levels and Arizona's population growth. There is clearly no consensus among state voters in this regard. This lack of consensus parallels similar findings of our May 2020 national survey presented above.

In question 15, however, about half (48%) of Arizonans would prefer to cut immigration while fewer (38%) would prefer not to cut immigration.

The lower level of immigration at around 500,000 a year would drive far less sprawl than the present levels exceeding a million a year. But unless Americans decide to lower their birth rates to far below replacement level, the 500,000 a year would still drive considerable population growth, sprawl, and environmental degradation indefinitely.¹⁰⁷

That is why another federal commission recommended far greater reductions in immigration. The President's Council on Sustainable Development in 1996 recommended that the United States stabilize its population in order to meet various environmental and quality-of-life goals, and it called for reducing immigration to a level that would allow for a stable population. At current just below-replacement native fertility rates, that would require a return down to at least the quarter-million level of immigration in the 1950s and 1960s.

¹⁰⁷ Camarota, Steve, *Projecting Immigration's Impact on the Size and Age Structure of the 21st Century American Population*, Center for Immigration Studies, December 2012

The Population and Consumption Task Force of President Clinton’s Council on Sustainable Development concluded in 1996: “This is a sensitive issue, but reducing immigration levels is a necessary part of population stabilization and the drive toward sustainability.”¹⁰⁸

It is important to underscore that the additional sprawl that occurs because of high immigration levels has nothing to do with the caliber of immigrants as people or individuals but everything to do with the quantity of population growth that occurs because of immigration. This can be seen by simply observing that cities with high population growth have high amounts of sprawl, regardless of whether most of the incoming new residents come from another region of the United States or from another continent.

In our 2003 national-level study, we devoted several pages to our findings on ways in which an Urbanized Area's population growth from immigrants would have either a greater or lesser effect on sprawl than a net population growth of the same size from U.S.-born residents. We could find no precise method of quantification but concluded that the various factors largely balanced each other.

A key way in which growth from immigration has a somewhat smaller effect on sprawl is the lower average income level and, thus, a lower consumption level of the average immigrant. But we found that an assumption about immigrants having less of an effect because they presumably prefer central cities to suburbs was false. The majority of immigrants now live in suburbs where the sprawl occurs.¹⁰⁹ And the adult children of immigrants were found to be just as likely to shun living in core cities as the adult children of natives. In fact, the lower incomes were causing immigrants to move to the edges of cities and even to rural settlements beyond the cities to find cheaper housing.

Arizona’s population growth is influenced by immigration in a major way not involving the actual immigrants settling in the state. Because its next-door neighbor California has experienced so many negative quality-of-life results from its massive population growth, for decades Arizona has received a large number of California “refugees” fleeing the effects of this overpopulation. Because nearly all of California’s population growth is due to immigration, much of the California migration into Arizona must be considered as another consequence of the quadrupled level of annual federal immigration since 1970.

On a local level, the sprawl pressures of population growth are similar regardless of where the new residents originate. But very few Urbanized Areas are likely to be able to subdue

¹⁰⁸ President’s Council on Sustainable Development. 1996. *Population and Consumption Task Force Report*. 1996. Co-Chairs: Dianne Dillon-Ridgley, Co-Chair, Citizen’s Network for Sustainable Development and Timothy E. Wirth, Under Secretary for Global Affairs, U.S. Department of State.

¹⁰⁹ Jill H. Wilson and Audrey Singer. October 2011. *Immigrants in 2010 Metropolitan America: A Decade of Change*. Metropolitan Policy Program at Brookings. Available online at: <https://www.brookings.edu/research/immigrants-in-2010-metropolitan-americaa-decade-of-change/>

population growth and sprawl if the federal government continues policies that add around 20 million people to the nation each decade, all of whom have to settle in some locality. The reality – which can only be mitigated but not eliminated by good planning or Smart Growth – is that these localities all occupy lands that were formerly productive agricultural lands or irreplaceable natural habitats.

This is not a sustainable path, and it is not one we believe that fully informed Arizonans would voluntarily choose.

Appendix A

Glossary

Central Place – The Census Bureau delineates an urbanized area (UA) as one or more “central places” and the “urban fringe” (the adjacent densely settled surrounding territory) that together contain a minimum of 50,000 residents. A central place functions as the dominant center of each UA. The identification of a UA central place permits the comparison of this dominant center with the remaining territory in the UA. A central place generally is the most densely populated and oldest city in a metropolitan area.

Density – Shorthand for population density, or the number of residents per unit area, usually measured in number of residents per acre or square mile. Density is the mathematical inverse or opposite of land consumption per person (per capita). For example, a density of five persons or residents per acre equals 3,200 per square mile. This in turn equals a per capita land consumption of 0.2 acre per person.

Developed Land – As defined by the U.S. Department of Agriculture’s Natural Resources Conservation Service in its National Resources Inventories (NRIs), issued every five years since 1982, built-up or paved land that is at least one-quarter acre in area. Developed land can include built-up areas outside of urbanized areas, towns, or cities. The NRI Developed Land category includes: (a) large tracts of urban and built-up land; (b) small tracts of built-up land less than 10 acres in size; and (c) land outside of these built-up areas that is in a rural transportation corridor (roads, interstates, railroads, and associated rights-of-way).

Foreign Born – Describing a person born in a country other than the United States. Excludes those born abroad to American parents. Can be used as a noun or an adjective.

High-Density – A large number of residents per unit area, usually measured in terms of residents per acre or square mile. While there is no one precise, agreed-upon criterion or threshold of high-density residential development, a density of approximately 5,000 per square mile would be considered relatively high-density.

Holdren Method – Mathematical methodology for determining the percentages of Overall Sprawl attributable to Per Capita Sprawl and Population-driven Sprawl, in other words, to increasing per capita land consumption (decreasing population density) and to population growth.

Hop – a connection from one urban area core to other qualifying urban territory along a road connection of half a mile (0.5 mile) or less in length; multiple hops may be made along any given road corridor. This criterion recognizes that alternating patterns of residential development and non-residential development are a typical feature of urban landscapes.

Immigration – Permanent movement (i.e., settlement) of a foreign-born person to the

United States either with permission from U.S. authorities (legal immigration) or without such permission (illegal immigration).

Immigrant Fertility – Fertility of foreign-born immigrants to the United States, usually expressed in terms of the Total Fertility Rate (TFR) of women, which is the average total number of children born to women of a defined group during the course of their reproductive years.

Jump – a connection from one urban area core to other qualifying urban territory along a road connection between 0.5 mile and 2.5 miles in length; only one jump may be made along any given road connection.

Low-Density – Relatively low population density, or low number of residents per unit area (acre or square mile). Urban / suburban densities of 1,000-2,000 per square mile would be considered low-density, though still enough to qualify as urban.

Native Born – A person born in the United States.

Natural Habitat – That portion of rural or undeveloped land that consists of upland and bottomland forests, woodlands, savanna, scrub-shrub, natural grasslands or prairie, wetlands (marshes, swamps, bogs), ponds, watercourses, deserts, alpine meadow and tundra. Natural habitats support wildlife and provide other ecosystem services. They may be in public or private ownership.

New Urbanism – A movement that sees urban centers as potentially vibrant communities that can mix and harmonize residential and commercial uses in clever and innovative ways to make cities satisfying and safe places to live and work. New urbanism supports such concepts as higher density in urban cores, mixed uses, mass transit, close proximity of dwellings to workplace, walkable communities, bicycle lanes, community gardens, and others. New urbanism sees relentless sprawl in America as one consequence of the abandonment of our central cities.

Per Capita Land Consumption – Average amount of land used by each resident of an urbanized area or developed area. Includes not just residential land but all developed land used by urban residents, including commercial, institutional, small park, transportation (e.g., streets, roads, railroads, freeways, parking lots), and industrial land uses.

Open Space – Land lacking significant built structures or pavement. Includes rural and undeveloped lands and natural habitat outside of urban boundaries; also includes larger natural areas, parks and green space within urban areas, such as golf courses and extensive lawns or gardens. Yards or wooded lots on quarter-acre lots in residential areas would not qualify as open space.

Overall Sprawl – See “sprawl” below. Overall sprawl is the sum of Per Capita Sprawl and Population-driven sprawl [the total amount of open space converted to development over a period of time].

Per Capita Sprawl – Sprawl that is driven by increase in per capita land consumption, that is, land consumption per resident, of an urbanized area, developed area, city or town; Per Capita Sprawl is measured in terms the increase in acres or square miles of developed or urbanized acres of land per person. Per Capita Sprawl and population-driven sprawl add up to 100 percent of Overall Sprawl.

Population-driven Sprawl – Sprawl that is driven by increase in the population of an urbanized or developed area. Population-driven and Per Capita Sprawl add up to 100 percent.

Population Growth – Increase in the number of residents of a given area, such as a town, city, urbanized area, state, or country over time. Population growth is equal to the total births of native-born residents minus the total deaths of native-born residents minus the emigration of native-born residents PLUS total immigration of the foreign born plus births to the foreign born minus deaths of the foreign born minus emigration of the foreign born (i.e., return to the country of their birth or a third country). In recent decades, annual population growth in the United States as a whole has been running about 2.5 million to 3 million per year on average, or roughly 30 million per decade.

Rural Land – Undeveloped lands outside of urban areas, including farmland, pastureland, rangeland, and natural or semi-natural habitats, like forests, woodlands, wetlands, grasslands or prairie, and deserts. Rural lands may be flat or mountainous, and publicly or privately owned.

Smart Growth – The use of a variety of land-use, planning, statutory, regulatory, taxing, and other tools by federal and state governments and local jurisdictions (municipalities) to reduce haphazard, low-density, and poorly planned development in a given region.

Smart Growth Movement – A loose, eclectic coalition of environmentalists, local growth-control activists, New Urbanists, municipal and regional planners, think-tanks, the federal government and many state governments, and even some home-builders united by their interest in slowing the rate of sprawl, and making existing communities more sustainable and livable.

Sprawl – As defined in this study, the increase in the physical area of a town or city over time – outward expansion – as undeveloped or rural land at its periphery is permanently converted to developed or urbanized land as population and/or per capita land consumption grow. More specifically, in this study, sprawl is 1) the increase in the area of the Census Bureau’s Urbanized Areas, as delineated every 10 years in the decadal censuses, and/or 2) the increase in the area of a state’s area of Developed Land, as determined by the Natural Resources Conservation Service.

Suburbs – Residential or commercial zones on the outskirts of a central city or town; generally corresponds to “urban fringe.” Tend to have a lower population density than the central place or urban core, though not always, as when downtown districts are dominated by office, institutional, and commercial zones.

Urban Core – Used in this report as another description for “central location” as defined by the Census Bureau. The urban core is the entire city that anchors a metropolitan area, and usually is

at its center. It generally is the oldest, most densely populated and most built-up portion of an urbanized area.

Urban Fringe – Built-up areas near the edge of an urbanized area, generally with lower population density than the urban core; generally corresponds to the inner and outer suburbs of a town or city.

Urban Sprawl – See “sprawl.”

Urbanized Area – As defined by the U.S. Census Bureau, an area of contiguous census blocks or block groups with a population of at least 50,000 and an average population density of at least 1,000 residents per square mile.

Appendix B

Calculating Per Capita Land Consumption

The per person land consumption in each state or Urbanized Area can be expressed as:

$$(1) a = A / P$$

where:

a = area of developed or urbanized land area for the average resident

A = Area of total developed or urbanized land in a state

P = Population of that state

For example, in 2015 Arizona had 6,758,251 residents and approximately 2,108,600 developed acres. Thus, per capita developed land use for all purposes was around 0.31 acre (slightly more than a third of an acre) per resident.

The land used per person is the total developed or urbanized land area divided by the total number of people. This is the inverse of population density, which is the number of people per unit area of land. When per capita land consumption goes up, density goes down; when per capita land consumption goes down, density goes up.

The developed land area of any given state can be expressed as:

$$(2) A = P \times a$$

This can be stated as: the total developed area in square miles (or acres) of a state can be simply expressed or “factored” into the product of the Population of the state (*viz.*, P) multiplied by the per capita urban land consumption (*viz.*, a). This second equation (2) is the basis for attributing or apportioning the shares of sprawl (*viz.* growth in A) back onto two contributing factors, the growth in P and the growth in a .

Appendix C

Apportioning Shares of Overall Sprawl Between Population Growth and Per Capita Sprawl

A methodology for quantifying the respective contributions of population growth and changes in per capita consumption of any type of resource use was outlined in a 1991 paper by physicist John Holdren (“Population and the Energy Problem.” *Population and Environment*, Vol. 12, No. 3, Spring 1991). Although Dr. Holdren’s 1991 paper dealt specifically with the role of population growth in propelling the increase in U.S. energy consumption, the same methodology can also be applied to many types of population and resource consumption analyses.

In the case of sprawl, the natural resource under consideration is rural land, namely the expansion over time in the total acreage of rural land urbanized or converted into developed land and subsequently used for urban purposes, such as for housing, commerce, retail, office space, education, light and heavy industry, transportation, and so forth.

As stated in Appendix B, the total land area developed in a city (urbanized area) or state can be expressed as:

$$(1) A = P \times a$$

Where:

A = Area of total are (in acres or square miles) of development in city or state

P = Population of that city or state

a = area of city or state used by the average resident (per capita land use)

Following the logic in Holdren’s paper, if over a period of time Δt (e.g., a year or a decade), the population grows by an increment ΔP and the per capita land use changes by Δa , the total urbanized land area grows by ΔA , expressed as:

$$(2) \quad A + \Delta A = (P + \Delta P) \times (a + \Delta a)$$

Subtracting eqn. (1) from eqn. (2) and dividing through by A to compute the relative change (i.e., $\Delta A/A$) in urbanized land area over time interval Δt yields:

$$(3) \quad \Delta A/A = \Delta P/P + \Delta a/a + (\Delta P/P) \times (\Delta a/a)$$

Now equation (3) is quite general and makes no assumption about the growth model or time interval. On a year-to-year basis, the percentage increments in P and a are small (i.e., single digit percentages), so the second order term in equation (3) can be ignored. Hence following the Holdren paradigm, eqn. (3) states that the percentage growth in urbanized land area (viz., 100 percent $\times \Delta A/A$) is the sum of the percentage growth in the population (100

percent $\times \Delta P/P$) plus the percentage growth in the per capita land use (100 percent $\times \Delta a/a$). Stated in words, equation (3) becomes:

$$(4) \quad \text{Overall percentage land area growth} = \text{Overall percentage population growth} + \text{Overall percentage per capita growth}$$

In essence, the Holdren methodology quantifies population growth's share of total land consumption (sprawl) by finding the ratio of the overall percentage change in population over a period of time to the overall percentage change in land area consumed for the same period. This can be expressed as:

$$(5) \quad \text{Population share of growth} = \frac{\text{Overall percentage population growth}}{\text{Overall percentage land area growth}}$$

The same form applies for per capita land use:

$$(6) \quad \text{Per capita land use share of growth} = \frac{\text{Overall \% per capita land use growth}}{\text{Overall \% land area growth}}$$

The above two equations follow the relationship based on Prof. Holdren's equation (5) in his 1991 paper. A common growth model follows the form (say for population):

$$(7) \quad P(t) = P_0(1 + g_p)t$$

Where $P(t)$ is population at time t , P_0 is the initial population and g_p the growth rate over the interval. Solving for g_p the growth rate yields:

$$(8) \quad \ln(1 + g_p) = (1/t) \ln(P(t)/P_0)$$

Since $\ln(1 + x)$ approximately equals x for small values of x , equation (8) can be written as:

$$(9) \quad g_p = (1/t) \ln(P(t)/P_0)$$

The same form of derivation of growth rates can be written for land area (A) and per capita land use (a)

$$(10) \quad g_A = (1/t) \ln(A(t)/A_0)$$

$$(11) \quad g_a = (1/t) \ln(a(t)/a_0)$$

These three equations for the growth rates allow the result of equation (4) to be restated as:

$$(12) \quad g_P + g_a = g_A$$

Substituting the formulae (equations 9 through 11) for the growth rates and relating the initial and final values of the variables P , a and A over the period of interest into equation (12), the actual calculational relationship becomes:

$$(13) \quad \ln(\text{final population} / \text{initial population}) + \ln(\text{final per capita land area} / \text{initial per capita land area}) = \ln(\text{final total land area} / \text{initial total land area})$$

In other words, the natural logarithm (ln) of the ratio of the final to initial population, plus the logarithm of the ratio of the final to initial per capita land area (i.e., land consumption per resident), equals the logarithm of the final to the initial total land area.

In the case of Arizona from 1982 to 2015, this formula would appear as:

$$(14) \quad \ln(7,044,008 \text{ residents} / 2,889,860 \text{ residents}) + \ln(0.298 \text{ acre per resident} / 0.340 \text{ acre per resident}) = \ln(2,098,900 \text{ acres} / 982,700 \text{ acres})$$

Computing the ratios yields:

$$(15) \quad \ln(2.4375) + \ln(0.8765) = \ln(2.1359)$$

$$0.8910 + (-0.1321) = 0.7589$$

Then, applying equations (5) and (6), the percentage contributions of population growth and per capita land area growth are obtained by dividing (i.e., normalizing to 100 percent) each side by 0.7589:

$$(16) \quad \frac{0.8910}{0.7589} - \frac{0.1321}{0.7589} = \frac{0.7568}{0.7589}$$

Performing these divisions yields:

$$(17) \quad 1.17 - 0.17 = 1.0$$

Thus, we note that in the case of Arizona from 1982 to 2015, the share of sprawl due to population growth was 117 percent [100 percent x (0.8910 / 0.7589)], while declining density (i.e., an increase in land area per capita) accounted for -13 percent [100 percent x (-0.1321 / 0.7589)]. Note that the sum of both percentages equals 100 percent.

In the main body of this report we modify this gross state-wide percentage of sprawl related to population growth by using a county-by-county weighting approach. This approach accounts for the sprawl that occurs in each county and lends a proportionately greater weight to those counties with greater amounts of sprawl. In essence, sprawl in counties around Phoenix, for example, should not be attributed to population growth in counties around Flagstaff. In this method, the amount of sprawl related to population growth in each county is summed for all 15 counties in the state. This sum or aggregate is then divided by the total amount of sprawl in the state. Using this procedure, 93 percent of the sprawl in Arizona between 1982 and 2017 is shown to be associated with population growth, which the authors believe is a more accurate rendering of population growth's role than 117 percent, which exaggerates population's role, and implies that all sprawl (and then some) in Arizona is related to population growth; this is not the case.

Appendix D

Anomalies – Urbanized Areas with populations that grew but areas that supposedly shrank, or populations that shrank

From 2000 to 2010 Panama City and Titusville, in Florida, both gained population, while at the same time losing overall urban area, according to the Census Bureau’s decadal inventories of Urbanized Land.

In each of these areas, the reduction in developed urban land was likely on paper only, the result of changes in assumptions and calculations by the Census Bureau. Although it is possible for an Urbanized Area to reduce its amount of actual developed land by returning large swaths of previously developed acreage to a natural, semi-natural, feral, or agricultural condition (as has happened in the case of Detroit, Michigan), that was not the case with these two Urbanized Areas that the Census Bureau shows as having decreased in land area from 2000 to 2010.

The cause for these anomalies can be traced to changes in the delineation criteria for the 2010 Census from the 2000 Census. The most notable of these changes is the use of census tracts rather than block groups for establishing initial urban cores. One consequence of these changes was for initial urban cores to decrease in territory for the 2010 Census from the 2000 Census.

In Arizona, among the nine UAs delineated in 2000 and 2010, there was one that had an increasing population but decreasing area. The single UA in question – Sierra Vista – had modest population growth – an increase of 5,804. Its delineated urbanized area decreased substantially, by more almost two thirds (from 80 square miles to 30 square miles in just a decade). Per capita land use,

Census Tracts, Blocks, and Block Groups

A **census tract** is a geographic area defined for the purpose of taking a census. Usually census tract boundaries coincide with the limits of cities, towns, or other municipalities. Several tracts typically exist within a single county. However, in unincorporated census tract boundaries are often arbitrary, except for coinciding with political lines.

Census tracts are divided into **block groups** and these are further subdivided into **census blocks**. According to the Census Bureau, tracts are “designed to be relatively homogeneous units with respect to population characteristics, economic status, and living conditions.” On average, about 4,000 inhabitants live in a census tract.

While censuses are conducted the world over, and have been carried out for centuries, the concept of the census tract was developed in the United States, where it was first applied in the 1910 decadal census.

A **census block** is the smallest geographic unit used by the Census Bureau for tabulation of 100-percent data (data collected from all houses, rather than a sample of houses). Several blocks comprise a **block group**. There are on average about 39 blocks per block group, but this varies. Blocks typically have a four-digit number, where the first digit indicates which block group the block is in. For example, census block 3019 would be in block group 3. There are about 8,200,000 blocks in the U.S.

Block boundaries are typically streets, roads or creeks. The size of census block populations varies considerably. There are about 2,700,000 blocks with zero inhabitants, while a block that is entirely occupied by an apartment complex

in turn apparently shrank by 66 percent, from 1.1 acre per person to 0.37 acre per person, to a level much closer to but still well above the state average of 0.22 urbanized acre/capita in 2010. However, as noted above, this is more a function of a change in the delineation criteria (using census tracts rather than block groups for establishing initial urban cores) than an indication that Sierra Vista residents abruptly reduced their home and yard sizes or other non-residential urban land uses.

Source:

Christopher J. Henrie. U.S. Census Bureau, Geography Division, Geographic Standards and Criteria. "Urban Area Data Anomalies." Email message to Brian S. Schoepfer, NumbersUSA. 5 June 2013.

Appendix E

Population Growth in Arizona Counties, 1982-2017

County	Population in 1982	Population in 2002	Population in 2017	% growth 1982-2017
Apache	52,152	67,319	71,545	37%
Cochise	88,373	119,847	124,864	41%
Coconino	79,156	121,308	141,001	78%
Gila	38,924	51,478	53,578	38%
Graham	23,830	33,224	37,481	57%
Greenlee	11,747	7,831	9,443	-20%
La Paz	12,692	19,464	20,706	63%
Maricopa	1,611,847	3,255,388	4,327,184	168%
Mohave	62,539	166,155	207,017	231%
Navajo	66,910	100,123	109,079	63%
Pima	568,004	874,267	1,026,391	81%
Pinal	96,802	197,082	431,564	346%
Santa Cruz	21,689	40,009	46,566	115%
Yavapai	74,009	177,362	228,082	208%
Yuma	81,186	165,398	209,507	158%
All Arizona Counties	2,889,860	5,396,255	7,044,008	144%

Appendix F

Advisors* to the 2001 study “Weighing Sprawl Factors in Large U.S. Cities”

All sprawl studies published by NumbersUSA Education & Research Foundation have been conducted with methodologies and analysis that were developed with the assistance and review by the following professional advisors.

Urban Planning Oversight

Earl M. Starnes, *Ph.D.*, professor emeritus, urban and regional planning, University of Florida
Eben Fodor, urban planning consultant, Eugene (OR); author, *Better not Bigger: How to Take Control of Urban Growth and Improve Your Community*

Gabor Zovanyi, *Ph.D.*, professor of urban planning, Eastern Washington University

Robert Seaman, associate professor of environmental science, New England College; executive committee, American Society of Civil Engineers' Urban and Development Division

Ruth Steiner, *Ph.D.*, professor of urban and regional planning, University of Florida

Statistical Oversight

Alan J. Truelove, *Ph.D.*, statistician, retired professor, University of the District of Columbia

B. Meredith Burke (1947-2002), *Ph.D.*, demographer

Ben Zuckerman, *Ph.D.*, professor of physics and astronomy, UCLA; member, UCLA Institute of the Environment

David Simcox, director, Migration Demographics

Dick Schneider, chair, Sierra Club Northern California Regional Sustainability Task Force

Leon Bouvier (1922-2011), *Ph.D.*, demographer, Old Dominion University (VA)

Mark C. Thies, *Ph.D.*, *P.E.*, professor of chemical engineering, Clemson University

Marshall Cohen, *Ph.D.*, professor emeritus of astronomy, California Institute of Technology

Paul Nachman, *Ph.D.*, physicist

Scott Briles, *Ph.D.*, engineer, Los Alamos National Laboratory, University of California

Steven A. Camarota, *Ph.D.*, public policy analyst

William E. Murray, Jr., *Ph.D.*, physicist

Michael Mueller, *Ph.D.*, natural resource economist

Continued on next page

* The individuals on this list volunteered to provide advice and guidance to the 2001 Kolankiewicz-Beck sprawl study for NumbersUSA and to have their names listed prominently as Advisors inside the front cover.

The affiliations of the Advisors were listed for identification purposes only, and it was emphasized that the views in the report did not necessarily reflect the views either of the institutions listed alongside them or of all views of the Advisors. Several Advisors helped shape the methodology of the study during the

18 months it lasted, and also assisted with production of interim reports on California and Florida. As the national-level study neared completion, the authors sought the assurance of having many more Advisors with a broad array of expertise to read the results and examine the analysis and methodology. The authors gratefully acknowledged the detailed recommendations, rigorous reviews, and vigorous discussion from and among the Advisors.

Environmental and General Oversight

Albert Bartlett (1923-2013), *Ph.D., professor emeritus of physics, University of Colorado*

Betty B. Davis, *Ph.D., psychologist*

Bill Smith, *Ph.D., dean, College of Global Economics, EarthNet Institute*

Craig Diamond, *adjunct faculty, environmental studies, Florida State University; technical advisor to the Sierra Club carrying capacity campaign*

David Pimentel (1925-2019), *Ph.D., professor of ecology and agricultural sciences, Cornell University*

Diana Hull (1924-2017), *Ph.D., behavioral scientist, retired, Baylor College of Medicine*

Edward G. Di Bella, *adjunct faculty, Grossmont Community College (CA); president, Friends of Los Penasquitos Canyon Preserve*

Garrett Hardin (1915-2003), *Ph.D., professor emeritus of human ecology, University of California, Santa Barbara*

George Wolford, *Ph.D., president, EarthNet Institute*

Herbert Berry, *Ph.D., retired associate professor of computer information systems, Morehead State University (KY)*

James G. McDonald, *attorney, civil engineer*

Jeffrey Jacobs, *Ph.D., National Academy of Sciences*

John Bermingham (1923-2020), *former Colorado state senator and Colorado Land Use Commissioner*

John Rohe, *attorney; board, Conservation News Service*

Linda Thom, *retired government budget analyst, Santa Barbara County (CA)*

Michael Hanauer, *member, Vision 2020, growth management project of Lexington, (MA)*

Ross McCluney, *Ph.D., principal research scientist, Florida Solar Energy Center, University of Central Florida*

Steve Miller, *former Las Vegas councilman, Clark County (NV) Regional Transportation Commissioner*

Stuart Hurlbert, *Ph.D., professor of biology, San Diego State University*

Terry Paulson, *Mayor Pro-tem, Aspen (CO) City Council*

Tom Reitter, *Livermore (CA) City Council*

Appendix G

2020 and 2014 National Polls on Sprawl and Population

National Survey of 1,500 Likely Voters

Conducted May 25-27, 2020

By Pulse Opinion Research

Margin of Sampling Error, +/- 2.5 percentage points with a 95% level of confidence

1* The U.S. Department of Agriculture calculates that in recent decades urban sprawl has destroyed 43 million acres of farmland and natural habitat, an area about equal in size to all of New England. If this trend were to continue, would it be a major problem, somewhat of a problem, not much of a problem, or not a problem at all?

44% A major problem

35% Somewhat of a problem

11% Not much of a problem

4% Not a problem at all

6% Not sure

2* How important is it to protect farmland from development so the United States is able to produce enough food to completely feed its own population in the future?

62% Very important

27% Somewhat important

6% Not very important

1% Not important at all

3% Not sure

3* How important is it for the United States to have enough farmland to be able to feed people in other countries as well as its own?

32% Very important

45% Somewhat important

16% Not very important

4% Not important at all

3% Not sure

4* Which do you agree with more: That it is unethical to pave over and build on good cropland or that the need for more housing is a legitimate reason to eliminate cropland?

62% It is unethical to pave over and build on good cropland

18% The need for more housing is a legitimate reason to eliminate cropland

20% Not sure

5* The government reports that to make room for growing cities the last three decades, 19 million acres of surrounding woodlands have been cut down. How significant a problem is this loss of natural wildlife habitat?

51% Very significant

34% Somewhat significant

9% Not very significant

2% Not significant at all

4% Not sure

6* Does the United States have a responsibility to the rest of the world to preserve a certain amount of its natural habitat or is preserving the United States natural habitat not a matter of global concern?

62% The United States has a responsibility to the rest of world to preserve its natural habitat

27% Preserving the natural habitat is not a matter of global concern

11% Not sure

7* Do you feel an emotional or spiritual uplift from time spent in natural areas like woodlands, wetlands and grasslands?

73% Yes

16% No

11% Not sure

8* How important is it that you can get to natural areas fairly quickly from where you live?

- 45% Very important
- 40% Somewhat important
- 10% Not very important
- 2% Not important at all
- 3% Not sure

9* A study of government data found that most of the development destruction of farmland and natural habitat in the last decade has been related to the country's population growing by 22 million people. The Census Bureau projects the population is on pace to add another 86 million in the next 40 years. Would this rate of population growth in YOUR area make it a better place to live, a worse place to live, or would it not make much difference?

- 16% A better place to live
- 50% A worse place to live
- 25% Not make much difference
- 9% Not sure

10* If the population in YOUR AREA were to increase significantly, would the government be able to build enough extra transportation capacity to accommodate the extra people or would traffic likely become much worse?

- 28% The government would be able to build enough extra transportation capacity to accommodate the extra people
- 61% Traffic likely would become much worse
- 12% Not sure

11* Over the rest of this century, would you prefer that the nation's population continue to grow toward 500 million, grow much more slowly, stay about the same as it is now at 331 million, or slowly become smaller?

- 17% Continue to grow toward 500 million
- 43% Grow much more slowly
- 22% Stay about the same at 331 million

10% Slowly become smaller

8% Not sure

12* Census data shows that since 1970, annual immigration has tripled and is now the cause of nearly all long-term population growth. Should the federal government reduce annual immigration to slow down population growth, keep immigration and population growth at the current level, or increase annual immigration and population growth?

47% Reduce annual immigration to slow down population growth

33% Keep annual immigration and population growth at the current level

12% Increase annual immigration and population growth

8% Not sure

13* Currently the government allows one million legal immigrants each year. How many legal immigrants should the government allow each year -- two million or more, one million, a half-million, or 100,000 or less?

17% Two million or more

27% One million

21% Half a million

22% 100,000 or less

14% Not sure

14* One way to handle continued population growth without losing as much natural habitat and farmland would be to increase population density by changing zoning and other regulations so more residents live in apartments and condo buildings instead of single-family houses. Do you strongly favor, somewhat favor, somewhat oppose or strongly oppose this kind of change?

16% Strongly favor

32% Somewhat favor

24% Somewhat oppose

17% Strongly oppose

12% Not sure

15* Which best describes your current neighborhood – is it higher population-density with at least some apartments or townhouses, is it less-densely populated with mostly single-family houses, or is it rural?

32% Your neighborhood is higher population-density with at least some apartments or townhouses

50% Less-densely populated with mostly single-family houses

14% If rural

3% Not sure

16* Would you prefer to live in a mixed higher-density neighborhood of stores, townhouses, apartments and condos, a neighborhood of single-family houses, or a rural area?

26% Mixed higher-density neighborhood of stores, townhouses, apartments and condos

45% Neighborhood of single-family houses

24% Rural area

5% Not sure

17* As a result of the coronavirus pandemic, does living in a more densely populated area appear more attractive, less attractive or has it not made much difference?

14% More attractive

50% Less attractive

32% It has not made much difference

3% Not sure

National Survey of 1,500 Likely Voters

Conducted April 1-2, 2014

By Pulse Opinion Research

Margin of Sampling Error, +/- 3 percentage points with a 95% level of confidence

1* The U.S. Department of Agriculture calculates that over the last decade urban sprawl destroyed millions of acres of farmland and natural habitat equal in size to the entire state of Maryland. If this were to continue, would it be a major problem, somewhat of a problem, not much of a problem or not a problem at all?

42% A major problem

35% Somewhat of a problem

17% Not much of a problem

3% Not a problem at all

4% Not sure

GROUPINGS: 77% A major or somewhat PROBLEM

20% NOT MUCH or at all a problem

2* How important is it to protect farmland from development so the United States is able to produce enough food to completely feed its own population in the future?

71% Very important

21% Somewhat important

6% Not very important

0% Not important at all

2% Not sure

GROUPINGS: 92% Very or somewhat IMPORTANT

6% NOT VERY important

3* How important is it for the United States to have enough farmland to be able to feed people in other countries as well as its own?

26% Very important

46% Somewhat important

19% Not very important

6% Not important at all

2% Not sure

GROUPINGS: 72% Very or somewhat IMPORTANT

25% NOT VERY or at all important

4* Which do you agree with more: That it is unethical to pave over and build on good cropland or that the need for more housing is a legitimate reason to eliminate cropland?

59% It is unethical to pave over and build on good cropland
 19% The need for more housing is a legitimate reason to eliminate cropland
 22% Not sure

5* The government reports that to make room for growing cities the last three decades, 17 million acres of surrounding woodlands have been cut down. How significant a problem is this loss of natural wildlife habitat?

53% Very significant
 32% Somewhat significant
 11% Not very significant
 1% Not at all significant
 3% Not sure

GROUPINGS: 85% Very or somewhat SIGNIFICANT
 12% NOT VERY or at all significant

6* Do you feel an emotional or spiritual uplift from time spent in natural areas like woodlands and open grasslands?

70% Yes
 18% No
 12% Not sure

7* How important is it that you can get to natural areas fairly quickly from where you live?

48% Very important
 37% Somewhat important
 11% Not very important
 2% Not important at all
 2% Not sure

GROUPINGS: Very or somewhat IMPORTANT
 NOT VERY or at all important

8*A study of government data found that most of the development destruction of farmland and natural habitat over the last decade was related to rapid growth in the United States population. The Census Bureau projects the population is on pace to double this century. Would doubling the population in YOUR area make it better, worse or not much different?

9% Better
 60% Worse
 24% Not much different
 7% Not sure

9* If the population in YOUR AREA were to double, would traffic become much worse or would the government be able to build enough extra transportation capacity to accommodate the extra people?

- 68% Traffic would become much worse
- 20% The government would be able to build enough extra transportation capacity to accommodate the extra people
- 13% Not sure

10* Over the rest of this century, would you prefer that the nation's population continue to double to 600 million, grow by half to 450 million, stay about the same as it is now at just over 300 million, or slowly become smaller?

- 9% Continue to double to 600 million
 - 26% Grow by half to 450 million
 - 43% Stay about the same at more than 300 million
 - 12% Slowly become smaller
 - 9% Not sure
- GROUPINGS: 9% Continue present pace
 81% Slow pace of growth by at least half

11* Census data show that since 1972, the size of American families has been at replacement-level. But annual immigration has tripled and is now the cause of nearly all long-term population growth. Does the government need to reduce immigration to slow down population growth, keep immigration the same and allow the population to double this century, or increase immigration to more than double the population?

- 68% Reduce immigration to slow down population growth
- 18% Keep immigration the same and allow population to double
- 4% Increase immigration to more than double the population
- 10% Not sure

12* Currently the government allows one million legal immigrants each year. How many legal immigrants should the government allow each year – two million, one million, a half-million, 100,000, or zero?

- 7% Two million
 - 14% One million
 - 23% Half a million
 - 20% 100,000
 - 20% Zero
 - 16% Not sure
- GROUPINGS: 21% Keep same level or increase
 63% Cut immigration at least in half

Appendix H

Arizona Survey of 1,500 Likely Voters

Conducted April 22-23 and 26-27, 2020

By Pulse Opinion Research

Margin of Sampling Error, +/- 3 percentage points with a 95% level of confidence

13* The U.S. Department of Agriculture calculates that Arizona over the last four decades has turned more than 1,700 square miles of natural habitat and agricultural land into housing, shopping malls, streets and other urban development. On balance, has this made Arizona a better place to live, a worse place to live or did it not have much effect?

- 32% This development has made Arizona a better place to live
- 37% A worse place to live
- 22% It did not have much effect
- 8% Not sure

14* Has Arizona developed too much, too little, or about as much as it should?

- 37% Too much
- 8% Too little
- 49% About as much as it should
- 6% Not sure

15* Government data show that the United States now has about one-third less cropland for each American than it did 30 years ago. How important is it to protect U.S. farmland from development so the United States is able to produce enough food to feed its own population in the future?

- 66% Very important
- 25% Somewhat important
- 5% Not very important
- 1% Not at all important
- 3% Not sure

16* If recent trends continue, Arizona demographers project that the state's population of 7.4 million will grow by another 3 million by 2050, joining Tucson and Phoenix together into a single "mega-city." Do you find this prospect to be more positive or more negative?

- 17% More positive
- 69% More negative
- 14% Not sure

17* Arizona cities compete for scarce water with the agriculture industry which relies on irrigation for most of its nearly million acres of cropland. Should water used to cultivate crops be diverted to support additional population growth?

- 19% Yes
- 55% No
- 26% Not sure

6. Arizona is an arid state with limited water in already depleted streams and aquifers. Is it more important for the remaining water to be used to support wildlife habitat, fish and water birds or is it more important to use the remaining water to support the needs of farms and a growing urban population?

- 47% More important for remaining water to be used to support wildlife habitat, fish and water birds
- 39% More important to use remaining water for farms and growing urban population
- 14% Not sure

7. Arizona faces decisions about how to provide sufficient water for urban needs if the state adds another 3 million people by 2050. In order to accommodate this additional population is it better to divert the water from the state's remaining surface water and aquifers, divert the water from agriculture, build a pipeline across Mexico and California to transport desalinated Pacific Ocean water, or is it better to no add another 3 million residents?

- 10% It is better to divert the water from the state's remaining surface water and aquifers
- 7% It is better to divert the water from agriculture
- 31% It is better to build a pipeline across Mexico and California to transport desalinated Pacific Ocean water
- 44% It is better not to add another 3 million residents
- 8% Not sure

8. From an environmental standpoint how important is it to preserve Arizona's deserts, grasslands, woodlands, forests, and canyons?

- 73% Very important
- 22% Somewhat important
- 3% Not very important
- 1% Not at all important
- 2% Not sure

9. How important is it that you can easily spend time in natural areas near where you live?

- 57% Very important
- 33% Somewhat important
- 6% Not very important
- 1% Not at all important
- 2% Not sure

10. A study of government data found that three-quarters or more of the depletion of Arizona’s natural habitat and farmland in recent decades was related to Arizona’s rapid population growth. Would continuing this level of population growth into the future make Arizona better, worse or not much different?

- 10% Better
- 64% Worse
- 19% Not much different
- 8% Not sure

11. If the population in YOUR AREA were to increase significantly, would traffic become much worse or would the government be able to build enough extra transportation capacity to accommodate the extra people?

- 78% Traffic would become much worse
- 14% Government be able to build enough extra transportation capacity to accommodate the extra people
- 8% Not sure

12. Arizona’s population has more than doubled since 1980 and is on pace to increase by another third over the next three decades. Would you prefer that Arizona’s population continue to double in size, that it grow much more slowly, that it stay about the same size, or that it become smaller?

- 8% You prefer that Arizona’s population continue to double
- 48% You prefer that Arizona’s population grow much more slowly
- 26% You prefer Arizona’s population remain the same
- 14% You prefer Arizona’s population become smaller
- 4% Not sure

13. A major source of Arizona’s population growth is people moving in from other states, especially California. Should local and state governments in Arizona make it more difficult for people to move to Arizona from other states by restricting development.

- 49% Yes
- 33% No
- 18% Not sure

14. Census data show that new immigrants and births to immigrants have been equal to 44% of all Arizona population growth since the year 2000. Should the federal government reduce annual immigration to slow down Arizona's population growth, keep immigration and population growth at the current level, or increase annual immigration and population growth?

- 44% Federal government should reduce annual immigration to slow down Arizona's population growth
- 39% Federal government should keep immigration and population growth at the current level
- 9% Federal government should increase annual immigration and population growth
- 8% Not sure

15. Currently the government allows one million legal immigrants each year. How many legal immigrants should the government allow each year – two million or more, one million, a half-million, or 100,000 or less?

- 14% Two million or more
- 24% One million
- 21% Half a million
- 26% 100,000 or less
- 15% Not sure

16. One way to handle continued population growth without losing as much natural habitat and farmland in Arizona is to change zoning and other regulations so that more residents live in apartments and condo buildings instead of single-family houses. Do you strongly favor, somewhat favor, somewhat oppose or strongly oppose this kind of change?

- 12% Strongly favor
- 26% Somewhat favor
- 27% Somewhat oppose
- 24% Strongly oppose
- 11% Not sure

17. Do you live in a rural area, a town, a small city, the suburbs or in a big city?

- 10% Rural
- 12% Town
- 18% Small city
- 36% Suburbs
- 22% Big city
- 1% Not sure

18. Where would you prefer to live... in a rural area, a town, a small city, the suburbs or in a big city?

18% Rural
11% Town
24% Small city
31% Suburbs
12% Big city
3% Not sure

19. Have you lived in Arizona since childhood or did you move to Arizona as an adult?

40% Since childhood
59% Moved as an adult
1% Not sure

20. About how long have you lived in Arizona, less than 10 years, 10 to 30 years, or more than 30 years?
(Answered only by those who moved to Arizona as an adult...590 voters)

19% Less than 10 years
53% 10-30 years
28% More than 30 years
0% Not sure

21. Were you born in the United States? (Answered only by those who moved to Arizona as an adult...590 voters)

92% Yes
8% No
0% Not sure

Appendix I

Major Findings of our First National Sprawl Studies in 2001 and 2003

Our two sprawl studies – conducted almost two decades ago (published in 2001 and 2003) – were titled “Weighing Sprawl Factors in Large U.S. Cities: A report on the nearly equal roles played by population growth and land use choices in the loss of farmland and natural habitat to urbanization”¹¹⁰ and “Outsmarting Smart Growth: Population Growth, Immigration, and the Problem of Sprawl.”¹¹¹ They made a number of key findings and conclusions.

The two main findings from the 2001 study on the 100 largest Urbanized Areas in the U.S. were the following:

(2) **Per Capita Sprawl:** About half the sprawl nationwide appears to be related to the land-use and consumption choices that lead to an increase in the average amount of urban land per resident (**Figure I-1**).

(2) **Population Growth:** The other half of sprawl is related to the increase in the number of residents within those 100 Urbanized Areas.

“On average, there are more of us, and each of us is using more urban land, and therein lie the two halves of the problem,” wrote the authors in the 2001 study. These findings then led the authors to the following conclusions:

- The toll of urban sprawl on ecosystems, farmland and scenic open spaces cannot be substantially halted unless anti-sprawl efforts include a two-pronged attack using both land-use/consumption tools and population tools.
- Anyone advocating U.S. population stabilization who derides the importance of consumption and planning controls is ignoring half the story of American sprawl.
- Similarly, any Smart Growth advocate who relegates population growth to a side issue is turning a blind eye to half the problem and, thus, approximately half the solution, which is U.S. population stabilization.

¹¹⁰ Kolankiewicz, L. and R. Beck. 2001. Weighing Sprawl Factors in Large U.S. Cities: A report on the nearly equal roles played by population growth and land use choices in the loss of farmland and natural habitat to urbanization. Analysis of U.S. Bureau of the Census Data on the 100 Largest Urbanized Areas of the United States. March 19. NumbersUSA: Arlington, VA. 64 pp. Available at: <https://www.numbersusa.com/content/resources/publications/publications/studies/weighing-sprawl-factors-large-us-cities.html>.

¹¹¹ Beck, R., L. Kolankiewicz, and S. Camarota. 2003. Outsmarting Smart Growth: Population Growth, Immigration, and the Problem of Sprawl. Washington, DC: Center for Immigration Studies. Center Paper 22. August. 122 pp. Available at: <http://www.cis.org/sites/cis.org/files/articles/2003/sprawl.html>.

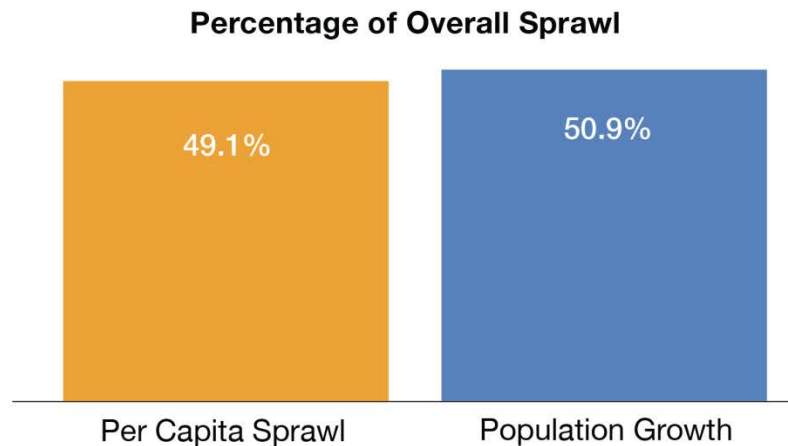


Figure I-1. Sources of Urban Sprawl in 100 Largest Cities, 1970-1990

Source: Kolankiewicz and Beck (2001). Footnote #1.

- Although the circumstances of each city are different, the power of both sprawl factors is potentially the same in each. Every city that wishes to restrain its land expansion will need to continually keep in mind the impacts on sprawl of both growth factors. Cities with no recent per capita land consumption growth should not throw away land-use tools, lest Per Capita Sprawl resume. And cities with no recent population growth will still need to be reminded regularly of the role population can play in sprawl, lest they inadvertently create incentives to promote population growth in the future.
- The forces driving overall national population growth cannot be ignored as contributors to sprawl, since national population growth manifests itself as growth in local communities.

The 2001 study concluded that cities with either, 1) no growth in population or, 2) no growth in per capita land consumption, still had sprawl. However, cities that had both types of growth had far higher sprawl (**Figure I-2**).

The main emphasis of the later 2003 study “Outsmarting Smart Growth” was analysis of sample data from the National Resource Conservation Service’s NRI that estimated the increase in developed land from 1982-1997. That study reached these findings and conclusions:

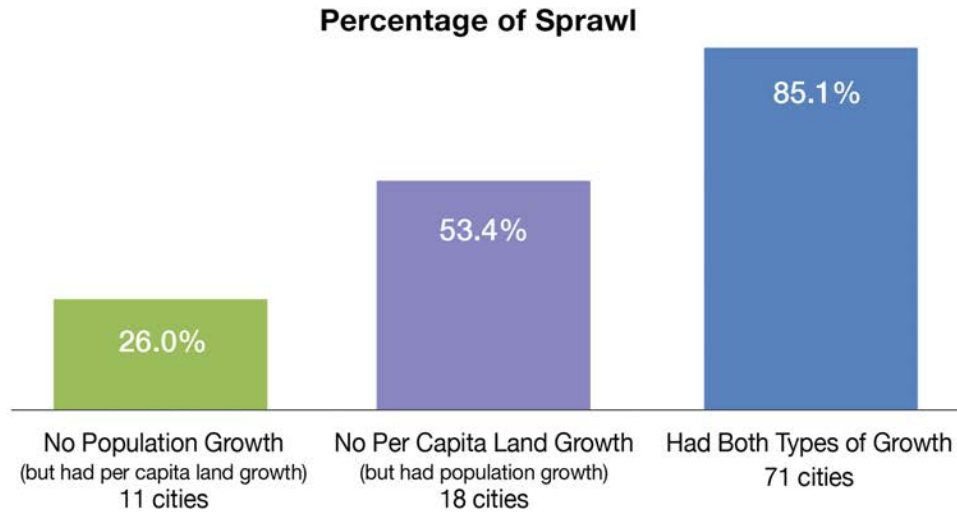


Figure I-2. Average Sprawl Rate by Type of Growth, 100 Largest Cities, 1970-1990

Source: Kolankiewicz and Beck (2001). Footnote #1.

- The more a given state’s population grew, the more the state sprawled (see **Figure I-3**). For example, states that grew in population by more than 30 percent between 1982 and 1997 sprawled 46% on average. In contrast, states that grew in population by less than 10% sprawled only 26% on average.
- On average, each 10,000-person increase in a state’s population resulted in 1,600 acres of undeveloped rural land being developed, even controlling for other factors such as changes in population density.
- Apportioning the share of sprawl that is due to increases in population versus increases in per-capita land consumption shows that, nationally, population growth accounted for 52 percent of the loss of rural land between 1982 and 1997, while increases in per-capita land consumption accounted for 48 percent.
- While population growth is a key factor driving sprawl, our findings indicate that Smart Growth must also play a significant role in anti-sprawl efforts because per capita land use has been increasing. Between 1982 and 1997, land use per person rose 16 percent from 0.32 acres to 0.37 acres.
- There is significant variation between states in the factors accounting for sprawl. For example, population growth accounted for more than half of sprawl in five of the 10 states that lost the most land, while increases in per-capita land use accounted for more than half of sprawl in the other five worst sprawling states.

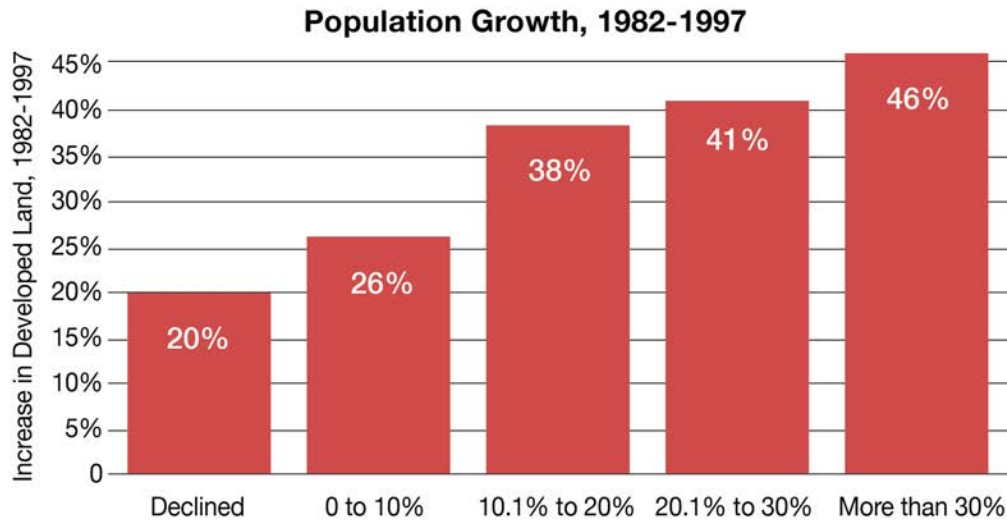


Figure I-3. Percentage Increase in Developed Land by State's Percentage Population Growth

Source: Beck, Kolankiewicz and Camarota (2003). Footnote #2.

- An examination of the nation's largest urban areas reveals the same pattern as in the states. Between 1970 and 1990, population growth accounted for slightly more than half of the expansion of urbanized land in the nation's 100 largest cities.
- In the 1990s, new immigration and immigrant fertility accounted for most of the 33-million increase in the U.S. population. Census Bureau data from 2002 indicate that the more than 1.5 million legal and illegal immigrants who settle in the country each year along with 750,000 yearly births to immigrants are equal to 87 percent of the annual increase in the U.S. population.
- Contrary to the common perception, about half the country's immigrants now live in the nation's suburbs. The pull of the suburbs is even greater in the second generation. Of the children of immigrants who have settled down and purchased a home, only 24 percent have done so in the nation's central cities.
- The suburbanization of immigrants and their children is a welcomed sign of integration. But it also means that they contribute to sprawl just like other Americans.

"In short," concluded the 2003 study, "Smart Growth efforts to slow or stop the increase in per capita land use are being negated by population growth. Immigration-driven population growth, in effect, is 'out-smarting' Smart Growth initiatives by forcing continued rural land destruction.

Appendix J

Forty-Eight Contiguous States Ranked by Percentage Increase in Developed Land (Overall Sprawl), 1982 to 2017

State	Developed Land Area 1982 (sq. miles)	Developed Land Area 2017 (sq. miles)	Overall Sprawl (square miles), 1982-2017	% Increase in Area of Developed Land	Ranking by Percentage Increase
Nevada	336	850	514	152.8%	1
Arizona	1,536	3,280	1,744	113.6%	2
Georgia	3,480	7,390	3,910	112.4%	3
North Carolina	3,686	7,681	3,995	108.4%	4
South Carolina	2,133	4,269	2,136	100.1%	5
Florida	4,398	8,751	4,353	99.0%	6
Utah	738	1,451	713	96.5%	7
Tennessee	2,570	4,924	2,354	91.6%	8
New Mexico	1,122	2,141	1,019	90.8%	9
Kentucky	1,770	3,352	1,582	89.4%	10
Delaware	250	466	216	86.8%	11
New Hampshire	628	1,152	524	83.6%	12
West Virginia	997	1,824	827	83.0%	13
Texas	8,258	14,891	6,633	80.3%	14
Alabama	2,565	4,588	2,023	78.9%	15

Virginia	2,872	5,052	2,180	75.9%	16
Maine	787	1,368	581	73.9%	17
Mississippi	1,828	3,045	1,217	66.6%	18
Idaho	876	1,458	582	66.5%	19
Colorado	1,878	3,084	1,206	64.2%	20
Louisiana	1,930	3,122	1,192	61.7%	21
Pennsylvania	4,358	7,045	2,687	61.6%	22
Massachusetts	1,738	2,776	1,038	59.7%	23
New Jersey	1,848	2,925	1,077	58.3%	24
Maryland	1,521	2,398	877	57.6%	25
Washington	2,515	3,951	1,436	57.1%	26
Vermont	412	636	224	54.4%	27
Arkansas	1,905	2,940	1,035	54.3%	28
California	6,401	9,821	3,420	53.4%	29
Michigan	4,402	6,610	2,208	50.2%	30
Oklahoma	2,320	3,454	1,134	48.8%	31
Ohio	4,452	6,601	2,149	48.3%	32
Oregon	1,524	2,212	688	45.1%	33
Indiana	2,795	3,999	1,204	43.1%	34
Minnesota	2,699	3,845	1,146	42.5%	35
Wisconsin	3,099	4,360	1,261	40.7%	36

Missouri	3,387	4,717	1,330	39.3%	37
Rhode Island	268	367	99	37.0%	38
New York	4,441	6,083	1,642	37.0%	39
Illinois	4,115	5,447	1,332	32.4%	40
Montana	1,334	1,749	415	31.2%	41
Wyoming	837	1,088	251	30.0%	42
Connecticut	1,320	1,701	381	28.9%	43
Kansas	2,711	3,338	627	23.1%	44
South Dakota	1,273	1,525	252	19.8%	45
Iowa	2,564	3,069	505	19.7%	46
North Dakota	1,419	1,652	233	16.4%	47
Nebraska	1,711	1,981	270	15.8%	48

Source: USDA Natural Resources Conservation Service, 2017 National Resources Inventory, Summary Report (September 2020), Table



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