The Costs of Sprawl

Fiscal, Environmental, and Quality of Life Impacts of Low-Density Development in the Denver Region

Ann Livingston
Elizabeth Ridlington
Matt Baker

Environment Colorado
Research and Policy Center

March 2003

ACKNOWLEDGEMENTS

The Environment Colorado Research and Policy Center gratefully acknowledges Elise Jones of the Colorado Environmental Coalition, Rich McClintock of the Livable Communities Support Center, Graham Billingsley of the American Planning Association, Stan Clauson of the American Planning Association, Larry Mugler of the Denver Regional Council of Governments, and Susan LeFever of the Sierra Club for peer review.

The Environment Colorado Research and Policy Center would also like to thank Mara Thermos for researching several of the case studies, Marc Cittone for research and writing assistance, Elena Nunez for research and editing input, Tony Dutzik for extensive editing help, and Brad Heavner for providing layout.

The authors alone bear responsibility for any factual errors. The recommendations are those of the Environment Colorado Research and Policy Center. The views expressed in this report are those of the authors and do not necessarily express the views of our funders.

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1530 Blake Street, Suite 220
Denver, CO 80202

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EXECUTIVE SUMMARY

In Colorado, the past several decades have been characterized by rapid population growth and poorly planned, sprawling patterns of development. Sprawl has led to higher costs for infrastructure such as sewer systems, schools, and roads; strained the region's water resources; destroyed agricultural land and open space; caused increased traffic congestion; and reduced the quality of life for many Coloradans.

Studies and recent experience—both in Colorado and elsewhere—show that continued sprawl in the Denver region would result in substantial direct and indirect costs to taxpayers and consumers.

- **Infrastructure**: Water and sewer lines, schools, roads, and emergency services such as fire and police protection can cost twice as much in low-density subdivisions as in traditional, more compact communities. Government operating expenses are also frequently higher in sprawling communities.
- **Water Availability**: Compact, planned development can use up to 35 percent less water than low-density sprawling development, mostly as a result of reduced water use for landscaping. Low water availability in the Denver region is currently imposing major quality-of-life costs on area residents and could lead to proposals for the construction of expensive water diversion projects.
- **Water Quality**: Sprawling development patterns subject additional waterways to runoff of toxic substances, sediments, and nutrients, and can threaten the survival of wetlands. The Denver Regional Council of Governments (DRCOG) estimates that sprawling development threatens 60 subwatersheds in the region—about 25 percent of which could be protected through more compact forms of development. Declining water quality in these watersheds could reduce their recreational, aesthetic, and environmental value.
- **Farmland and Open Space**: Between 1992 and 1997, Colorado lost more than 270,000 acres of agricultural lands to development and other uses each year, destroying a valuable, long-term economic resource. Ten thousand of those acres were prime farmland. DRCOG estimates that compact development patterns could save 60 percent of the region's farmland over the next two decades.
- **Traffic Congestion**: The Denver metropolitan area currently possesses the 11th worst traffic congestion in the nation, with time spent in congestion costing the economy an estimated $1.225 billion dollars annually. Sprawling development patterns lead to greater traffic congestion by requiring longer and more frequent automobile trips and reducing the viability of transit and other transportation alternatives. Smart growth policies could save the Denver region $4 billion in road and highway construction costs over 25 years.

In an effort to rein in sprawl and promote more compact development, DRCOG adopted a 731-square-mile urban growth boundary for the region in 1997. In the years since, DRCOG has been under sustained pressure to expand the boundary and allow more sprawling development on the region's urban fringe.

As DRCOG considers the size of the urban growth boundary in its revision of the "Metro Vision" regional plan, the Denver region faces a choice: a future of compact development within strong urban boundaries, or the expansion of sprawl farther out beyond the urban fringe. To prevent sprawling development—and all of its attendant costs—DRCOG should retain the current urban growth boundary and, in cooperation with local governments, apply smart growth principles to future development in the region. By continuing to promote smart growth policies, we can protect our environment, quality of life, and pocketbooks.

Sprawl in the Metro Region

For the past decade Colorado has experienced rapid population growth. In fact, four of the nation's 10 fastest growing counties are in Colorado.[1] Because this population growth occurred in an era characterized by sprawling patterns of development, the average rate of land consumption in the Denver metropolitan region was much greater than the rate of population growth: between 1982 and 1997, the Denver area's population grew by 30 percent while its land area grew 43 percent.[2]

Colorado is expected to continue to absorb large population increases over the next several decades. According to projections, an additional 2.2 million people will move to the state between 2000 and 2025.[3] DRCOG predicts that the population in the metro area alone will increase by approximately one million people in the next 25 years. That means that the nine-county Denver region, where about half of the state's population resides, will experience a 45 percent increase in population between 2000 and 2025.

How the Denver region will accommodate this expected population boom—without further straining the area's finances, natural resources, and quality of life—has been the subject of intense discussion among local governments in the region.

Metro Vision 2020

In the Denver region, 51 local governments work together to achieve a regional vision on land use and transportation through DRCOG. In 1997, DRCOG adopted Metro Vision 2020, which established regional goals and policies regarding urban development, transportation, open space, urban centers, and environmental quality through the end of the planning horizon in 2020. All of these policies were designed to ensure that the region retained a high quality of life in the future.

One key component of Metro Vision 2020 was the establishment of urban growth boundaries/areas (UGBs) in the Denver region. With the support of local governments and smart growth advocates, DRCOG adopted a 731-square-mile urban growth boundary that protected about 400 square miles of open space and agricultural land that might otherwise have been developed. The UGB is more than a line on a piece of paper. Through the Mile High Compact, 32 local governments in the region have committed to implement the policies of Metro Vision and other related smart growth policies through their locally adopted comprehensive plans and land-use regulations.

Characteristics of Sprawl

- Low density
- Unlimited outward expansion
- Leapfrog development
- No attempt at clustering, mixing of uses, or establishing city centers
- Resource-consumptive development
- Automobile-dominated transportation

While establishment of the UGB was a positive step, the boundary has not been completely successful in limiting sprawl. Since 1997, the boundary has been expanded at the request of a few local governments and now stands at 747 square miles. Criteria have not yet been established to evaluate the merit of expansion proposals. And the effectiveness of the boundary has been further compromised by policies that allow for unlimited semi-urban development on one- to 35-acre parcels outside the boundary. Currently, approximately eight percent of the metro area population lives in such areas, occupying about 800 square miles of land outside the UGB.[4] However, only about 500 square miles within the boundary have urban development, leaving ample room for future development while ensuring that such development is not permitted to sprawl out of control.

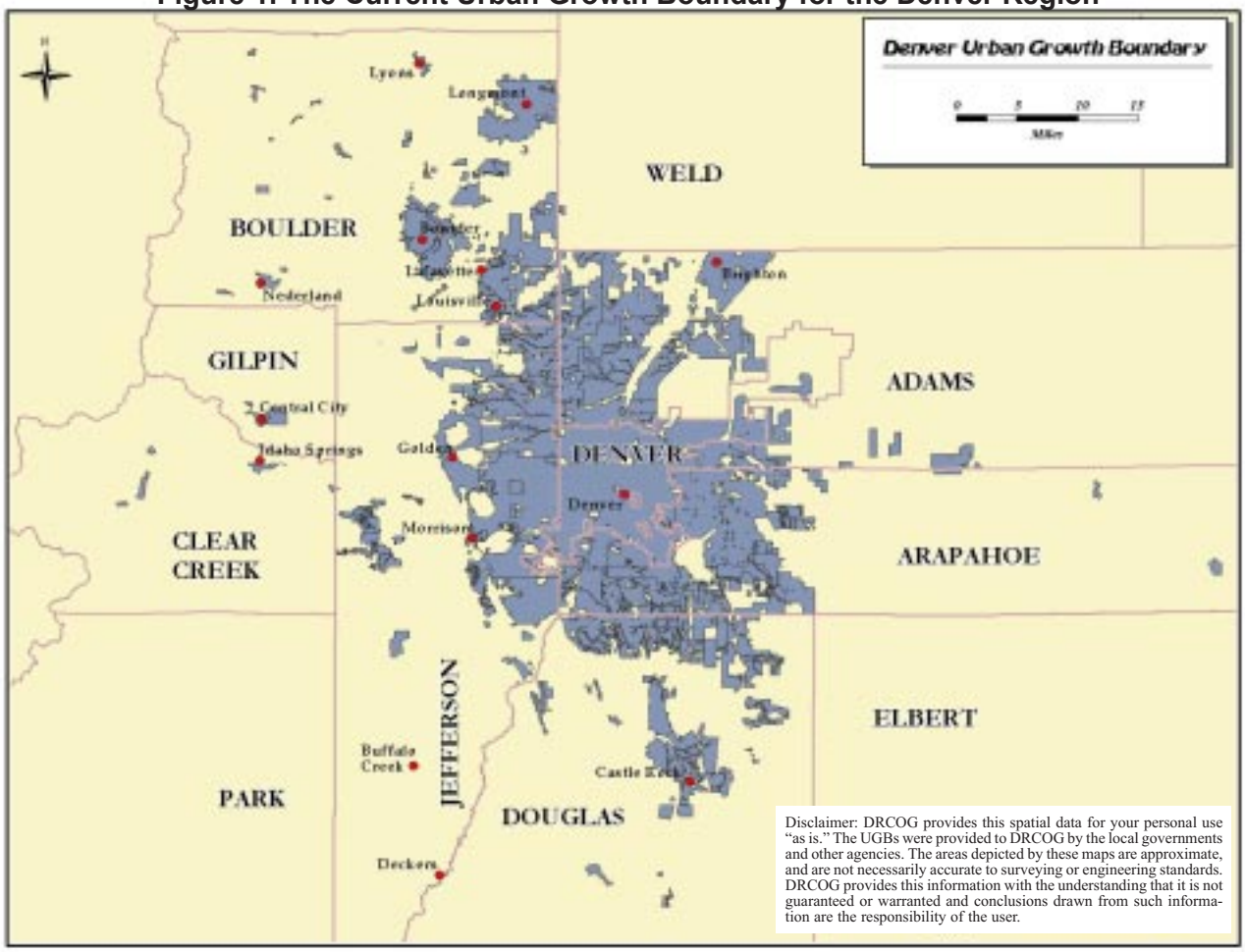
Metro Vision 2030

DRCOG is currently in the process of revising Metro Vision to extend the planning horizon through 2030. Proposed changes to the plan include policies regarding urban centers, open space, transportation, clean water, and semi-urban development. The revisions to the plan provide an opportunity to further promote and implement smart growth principles in the Denver region.

Also being discussed, however, are proposals to expand the UGB to allow development on more land on the fringes of the Denver metropolitan area. As noted above, the current boundary contains ample room for future development and can accommodate the region's significant increase in population through 2030 with only limited efforts to contain sprawl. On the other hand, extending the boundary could undermine smart growth and transportation policies in the region and allow for the spread of more sprawling development.

The costs of such a policy to the Denver region could be great. Experience in Denver and other regions across the country demonstrates that sprawling development imposes significant costs on taxpayers and consumers in comparison to more compact forms of development, while also damaging natural resources, open spaces, and quality of life.

Figure 1. The Current Urban Growth Boundary for the Denver Region



THE COSTS OF SPRAWL

Sprawling development imposes a variety of costs on Colorado taxpayers and consumers. Some of those costs are direct, such as the increased cost of government services to sprawling communities. Others are indirect, such as the impact of reduced recreational opportunities and a degraded quality of life on the health of the state's economy. Though property taxes and impact fees paid by new developments provide some income to governments, rarely does that income cover the full cost of necessary services or account for the indirect costs of sprawl. The preponderance of evidence suggests that more compact development patterns could reduce—or eliminate entirely—many of these costs, while still accommodating the population and economic growth anticipated for the Denver region over the next three decades.

Infrastructure Costs

All new development requires investments in infrastructure—the "publicly owned and maintained land, hardware, or structures" that enable delivery of public services.[5] For a variety of reasons, sprawling development tends to require more costly investments in infrastructure than more compact development patterns.

- Sprawling and "leapfrog" developments (those built far away from the current urban area) tend to be dispersed across the land, requiring longer public roads and water and sewer lines to provide service. In addition, such developments often impose costs on police and fire departments and schools.
- Automobile-dependent sprawl also typically drives the expansion of existing roads and leads to private investments—such as large paved parking areas—that can impose greater public-sector costs for stormwater management and water pollution abatement.
- Smart growth—and particularly compact development patterns and infill development—can substantially reduce local infrastructure needs as compared to low-density sprawl. By taking advantage of existing infrastructure, or reducing the need for extensions of road, water, and sewer networks, compact forms of development reduce the demand for costly public infrastructure investments.

The cost of the initial construction of infrastructure is not the only impact of sprawling development. Once new infrastructure is built, it has to be operated and maintained. A 1992 study of New Jersey found that modest smart growth measures could save 2 percent annually on operating costs—which, for example, represent 95 percent of education expenditures per capita.[6]

Adams County, Colorado recognizes that very low density residential development places a greater burden on finances and that land use plans may need to be adjusted to protect the county's financial situation.[7] Furthermore, the county found that by following current development trends, the county would be forced to reduce service levels or find additional revenue sources.[8]

Road Construction

All new subdivisions require roads, but those with larger lot sizes and more convoluted layouts require more paving. Additionally, many new developments have roads that are significantly wider than the streets in traditional neighborhoods.

This difference translates into huge costs for local governments and taxpayers. For example, a Maine community spent $400,000 to construct just five miles of new roadway to serve new development.[9]

In general, the cost of building local roads is estimated to be 25 percent lower in compactly developed areas than in sprawling areas, and clustering units can create a 50 percent to 75 percent reduction in road length and thus cost.[10] In southeast Michigan, planners have estimated that higher density development would reduce the need for roads and highways by nearly 200 lane-miles, saving $44.3 million for local governments and $8.9 million for the state.[11] A Federal Transit Administration report conducted by the Transit Cooperative Research Program estimates that smart growth would save the Denver-Boulder-Greeley metro area $4 billion in road and highway construction over 25 years—a savings of 21 percent.[12]

Water and Sewer Lines

Depending on the municipality and the development, the cost of constructing water and sewer lines is assumed by the public, the developer, or a combination of the two. In some cases, the developer pays for and installs new lines, presumably passing the costs on to new homebuyers. Some cities and counties do the installation and recoup a portion of the cost through impact fees assessed on new development. In other cases, the water district pays and charges all residents in the district a share of the cost.

Water and sewer services comprise a large portion of the capital costs of new communities. However, sprawl can inflate the cost of this infrastructure by 20 to 40 percent.[13] These costs are large: Denver Water is projected to need over $31 million by 2005 in order to address capital improvement needs for new and existing users.[14]

Emergency Services

Communities also need ambulance service, and police and fire protection. Response time—the time from when an emergency call is made to when help arrives—is key.[15] In sprawling developments, fewer houses are within the acceptable response time range of emergency service providers than would be the case in a more compactly developed area. As a result, sprawling communities often require more fire and police stations per capita than those in more compactly developed areas.

The Aurora Fire Department faces higher infrastructure costs due to sprawl. The department will consider establishing a new station for a leapfrog development once 100 housing starts are in place. A new station costs approximately $2.2 million. For development that occurs closer to town, the department often can simply alter station coverage assignments to make sure the new homes have adequate protection.[16]

Sprawling development has raised the Greater Brighton Fire Protection District's equipment costs. Because many of the homes needing protection are in outlying areas that do not have an adequate water supply, the district has ordered two new $200,000 tanker trucks to provide water in remote locations. The district expects it will also soon need a $130,000 brush and weed fire truck to fight fires in developments that are surrounded by forest and grassland.[17]

Applying the service standards adopted by the Parker Fire Protection District to a hypothetical community of 50,000 shows how compact development can lower infrastructure costs. The Parker District has established service standards that determine the placement of fire stations according to response time. A single station cannot serve more than seven square miles and maintain a five and a half minute response time. However, a station needs to receive at least 400 calls per year, which requires a service-area population of at least 6,600 people, or one house for every 1.6 acres. Theoretically, one station could serve as many as 30,000 people, but more a more realistic population base would be 12,000 people.[18] Parker Fire District estimates the cost of a new station with one engine and the necessary equipment at $1.5 million.[26] Thus, a town of 50,000 developed at the minimum density of one home

The Costs of Sprawl at Canyon Pines

In the foothills outside Arvada, developers Terry and Diana Ten Eyck are planning the construction of Canyon Pines, an upscale 90-home development on 180 acres.[19] The project will be located at the mouth of Coal Creek Canyon on previously untouched land bordered by Highways 93 and 72. Developers and open space activists disagree about how many homes will be visible from Colorado 93; estimates range from nine to 60 homes.[20]

The development site is approximately five to seven miles from the Arvada city border.[21] This means that all city services will have to extend an additional five miles to Canyon Pines. Though the developers will construct the roads, water and sewer lines, and other utility extensions, Arvada will pay all maintenance costs and provide police protection. Arvada will also pay for cleaning debris from the storm sewer system because Canyon Pines is constructing a simple system that cannot carry much debris. The sanitary sewer maintenance division is located at the eastern edge of Arvada. Canyon Pines will be five miles beyond the current western boundary. Thus, servicing Canyon Pines will cost more in time and mileage than would a development immediately on the edge of Arvada.[22]

The City of Arvada has dedicated approximately 280 acre-feet of water rights to Jefferson Center, a larger development area. This development includes the Canyon Pines area, and it is likely that the Ten Eycks will receive a large portion of the allocation.[23] However, the water allocation is inadequate for the development and the developers are responsible for acquiring additional water. The Ten Eycks have submitted an application with the Water Court in Greeley to drill wells on their property.[24] If permitted, the wells will take water from nearby Coal Creek.[25]

Canyon Pines, constructed in a high-risk fire zone, will receive fire protection from the Coal Creek Canyon Volunteer Fire Protection Department. The department is already short on volunteers, a situation which will be exacerbated by needing to serve an additional development.

The development would impose other environmental costs also. A staff memo to the Boulder City Council said that the development would "destroy the mountain backdrop and important wildlife habitats, and adversely impact the quality of life within the Boulder Valley and southeast Boulder County."

Future site of the Canyon Pines development

per 1.6 acres would need eight fire stations, for a total infrastructure cost of $12 million. Living in a town developed more compactly, that total same population could be served by just four or five stations, for an infrastructure cost of $6 million to $7.5 million.

Schools

Sprawling development can impact school costs in two ways. First, because many sprawling developments on the urban fringe are located in communities that had been sparsely populated, the developments often require the construction of entirely new school facilities. Second, the spread-out nature of sprawl imposes significant transportation costs on school districts.

The construction of new schools in outlying areas has often occurred even when existing schools in more densely populated areas have sufficient available capacity. For example, Minneapolis-St. Paul had to build 78 new suburban schools between 1970 and 1990. In the same period, the cities closed 162 urban schools that were in good condition.[27] The state of Maine spent $334 million constructing and expanding schools in fast growing areas from 1970 to 1995, even though in that same time frame the total number of students dropped by 27,000.[28]

In the Denver area, a new 600-student elementary school costs approximately $9.4 million. This does not include the cost of fees, permits, or interior furnishings and equipment, which can add $4 million. Land acquisition costs are an additional expense.[29] The alternative to building a school is to bus children to an existing school. Operating a bus twice a day, once to carry 60 grade school children and once to carry 40 high school students to and from school, costs $35,000 per year.[30] This does not include the bus purchase, which can cost from $92,000 for a new diesel bus to $120,000 for a compressed natural gas school bus.[31]

Infill and compact development can reduce these costs. In infill development, children may have the option of attending existing or expanded schools, while more compact forms of development can reduce transportation costs or eliminate the need for busing of some students altogether.

How It Adds Up

Building new neighborhoods with traditional or smart growth development patterns can result in savings of 20 to 50 percent on the per-unit costs of new roads and utilities.[32] While typical sprawling subdivisions may be built at three or four units per residential acre, new traditional-style neighborhoods often have a single-family home density of eight or more units per acre.[33] Development can be even more compact, such as in a mixed-density neighborhood in which 40 percent of the units are single-family homes with other units a mix of townhomes and apartments. At 12 units per acre, this type of neighborhood is the same density as Denver's Stapleton development.

A review by the Chesapeake Bay Foundation reveals that any of these more compact development patterns yield significant per unit savings on infrastructure, as compared to low density (conventional) or leapfrog developments. (See Table 1.)

Many municipalities charge development impact fees for new housing units, but these seldom cover the capital costs of servicing the development. A study of costs in Oregon found that in 1997 the full infrastructure cost of the average new three-bedroom house was $24,502, of which $11,377 was for schools. Municipalities recouped only $1,000 to $6,500 per unit through fees.[34]

How do these costs translate to the Denver region? In 1994, DRCOG compared the infrastructure costs of four potential development scenarios: a dispersed scenario that followed current trends; a compact scenario limiting growth to existing communities and designated areas such as Stapleton, Lowry, and the Central Platte Valley; a corridor development scenario in which development occurs along highways and transit lines with new urban centers in each corridor; and a

satellite cities scenario in which much new growth would be channeled to exiting satellite cities of Castle Rock, Bennett, Evergreen, Brighton, Erie, Longmont, and Idaho Springs as well as Stapleton, Lowry, Denver International Airport, and the Denver Tech Center. The costs of infrastructure over 20 years, from 2000 to 2020, were estimated for each scenario, as shown in Table 2.

DRCOG found that alternative development scenarios have the potential to save over 60 percent in infrastructure costs. Moreover, pursuing a compact development strategy would result in significantly less total urbanized land and would ensure it could be encompassed within the current urban growth boundary.[35]

Table 1. The Cost of Providing Government Services to Alternative Residential Patterns[36]

Neighborhood Form	Per Unit Cost of Infrastructure* (2001 dollars)	Savings vs. Conventional Leapfrog	Savings vs. Conventional Contiguous
Single Family Conventional Leapfrog			
3 units/acre, 5 miles from city edge	$53,985	0%	N/A
Single Family Clustered Leapfrog			
5 units/acre, 5 miles from city edge	$45,135	16.4%	N/A
Single Family Conventional			
3 units/acre, in town	$43,618	23.8%	0%
Single Family Clustered			
5 units/acre, in town	$34,768	36%	20%
Townhomes			
10 units/acre, in town	$27,688	49%	47%
Mixed Density			
12 units/acre, in town	$26,550	51%	49%

* Excluding regional highways, new sewer and water plants, and new water supply capacity, but including water lines, roads, and other local improvements.

Table 2. Capital Costs of Infrastructure and Land Savings in Denver Metro Region, 2000-2020[37]

Impact	Dispersed	Compact	Corridor	Satellite Cities
Capital Costs (roads and utilities)	$5.4 billion	$1.1 billion	$1.6 billion	$2.0 billion
Savings (compared to dispersed)	0%	80%	70%	63%
Land Consumed (square miles)				
Total Urbanized Land	850	650	750	750
Potentially Prime Agricultural	100.8	42.8	52.7	66.3
Wildlife Habitat	181.8	71.8	97.4	109.7
Woodland	28.4	6.6	15.7	14.1
Infrastructure Cost/Acre	$9,926	$2,644	$3,333	$4,166

Water Resources

Sprawl results in the inefficient use of water resources and decreased water quality. Colorado's population growth combined with the state's lack of growth management policies have affected both the quantity and quality of the state's limited water supplies. Additionally, some areas within the region have been exposed to increased risk of flooding.

The economic cost of water resources-related problems are difficult to calculate, but certainly significant. The most direct costs are those related to stormwater management, flood damage, water treatment, and the acquisition of increasingly scarce water resources. The region's continued problems with water scarcity are also likely to influence the economic decisions of industries, farmers, and businesses operating in Colorado. Indirectly, degraded water quality affects the sustainability of the state's wildlife populations and the recreational choices of many Coloradans—adversely affecting the region's quality of life.

High Water Use at Castle Pines Village

Residents of Castle Pines Village, a gated residential community in Douglas County, consume twice as much water per capita as the average Denver-area resident. Per capita water consumption in Castle Pines Village averages over 150,000 gallons annually, compared to the Denver area's 74,410 gallon average. Water consumption figures for Castle Pines Village exclude irrigation of the two golf courses.

Both the manager of the Castle Pines Village metro district and Denver Water's chief planner blame large lot sizes for Castle Pines Village's high water use.[38] Lots range from one-half acre to eight acres and often are planted entirely in grass. Bluegrass, one of the most common types of lawn, has a high water requirement and needs two inches of water per week in the summer.[39]

Water Use

The recent drought—coming on the heels of years of below-average snowpack—has sparked a water availability crisis in the Denver metro region. But even an easing of the drought will not solve Denver's long-term water problems. The Metropolitan Water Supply Investigation for the Denver region projects a shortage of about 100,000 acre-feet of water (enough to cover an area bigger than the city of Denver in one foot of water) for the projected population in 2020 if current rates of consumption continue.[40]

The rate of water consumption in the Denver metro area exceeds that of many western cities. The Denver region's average consumption of 200 gallons per capita per day (GPCD) far exceeds the consumption of cities such as Tucson, Arizona (160 GPCD), San Antonio, Texas (143 GPCD), and Los Angeles (170 GPCD).[41]

Sprawl has a direct impact on water consumption. Some of the most significant non-agricultural water users are single-family residences. Denver households use more water outdoors than indoors, and the single biggest use of water is for lawn watering.[42] Large lots increase the landscaped areas of individual homes.[43] Utilizing more compact development patterns can help reduce the region's water demands. High-density planned development may use up to 35 percent less water than low-density sprawling development.[44] Denver Water imposes a system development charge on new homes to pay for some of the cost of water provision, storage, and treatment. Because homes on large lots generally consume more water, the development charge varies according to lot size.[45]

The layout of the typical sprawling subdivision's streets can also increase water use. Ideally, water systems are arranged in a grid or loop system, which connects water mains and allows water to circulate. Cul de sacs, a hallmark of sprawl, often result in "dead ends" that reduce circulation, potentially causing water quality problems unless

the water provider flushes the system, which wastes water.[46]

The increased water demands associated with sprawl and the current drought have led to a renewed interest in large storage projects—despite the fact that water conservation measures and more compact development patterns can reduce overall water demand in a more immediate, less expensive, and less harmful manner. Water storage projects can take decades to complete, are enormously expensive, and are often environmentally harmful. Many new supply projects cost $10,000 per acre-foot.[47] Most cost-effective dam sites already have been developed, making future water development increasingly expensive.[48] In contrast, reducing future increases in household consumption through more compact development would cost next to nothing.

Water Quality

The region's water availability problems are compounded by the threats sprawling development poses to water quality. Natural areas contain water-permeable soils that slow runoff and filter out pollutants. Development covers over natural soils with structures that allow almost no absorption of water. These impervious surfaces include roads, parking lots, rooftops, sidewalks, and other structures. Precipitation that runs off these hard surfaces transports pollutants—sediment, nitrogen, phosphorus, organic carbon, copper, zinc, lead, petroleum hydrocarbons, and pesticides—directly into streams and rivers.[49]

Studies across the nation have found that once a given land area is 10 percent covered with impervious surfaces, water quality quickly and significantly declines.[50] Streams and rivers in areas with greater than 10 percent impervious surfaces contain higher levels of pollutants, are affected in their physical structure, and are less able to support wildlife.[51] Further, as impervious surfaces cover a watershed, the water temperature increases, which is often detrimental to fish and other aquatic life. Good management practices—such as buffer zones between impervious surfaces and water bodies, on-site stormwater practices, and new paving techniques—can mitigate but not eliminate development's impact on water quality.[52]

A very low-density development of only one unit per two or three acres creates a 10 percent impervious surface ratio and thus harms water quality.[53] This housing density is much lower than the average density of urban or suburban areas. As a result, most developments substantially impair water quality.

Another impact of sprawl on water quality is the destruction of wetlands—which serve to collect and filter excess runoff. Between 1986 and 1998, the Denver metro area lost 59 percent of its wetlands. The total area covered by wetlands declined from 8 percent to 3 percent.[54] These wetlands have more than just environmental value: the Minnesota Department of Natural Resources conducted a study that found that wetlands provide natural flood control that would cost $300 per acre foot to replace.[55]

Converting to more compact forms of development would have two positive impacts on water quality. First, because auto-dependent sprawling development requires the construction of vast areas of roads and parking lots, more compact development should result in a reduced amount of impervious surface per capita and thus runoff over the region as a whole. In the Denver region,

DRCOG estimates that a sprawling development scenario would increase zinc runoff by 18 percent and phosphorus runoff by 27 percent compared to a compact growth scenario. Total annual runoff would be 1.3 million tons under a dispersed development scenario and one million tons under compact development.[56]

Second, compact development would prevent the spread of impervious cover to new watersheds on the metropolitan fringe. DRCOG estimates that sprawling development threatens 60 sub-watersheds in the Denver metro region. Compact development could protect about 25 percent of these subwatersheds from degradation.[57]

It should be acknowledged that more compact forms of development would likely increase the percentage of impervious cover in some areas and could lead to increased impacts on some local waterways. Nonetheless, compact development would spare many of the region's pristine watersheds and therefore has a more limited impact on water quality than does sprawl.

Transportation-Related Water Quality Impacts

Special attention must be paid to the influence of transportation facilities on water quality. Auto-dependent sprawling developments reserve great amounts of space—the vast majority of it paved—for automobiles. Not only do these facilities add to an area's impervious cover, but because transportation surfaces are often continuous and are directly connected to storm drainage systems, pollutants are typically directly flushed into waterways, further degrading water quality.[58]

Airborne pollutants from automobiles and toxic particles released from tires and brakes also reach water supplies. A study of the San Francisco Bay found that cars and trucks were one of the largest sources of pollutants in the bay. Of the toxic metals found there, half of the cadmium and zinc came from tire wear, half the copper came from brake pad wear, and an additional 25 percent of the copper originated as air pollution from cars. Lead came mainly from diesel-powered vehicles.[59]

Compact development can provide transportation benefits that can help protect both air and water quality. Infill development and redevelopment of older suburbs could reduce vehicle miles traveled per capita by 39 to 52 percent compared to sprawling patterns of development.[60] Currently, due to sprawling development patterns and a resulting lack of transit options, almost 90 percent of the Denver region's workers drive to work.[61] Diverting significant numbers of commuters to transit—as Denver has done through construction of the Southwest light-rail line—and constructing urban centers that can be navigated on foot, rather than by car, can re-

Sprawling development includes large parking areas that degrade water quality.

duce emissions of pollutants from vehicles, further protecting water quality.

Flooding

Impervious surfaces allow runoff from precipitation to quickly reach streams and other water bodies, creating the potential for flooding. A one-acre parking lot produces about 16 times the volume of runoff that comes from a one-acre meadow.[62] Thus, the runoff from a one-inch rainstorm would fill a standard-sized office to a depth of two feet if the runoff came across a one-acre meadow, but if the runoff came across a parking lot it would completely fill three offices.[63]

Because compact development requires less impervious cover per capita, it can reduce the threat posed by runoff-related flooding. Proper management techniques, the maintenance of appropriate buffer zones around waterways, and the channeling of development outside of flood-prone areas can also help to ameliorate the impact of sprawl on flooding.

Agricultural Lands and Open Space

Open space, agricultural land, mountains, and wildlife habitat have all become hallmarks of Colorado. Open space provides a wide range of environmental services in addition to recreational opportunities. Agricultural lands are a central part of Colorado's culture and economy. Failing to protect our open spaces and agricultural lands from sprawl will sacrifice part of what makes the Denver area special and draws businesses and residents from across the country.

Agricultural Lands

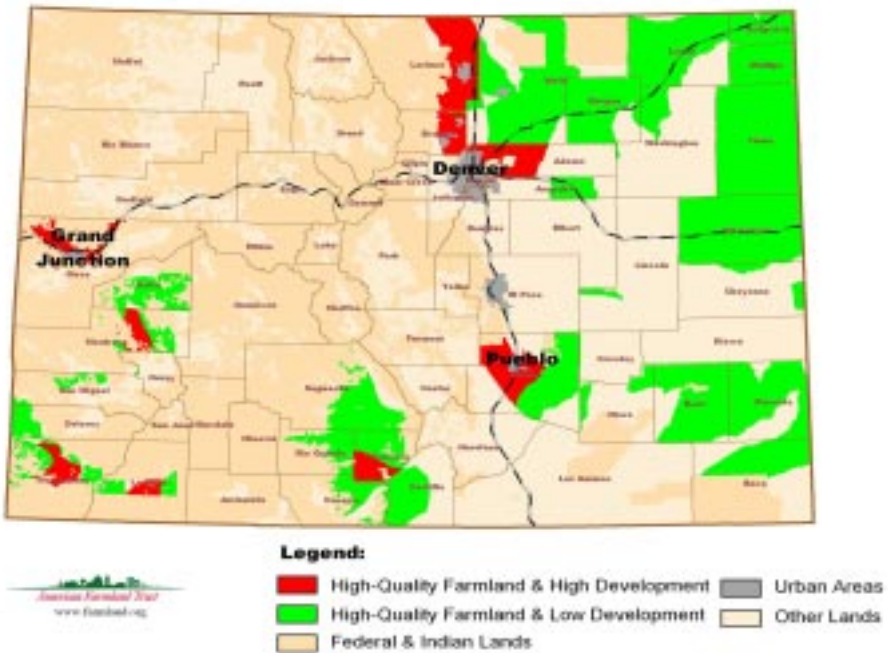
Farming and ranching contribute greatly to Colorado's economy. In 1997, agriculture created 105,000 jobs, 4.15 percent of the state's total employment, and had sales totaling over $15 billion.[64] Eighty-two percent of Colorado's 30,000 farms and ranches are owned by individuals or families, strengthening communities around the state.[65] But more than its economic value, agriculture represents an important part of our state's way of life: 84 percent of Coloradans said that maintaining land in agriculture was important to their quality of life.[66]

Unfortunately, due to a variety of factors, including land development pressures exacerbated by sprawl, agriculture is receding as a central part of Colorado life: 1.4 million acres of agricultural land were shifted from agricultural production to urban development, low-density rural use, or public open space from 1987 to 1997. The average annual rate of conversion in that 10-year period was 141,000 acres. However, the 10-year average masks the fact that conversion accelerated from 1992 to 1997 to a rate of 270,000 acres per year.[67]

While agricultural land is scattered throughout the state, much prime agricultural land lies in the Front Range, near urban areas. Land development pressures, however, are depleting this important resource. More than 10,000 acres of prime agricultural land were developed in the state from 1992 to 1997. DRCOG estimated that by 2020 the Denver area will consume 100 square miles of the region's agricultural land.[68]

Compact development patterns would facilitate protection of many important agricultural areas. Under a compact development

Figure 2. Prime Farmland in Colorado Threatened by Development



scenario, DRCOG estimates that only 42 square miles of farmland would be consumed by 2020, saving almost 60 percent of the land that would otherwise be developed.[69]

Open Space

The preservation of open space in and around our communities provides a number of benefits. Undeveloped land filters water and allows for the recharge of aquifers. When forested, it can filter pollutants from the air. It provides habitat for wildlife. Open space interlaced with parks and trails can provide valuable recreational opportunities to the public. And its aesthetic value can increase property values.

Across the country and in Colorado, sprawling development has made the preservation of crucial open spaces more difficult, imposing new costs on communities. In northern New Jersey, for example, the threat of new development in Sterling Forest—a watershed that supplies two million people with drinking water—forced state officials to decide between acquiring the land or paying for the cost of new water treatment facilities to deal with degraded water quality. In the end, the state decided to purchase the land rather than spend $160 million for a new filtration plant.[70]

Many Colorado communities have faced similar decisions. In 1998, Colorado cities and counties were spending $65 million annually for open space protection, while the lottery added $12 million through Great Outdoors Colorado (GOCO).[71]

Coloradans remain dedicated to funding open space protection. In the November 2002 elections, nine out of 12 open space protection measures on the ballot passed in Colorado.[72] However, with the recent decline in the economy and with state and local governments facing fiscal crises, public purchases of open space will not be able to keep pace with growth.

Encouragement of more compact growth patterns would ease the pressure on many farmers and owners of open space to develop their lands, preserving these important resources. For example, according to DRCOG, a compact growth scenario would save 110 square miles of wildlife habitat and 22 square miles of woodlands in the Denver region.[73]

Transportation Impacts

The transportation facilities associated with sprawling development are the product of subsidies provided by taxpayers and consumers. Society subsidizes driving in numerous ways—from federal funding for freeways to environmental and medical costs of air pollution and clean-up of polluted runoff water from paved areas. If drivers were to pay the full price of driving, gasoline would cost between $3.03 and $7.55 per gallon, excluding the costs to individuals of accidents and travel time.[74]

These subsidies cost Coloradans money directly. But the increasing failure of sprawling communities—which assume dependence on the automobile—to serve our transportation needs also imposes its share of costs: congestion, road construction and maintenance, impaired air quality and its impacts on public health, and household transportation costs.

Congestion and the Failure of Auto-Centered Development

The greatest of these indirect costs is the cost of congestion. Despite billions of dollars in public subsidies for highways, the region's automobile-centered transportation system continues to fail to provide swift, efficient levels of service to many area residents.

A major reason for this is the impact of sprawling development patterns. There is a clear connection between sprawl and vehicle miles traveled—sprawling development forces residents into their cars to complete even the most mundane of daily tasks while increasing the total number of miles residents must travel to and from work each day. In the Denver metro area and nationally, growth in vehicle miles traveled and congestion has exceeded the rate of population growth. (Congestion is how much longer a trip takes during peak travel hours compared to travel when traffic flows freely.[75]) From 1990 to 2000, the Denver region's population grew by 1.9 percent annually, while vehicle miles traveled grew 3.7 percent annually and congestion grew by 13.7 percent each year.[76] Most of the increase can be attributed to the auto-dependent way in which new communities are built: 18 percent of congestion can be accounted for by an increasing number of trips taken; 35 percent by increasing trip lengths; and 17 percent by a switch from walking or transit to driving.[77]

Traffic congestion costs Denver area residents time and money.

The Denver area currently ranks as the 11th most congested metro region in the nation. Time spent in congestion each year consumes 66,165 person-hours of time and 105 million gallons of gasoline, costing residents $1.2 billion in lost time and added gasoline costs—$1,235 for each rush hour traveler. The environmental and quality of life impacts of sprawl-induced congestion are significant.[78] In the Denver region, 88 percent of employees currently drive to work. Of those who do not drive, 5 percent take transit, 3.4 percent walk or bicycle, and 3.3 percent work at home. Alternative forms of transportation reduce the number of cars on the road by nearly 175,000.[79]

Road Building: An Expensive Approach

Building more highways to serve even more sprawling developments will not alleviate congestion. Adding more lanes to existing highways simply creates new demand as people who once avoided these corridors are drawn to the new lane capacity. Seven

Photo courtesy RTD

Compact development increases the viability of transportation alternatives.

studies have found that in the long term, 50 to 100 percent of added lane capacity is filled by induced demand.[80] In the fastest growing regions of the country, there was no discernible difference in congestion between those areas where highway growth kept up with or outpaced population growth and those where it lagged behind.[81] In California's urban counties, every 10 percent increase in lane-miles generated a 9 percent increase in traffic.[82] An expansion of Washington D.C.'s Capitol Beltway in Montgomery County, Maryland, to 12 lanes has not made things better—traffic exceeds not only state planners' forecasts, but also exceeds capacity, and this section of the Beltway remains a "rolling parking lot."[83]

In addition, expanding highways increases the drain on the public treasury for highway construction and maintenance. In other words, sprawling development patterns force Denver-area residents to pay twice for transportation—first for construction and maintenance of the roads themselves, and then for the cost of sitting in traffic once the roads are completed.

Air Pollution and Public Health

Technological improvements to automobiles should be improving air quality—after all, the average car is much cleaner today than it was in the 1970s. Yet air quality in major cities is not significantly improving because the gains achieved through technology are being wiped out by sprawl and greater distances driven.[84] In the top 10

Table 3. Pollution Emissions by Private Vehicles
(grams per vehicle mile)[85]

	Volatile Organic Compounds	Carbon Monoxide	Nitrogen Oxides	Carbon Dioxide
Automobiles	1.88	19.36	1.41	415.49
SUVs, light trucks	2.51	25.29	1.84	521.63
Weighted Average	2.10	21.45	1.56	452.92

sprawling metro areas in the U.S., Americans traveled 9,855 miles per capita by car—28 percent more than in other metro areas.[86]

Cars in Denver add 78 pounds of pollutants per person per year to air in the Denver region, causing 28 percent of the region's smog.[87] Exposure to smog has been linked to asthma, bronchitis, heart disease, emphysema, and pneumonia. Asthma, a chronic inflammation of lung tissues that makes it difficult to breathe, affects 26.8 million Americans, over one-third of whom are children. Reductions in vehicle miles traveled result in reductions in smog and related health impacts. During the 1996 Olympic Games in Atlanta, peak traffic was reduced by 22 percent, resulting in a 29 percent decline in smog and a 42 percent decline in admissions to hospitals and emergency rooms for asthma.[88]

While it is difficult to quantify the economic impacts of air pollution-related health problems, those impacts are almost certainly significant. Hospital stays, medical treatment, premature death, and lost productivity all act as a drag on Colorado's economy. Sprawling development that results in more driving—and more pollution—only exacerbates the problem.

Household Expenditures

Sprawling development patterns increase transportation costs for residents of the Denver region. The average American household spends 18 cents of every dollar on transportation—98 percent of that is for the purchase, operation, and maintenance of automobiles. Most families spend more on driving than on health care, education, or food. Between 1990 and 1998, households in major metropolitan areas increased their transportation expenditures by 8 percent.[89] In the Denver-Boulder-Greeley area, this figure was $7,361 (17.2 percent of household income) and is growing.[90] For Denver residents, spending on transportation is second only to spending on housing.

Smart Growth, Transit, and Other Alternatives

Sprawling development patterns generally inhibit the effective use of public transportation, bicycling, walking, and other transportation options as alternatives to the automobile. As a result, sprawl necessarily drives demand for more highway capacity, which in turn allows for more sprawl—resulting in spiraling costs for highway construction, congestion-related delays, public health problems, and personal transportation-related expenses.

The alternative is to promote compact development patterns that provide for efficient transit service and allow for transportation on foot or by bicycle to the extent possible. Even within such compact communities, automobiles are likely to provide the majority of transportation, but the availability of alternatives would enable residents of those communities to make other transportation choices that could reduce the pressure to build and maintain expensive new highways.

Density does not need to be greatly increased to make transit choices efficient—public transit, cycling, and walking can be supported at a density of five to ten residential units per acre.[91] This density is typical of new urbanist suburbs and traditional American "streetcar suburbs." Similarly, the Institute of Transportation Engineers recommends a density of seven to eight units per acre to provide efficient bus service every 30 minutes—although this figure is affected by the concentration of employment, shopping, and activities in urban centers.[92]

But it is not just—or primarily—density that matters. Walkability of neighborhoods is important. Where streets are unconnected and neighborhoods dominated by cul-de-sacs, walking and cycling distances become longer. Most Americans are willing to walk 2,000 feet, or about three-eighths of a mile, rather than drive.[93] (Americans walk an average of 800 feet from their car to work.[94]) That distance can be as much as doubled if they walk through appealing spaces.[95] Re-

Table 4. How Neighborhood Form Influences Mode of Transportation[96]

Neighborhood Type	Households per Acre	Average Daily Trips per Household		
		Automobile	Transit	Walking
Conventional Suburb	2-5	5.9	0.2	0.5
New Urban or Traditional Suburb	5-10	5.0	0.3	0.6
Mixed Density, Apartments, Townhomes	10-20	3.8	0.8	0.9
Town Center, Urban	20-50	2.9	1.3	1.4

Table 5. Vehicle Miles Traveled, by Density and Transit Availability[97]

Neighborhood Type	Households per Acre	Annual Vehicle Miles Traveled		
		TAI 100*	TAI 50	TAI 20
Urban	30	10,319	10,877	11,622
Townhomes or Mixed Density	10	13,580	14,315	15,347
Compact, Single-Family	5	16,150	17,024	18,251
Sprawling Suburb	3	18,350	19,342	20,737

* The Transit Availability Index (TAI) measures the frequency and proximity of public transportation. A higher TAI score means greater availability of transit.

search conducted in Houston found that every 10 percent increase in pedestrian amenities—adequate sidewalk space, shop fronts, benches—resulted in a 15 percent decline in motorized trips.[98] Likewise, cycling increases with the provision of safe cycling paths.

Improving walkability can also reduce public-sector costs over the long haul. For example, in newer neighborhoods, children are often bused to school even though the distance is less than one mile—so-called "hazard busing" because walking routes are deemed unsafe.[99]

Controlling for income and transit availability, residents of traditional suburbs make 20 percent fewer auto trips, 50 percent more transit trips, and 20 percent more walking trips than residents of sprawling suburbs. In medium-density neighborhoods with a mix of housing types, similar to the plans for redeveloping Stapleton airport, residents make 35 percent fewer auto trips, four times as many public transit trips, and twice as many walking trips. In urban neighborhoods such as downtown Denver, auto trips decline by 50 percent, transit trips increase more than six-fold, and walking trips triple. Beyond 30 units per acre, there is not a significant reduction in auto use.[100]

Living in a compact suburb with good transit options reduces household driving by 4,543 miles annually—or 22 percent—compared to a sprawling suburb with poor transit. This yields an estimated savings of $1,135 annually to the average household.[101] While not everyone will live in transit-friendly neighborhoods, everyone benefits from the reduction in congestion and pollution, and the reduced cost for new roads.

A final benefit of transit is that, in some cases at least, the infrastructure costs are cheaper than those that would be incurred in a highway expansion. Highway expansions are exceedingly costly—$30 million to $70 million per mile, not counting the costs in lost open space, increased pollution-related health problems, depressed land values near highways, and the cost of auto accidents. In comparison, extensions of existing light-rail systems in the United States have cost as little as $14 million per mile, while com-

One Alternative to Sprawl: CityCenter Englewood

In Colorado, sprawling development is a common sight. Less familiar is compact growth or infill development. Englewood's redevelopment of the Cinderella City shopping mall provides a strong example of a large, mixed-use project that is not auto-dependent and that does not pave over any greenfields.

The 1.35 million square foot Cinderella City shopping mall, built on Englewood's main park, opened in 1968 as the largest enclosed shopping center west of the Mississippi.[102] It occupied 55 acres in the heart of Englewood, offering customers 275 shops and a 7,000-space parking lot.[103] The mall was an economic boon to Englewood in the decade after opening, but the recession in the early 1980s and regional competition undermined the mall. It closed in 1997.

The City of Englewood, seeing an opportunity for revitalizing downtown, purchased the mall and reopened it in 2000 as CityCenter Englewood. The complex is now connected to adjacent neighborhoods, linked to transit, and is an economic and cultural center. CityCenter Englewood includes 440 residential units, 330,000 square feet of retail, 300,000 square feet of offices, and 50,000 square feet of restaurant space.[104] Mixed-use development allows residents to complete errands on foot, rather than by car, and permits the combining of multiple errands into one trip.

The city has moved the municipal courts, the library, and many city offices to the complex. A cultural arts center and a two-acre public plaza make CityCenter Englewood a community gathering place. Had the city opted to construct municipal office space, a library, and art and community space from scratch the cost would have been $17 million.[105] Infill redevelopment allowed the city to make use of existing utility service and basic infrastructure, and did not require destruction of any greenfields.

Photos courtesy City of Englewood

Auto-dependency is reduced by a light rail stop and a bus transfer station that are expected to bring 1.5 million light rail and one million bus passengers through CityCenter Englewood annually by 2015.[106] The transit-oriented nature of the development should help minimize additional car traffic to the site.

Finally, the mix of shopping, offices, and residential units contribute to a small town atmosphere that is fitting for this community of 33,000 people.[107]

muter rail on existing rail beds, as FasTracks envisions for the Denver-Boulder corridor, costs only $700,000 per mile. The cost of simply maintaining our existing—and aging—highway infrastructure is already putting a financial strain on government.[108] Rail may be cheaper in the long run because it lasts longer; highways last only 25 years without substantial reconstruction, whereas light rail infrastructure lasts 60 to 75 years.[109]

A transportation system that reduces congestion, reduces public and private sector transportation costs, reduces air pollution and public health costs, and improves quality of life can only happen within a framework of smart growth and compact development.

Quality of Life and Economic Development

High infrastructure costs, lack of water availability, poor water quality, destruction of agricultural land and open space, and high transportation costs all have the potential to depress Colorado's economy and pose a threat to the state's quality of life. The combination of these factors could drive away businesses and investors who can bring additional resources to the region.

Increasingly, corporations look to quality of life concerns as a key factor in their location and investment decisions, because these factors are important to the trained workforce they want to attract. For this reason, regions that commit to restraining sprawl and promoting compact, well-planned development may have a leg up in the race for investment.

Corporate CEOs say that quality of life is the third most important factor in deciding where to locate a business, behind access to domestic markets and skilled labor. Chattanooga, Tennessee is one example of a city that has turned itself around by creating a network of open spaces, trails and riverfront parks, drawing residents and businesses into the city. Between 1988 and 1996, the number of full-time jobs in Chattanooga doubled. New homes and businesses doubled the city's tax revenue, allowing infrastructure, education, and parks to be fully funded.[110]

When Portland adopted a metropolitan urban growth boundary, some predicted that it would constrain economic growth. However, Portland has become a center of the high-tech economy with its "Silicon Forest" of over 1,200 high-tech companies, as well as traditional companies like Columbia and Nike.[111] *Money* magazine ranked Portland as the nation's best big city for quality of life in 2000. *Money* mentions riverfront renewal, preservation of open space through an urban growth boundary, and walkable city neighborhoods as some amenities that draw professionals.[112] As one Intel spokesman said, "Companies that can locate anywhere they want will go where they can attract good people in good places."[113]

The reverse is true as well. The Bank of America teamed up with housing and conservation advocates to warn of the threat that sprawl presents to California's economy. According to the report, "Unchecked sprawl has shifted from an engine of California's growth to a force that threatens to inhibit growth and degrade the quality of our life."[114] The costs of sprawl were said to hurt California's attractiveness as a place to open or expand a business. At a 1997 conference of 600 business leaders, one in three said that the state's deteriorating quality of life had led them to consider leaving the state. In 1998 the *Wall Street Journal* reported that Seattle's worsening traffic was threatening its economic growth.[115]

Colorado and the Denver region face a stark choice: whether to continue with costly patterns of sprawling development or commit to measures—such as enforcement of the current urban growth boundary and implementation of the smart growth principles embodied in Metro Vision 2020—that will steer the region to sensible, sustainable patterns of compact growth. Absent these principles, the urbanized area of Denver would reach 1,150 square miles, a city stretching along the Front Range from Colorado Springs in the south to Fort Collins in the north. This would be larger than the cities of Los Angeles, San Francisco, San Jose, and Oakland combined.[116] The time has come for the Denver region to recommit itself to the visionary smart growth principles adopted in the mid-1990s, and set the region on a long-term course toward a more economically and environmentally sustainable future.

POLICY RECOMMENDATIONS

Sprawling development costs more than smart growth. Especially in this period of state and local government budget shortfalls, the best land use and transportation decisions are those that help save money, not increase costs.

DRCOG should retain the current 747-square-mile urban growth boundary in its revision of the Metro Vision regional plan.

- Doing so will encourage local government efforts to apply smart growth principles—such as integration of transit, construction of urban centers, and phased growth—to their future development. It can also be done without severely constraining development in the region.
- These smart growth principles will save local governments money.

Even if the Denver region were to grow at the rate it did from 1990 to 2000, the current urban growth boundary would not be reached until at least 2028.[117] With even minor efforts to curtail sprawl, the current boundary can accommodate the region's growth until 2030 or beyond.

Denver possesses great potential to restrain sprawl within the growth boundary. The region's current residential density of 4.47 persons per acre is low compared to other western metropolitan regions: the Portland, Oregon-Vancouver, Washington metropolitan area has 5.1 people per acre, Phoenix has 7.2 people per acre, and Los Angeles has 8.31 people per acre.[118]

The revised Metro Vision plan should take further steps to encourage infill development within the current boundary.

- With a strong urban growth boundary, the Denver region can encourage infill development that will take advantage of the region's existing infrastructure and schools. The old Stapleton airport redevelopment, for example, will create 12,000 mixed-income homes for 30,000 people in a new urbanist enclave, close to downtown, that includes 1,600 acres of open space.
- Between 1990 and 2000, the city of Denver added 87,000 residents, an increase of 19 percent. All of this growth occurred within existing urban areas through redevelopment or infill projects.

Expanding the urban growth boundary—and allowing more dispersed development on the metropolitan fringe—would both reverse this momentum toward smarter growth and impose intolerable new costs on Colorado's economy and quality of life. Maintaining the current boundary will keep the Denver region an attractive, livable place.

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