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Site Planning and Design Handbook

- LANDSCAPE RESTORATION
- STORMWATER STRATEGIES
- IMPACT MINIMIZATION

CD-ROM INCLUDED

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1

Sustainability and Site Design

The activities of human beings have had and will continue to have a significant impact on the earth's environment. It has been said that 60 percent of the earth's land surface is under the management of people, but 100 percent of the earth's surface is impacted by the practices of that management. Paul Erhlich (1994) used the formula $I = PAT$, or impact = population $\times$ affluence $\times$ technology, to illustrate the relationship of the number of people, the per capita rate of consumption, and the economic efficiency of consumption. Thus, for example, although the United States may have more efficient and cleaner technologies than some nations, its rate of consumption afforded by its relative affluence may offset those efficiencies. In contrast, although China has a high population, its relative low levels of affluence and technology may offset its high population. In both countries, however, the environmental footprint is clearly significant.

In 1987 the Brundtland Commission published *Our Common Future,* which said that to avoid or at least minimize the environmental impact of human behavior, it is necessary for society to adopt a sustainable approach to development. "Sustainability" was defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

In February 1996 the President's Council on Sustainable Development (PCSD) published *Sustainable America—A New Consensus for Prosperity, Opportunity and a Healthy Environment for the Future.* The PCSD identified 10 goals, but the first 3 could be viewed as encompassing them all: health, economic prosperity, and equity. Equity refers to social equity (equal opportunity) and intergenerational equity (equity for future generations).

To meet the challenges of sustainability, we need to change our behaviors and adapt to a paradigm of economic prosperity, social equity, and environmental sustainability. Unfortunately, these goals have traditionally been viewed as antagonistic or mutually exclusive. We tend to think of extremes: the most damaging economic activities affecting the best of the environment or the most restrictive environmental regulations resulting in dire economic consequences.

So we tend to think of economic health and environmental sustainability as mutually exclusive. The challenge we face is to reconcile our economic interests with our environmental interests.

We have learned that gains in some factors may be offset by losses in other factors. Between 1980 and 1995, per capita energy consumption in the United States fell, but total energy consumption increased by 10 percent because of a 14 percent increase in population. Likewise, while cars built in 2001 are 90 percent cleaner than cars built in 1970, there are so many more cars that the efficiency gains have been offset to some degree.

The impacts of development and land use patterns have been well documented during the last half of the twentieth century. Impacts range from a loss of water quality, a loss of wildlife habitat, a decrease in human health, the loss of native plants caused by the spread of invasive exotic plants, the loss of biodiversity, an increase in the cost of infrastructure maintenance, a decrease in groundwater tables, and more. In addition to these local impacts, human activities are having significant impacts on global climate. People around the world have become more aware of general environmental degradation, and they are turning to action.

Generally it takes from 20 to 30 years for technology to move from research and development to implementation in the land development and construction field. Reasons for the lag time vary but include the time it takes to raise public awareness of problems and available technological solutions to those problems. It takes still more time for the public to adopt the new solutions, both funding them and passing the necessary ordinances to implement them. Yet another reason for the lag time is the natural and predictable resistance of people to change. The various parties to a development project all have interests that they bring to the process, and all of them assess the development differently—how will the site fit into the community, will it be a financial success, does the plan meet codes and ordinances, and so on.

It is the job of the designer to synthesize all of these, often adversarial, views. It is also the designer who has the greatest opportunity to innovate and introduce alternatives to the planning and design of sites and landscape. As a professional, with a duty and responsibility for the health and safety of the public, it is the designer that has the burden to make the site “work.” With the realization of the environmental impacts of a site’s development, the introduction of innovative, more sustainable practices to a site’s development can best be done by the site design professionals. While regulatory agencies may create a framework for more sustainable design practices, it is in the final analysis the site design professional that must implement these guidelines. Public officials and reviewers, however, share the responsibility to educate the public and elected officials as to the importance and desirability of change.

Most people’s experience with change has been based largely on the introduction of new materials or methods into design and construction and new regulatory or permitting programs. However, the need for change has accelerated. Contemporary site planning and design must take into consideration much of the knowledge and information gained in recent years as our awareness of environmental impacts has improved. The leadership in incorporating this knowledge in site planning is coming from many different places, and it may require many of us to reevaluate our past work and assumptions in new terms and to begin approaching design differently. There can be a great deal of resistance to such change; methods and principles that have been acceptable in the past and that we thought were successful may have to be abandoned for other methods and new ways of thinking. Some of the logic we have used to plan and design sites will be augmented with new and additional considerations (see Table 1.1). In some cases such logic may be replaced entirely. In studying the impacts of past practices, it will be clear that a new paradigm is in order. This period of change is an exciting time for design professionals as we determine principles of land development for a sustainable postindustrial society.

In the United States site design has always been an issue of local control and practices because, in part, the conditions and needs of local communities and landscapes are too diverse to be addressed entirely in any single ordinance or set of regulations. Nonetheless, there have been common, if not universal, practices and methods that have served design professionals and communities well. The increasing awareness of the need for more sustainable land development includes emergent practices that also have broad application and value. In recent years the federal government and many states have passed incentives to encourage green building. Some states offer tax incentives to encourage energy efficiency and the use of green methods and materials. It is a practical certainty that being able to provide such service to clients will be a competitive necessity in only a few short years. It is through the design professionals that these changes to land development, site planning, and design will be introduced to most communities.

Population and Demographics

Trends in population and demographics have important implications for planners. Projections call for there to be an increase of about 130 million people in the U.S. population by 2050. Much of the population growth in the United States is occurring in the southwest and southeastern United States, the Sun Belt. Much of this area has semiarid to arid climate, and water may be in

TABLE 1.1 Environmental Risks As Ranked by Scientists

Relatively high risk problems	Relatively medium risk problems	Relatively low risk problems
Habitat alteration and destruction	Herbicides and pesticides	Oil spills
Species extinction	Toxics, nutrients	Groundwater pollution
Overall loss of biodiversity	Biochemical oxygen demand and turbidity in surface water	Radionuclides
Stratospheric ozone depletion	Acid deposition	Acid runoff to surface water
Global climate change	Airborne toxics	Thermal pollution

Adapted from *The Report of the Science Advisory Board Relative Risk Reduction Strategies Committee to the EPA* (Washington, D.C.: Government Printing Office, September 1990).

short supply. Shifts in populations will put increasing pressure on existing supplies and require more conservation. The use of more Xeriscaping and infiltration of storm water are already becoming standard practice as part of conservation efforts.

The energy issues that arose in California in 2000 and 2001 is an example of the complexity of the problems we face. The consumers are interested in access to affordable power but have been reluctant to authorize the construction of new generating plants. Although conservation is not a significant part of our national energy strategy, designers might anticipate more opportunities for innovation in site design that contribute to energy and water use efficiency as well as conservation. Conservation-related design is viable because it pays for itself and contributes to the bottom line of businesses.

At the time the 2000 U.S. Census was conducted, there were 77 million people in the United States over 50 years old. The midwestern and northeastern states are growing older. In some northern states the number of births per year is less than the replacement level. It is possible some northern states may experience a decline in population even while other parts of the country are expanding rapidly. Florida is already well known as a retirement destination, but other states such as Pennsylvania, West Virginia, Iowa, and North Dakota are seeing growth in their populations of retired people. In part this is because many younger people are moving to the Sun Belt states while older folks tend to remain close to home even in retirement—"aging in place" it has been called. The number of older people is expected to double in Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, the Carolinas, and Texas by 2025. Another factor contributing to the shifts occurring in the U.S. population is immigration. The number of immigrants to the United States promises to continue to grow, and immigrants tend to concentrate in "gateway" cities like Chicago and New York.

With the anticipated increase in population, the need for water and energy conservation and planned growth becomes even more important. Issues of "smart growth" will become more critical. For communities in some parts of the country, development pressure will only grow. Local government will have the opportunity to deal with growth-related issues including open space and public facilities before the crush. The community consideration of the standards to be used for that future growth should be undertaken as soon as possible, in accordance with the community's vision for its future.

The growing population of older Americans presents opportunities for design firms as well as significant challenges in some states where the majority of population growth is among the oldest people (see Table 1.2). It is expected that the baby-boomers will enjoy a relatively healthy and active retirement that may yet increase the continuing demand for housing and recreation. The nature of these products should be expected to change, however. Some cultural observers anticipate a return to simpler values and even a growing spirituality in the culture as the boomers reach retirement. These trends may indicate a growing philosophical awareness of the boomers or simply a reflection of lower retirement income. Some communities that allow for real estate and school tax

TABLE 1.2 Population Change from 2000 to 2025

	Total population			Population age 65 and older		
State	2000	2025	Change, %	2000	2025	Change, %
Alabama	4,451	5,224	17.4	582	1,069	83.7
Alaska	653	885	35.5	38	92	142.1
Arizona	4,798	6,412	33.6	635	1,368	115.4
Arkansas	2,631	3,065	16.5	377	731	93.9
California	32,521	49,285	51.5	3,387	6,424	89.7
Colorado	4,168	5,188	24.5	452	1,044	131.0
Connecticut	3,284	3,739	13.9	461	671	45.6
Delaware	768	861	12.1	97	92	(5.2)
District of Columbia	523	655	25.2	69	92	33.3
Florida	15,233	20,710	36.0	2,755	5,453	97.9
Georgia	7,875	9,869	25.3	779	1,668	114.1
Hawaii	1,257	1,812	44.2	157	289	84.1
Idaho	1,347	1,739	29.1	157	374	138.2
Illinois	12,051	13,440	11.5	1,484	2,234	50.5
Indiana	6,045	6,215	2.8	763	1,260	65.1
Iowa	2,900	3,040	4.8	442	686	55.2
Kansas	2,668	3,108	16.5	359	605	68.5
Kentucky	3,995	4,314	8.0	509	917	80.2
Louisiana	4,425	5,133	16.0	523	945	18.2
Maine	1,259	1,423	13.0	172	304	76.7
Maryland	5,275	6,274	18.9	589	1,029	74.7
Massachusetts	6,199	6,902	11.3	843	1,252	48.5
Michigan	9,679	10,072	4.1	1,197	1,821	52.1
Minnesota	4,840	5,510	13.8	596	1,099	84.4
Mississippi	2,816	3,142	11.6	344	615	78.8
Missouri	5,540	6,250	12.8	755	1,258	66.6
Montana	950	1,121	18.0	128	274	114.1
Nebraska	1,705	1,930	13.2	239	405	69.5
Nevada	1,871	2,312	23.6	219	486	121.9
New Hampshire	1,224	1,439	17.6	142	273	92.3
New Jersey	8,178	9,558	16.9	1,090	1,654	51.7
New Mexico	1,860	2,612	40.4	206	441	114.1
New York	18,146	19,830	10.9	2,358	3,263	38.4
North Carolina	7,777	9,349	20.2	991	2,004	102.2
North Dakota	662	729	10.1	99	166	67.7

TABLE 1.2 Population Change from 2000 to 2025 (Continued)

	Total population			Population age 65 and older		
State	2000	2025	Change, %	2000	2025	Change, %
Ohio	11,319	11,744	3.8	1,525	2,305	51.1
Oklahoma	3,373	4,057	20.3	472	888	88.1
Oregon	3,397	4,349	28.0	471	1,054	123.8
Pennsylvania	12,202	12,683	3.9	1,899	2,659	40.0
Rhode Island	998	1,141	14.3	148	214	44.6
South Carolina	3,858	4,645	20.4	478	963	101.5
South Dakota	777	866	11.5	110	188	70.9
Tennessee	5,657	6,665	17.8	707	1,355	91.7
Texas	20,119	27,183	35.1	2,101	4,364	107.7
Utah	2,207	2,883	30.6	202	495	145.0
Vermont	617	678	9.9	73	138	89.0
Virginia	6,997	8,466	21.0	788	1,515	92.3
Washington	5,858	7,808	33.3	685	1,580	130.7
West Virginia	1,841	1,845	0.2	287	460	60.3
Wisconsin	5,326	5,867	10.2	705	1,200	70.2
Wyoming	525	694	32.2	62	145	133.9

Adapted from U.S. Bureau of the Census, 2000.

abatement for older taxpayers may experience a shrinkage in local tax income as local population ages in place at the same time as demand for services for older citizens rises.

Anticipated Effects of Global Climate Change

Global climate change models anticipate a broad range of impacts. These impacts are believed to be underway already, and we are to expect that many will begin to manifest significant impacts on the environment within the next 25 to 100 years. Many of these changes and impacts have direct implications for the development of land.

North America has a largely urban population: 75 percent of the population lives in cities or the suburban fringe of metropolitan areas. Moreover, 75 percent of the population lives in what are termed *coastal communities,* that is, communities influenced or situated by large bodies of water. The United States is the world leader in the production of greenhouse gases—the human-caused component in climate change. As governments around the world have recognized the trends indicating that climate change is already occurring, there has been growing international pressure on the United States to change its behavior.

Most climate change models are based on a doubling of carbon dioxide in the atmosphere. Carbon dioxide is a minor constituent in the atmosphere, representing only about 0.03 percent. At the time the industrial revolution began, there were about 280 parts per million (ppm), down from 1600 ppm about 300 million years ago. Much of the carbon dioxide from earlier epochs has been sequestered in deposits of coal and oil, in peat bogs and tundra. In 2001 there was about 360 ppm carbon dioxide, approximately a 30 percent increase. The increase is estimated to be about 2 percent each year, and it is predicted that a doubling of carbon dioxide over preindustrial revolution levels will occur in the second half of the twenty-first century. It is anticipated that there will be important changes in world climate with such a rapid and dramatic increase in carbon dioxide levels.

The models used to predict climate change trends are projections based on complex sets of factors. Different models give different results, but in general there is a valid and significant agreement on the global climate trends (see Table 1.3). There is a great deal of variability in the climate and weather of the United States and Canada, which means that projections based on these models may have limited use on a local level. Nevertheless, it is important to note that observed changes in weather and climate are consistent with the predictions of global climate change. Uncertainty exists in the models partly because of the limitations of data and science's ability to model something as complex as world climate and partly because it is unknown how people and governments will react to the information. If governments and business respond and reduce the emissions or alternatively increase the sequestration of carbon, for example, the impacts and degree of change may be less. All of the models presume a doubling of carbon dioxide by 2100 although more recent data from the International Panel on Climate Change indicate that the doubling may occur faster than originally expected. Recent work has indicated that the global average temperature increased 1°F in the twentieth century, but most of that increase occurred in the last 30 years, indicating that the rate of warming was increasing.

The area of greatest temperature change is expected to be in a zone from northwestern Canada, across southern Canada and the northern United States to southeastern Canada and northeastern United States. Average temperatures are expected to increase as much as 4°F over the next 100 years. This increase in temperature will decrease the area and length of time of annual snow cover and should result in earlier spring melts. The risk of rain-on-snow storms will also increase, and with it the risk of associated floods will increase. Most of the increase in temperature is occurring as warmer nights, that is, our daytimes are not necessarily significantly warmer but our nights are not as cool as they used to be so there is an increase in the average daily temperature. In effect, there is less cooling at night because greenhouse gases tend to hold the heat longer so the rate of nighttime cooling is slowed. Average temperatures are rising a great deal because the lows are not as low as they used to be.

In addition, the world's oceans are warming as well. The temperature of the sea is expected to rise and influence the weather. Thermal expansion of the ocean

TABLE 1.3 Anticipated Impacts of Global Climate Change on Temperature and Precipitation in Individual States

	Temperature change, °F				Precipitation change (−), %			
State	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
Alabama	3	2	4	2	10	15	15	N/C
Alaska	5	5	5	10	15	10	Slight	Slight
Arizona	3–4	5	3–4	5	20	Slight	30	60
Arkansas	3	2	3	2	15	25	15	N/C
California	<5	5	<5	5	20–30	N/C	20–30	>20–30
Colorado	3–4	5–6	3–4	5–6	10	Little change	10	20–70
Connecticut	4	4	4	4	<10–20	<10–20	10–20	>10–20
Delaware	3	4	4	4	<15–40	15–40	<15–40	>15–40
Florida	3–4	3–4	3–4	–4	Little change	Little change	Little change	Little change
Georgia	3	2	4	3	10	15–40	15–40	10
Hawaii	3	3	3	3	Uncertain of changes	Uncertain of changes	Uncertain of changes	Uncertain of changes
Idaho	4	5	4	5	10	Little change	1	20
Illinois	3	2	4	3	10	25–70	15–50	10
Indiana	3	2	4	3	10	10–50	20	10
Iowa	3	2	4	4	10	20	15	10
Kansas	2	3	4	4	15	15	15	Little change
Kentucky	3	<3	>3	3	20	30	20	<10
Louisiana	3	3	>3	<3	Little change	10	10	Little change
Maine	<4	>4	>4	<4	Little change	10	10	30
Maryland	3	4	4	4	<20	20	<20	20
Massachusetts	4	5	5	4	10	10	15	20–60
Michigan	4	4	4	4	5–15	20	5–15	5–15
Minnesota	4	<4	4	4	Little change	15	15	15
Mississippi	3	2	4	2	10	15	15	Little change
Missouri	3	2	3	3	15	20–60	15	Little change
Montana	4	4	5	5	10	10	10	15–40
Nebraska	3	3	4	4	10	10	10	15
Nevada	3–4	5–6	3–4	5–6	15	(10)	30	40

TABLE 1.3 Anticipated Impacts of Global Climate Change on Temperature and Precipitation in Individual States (Continued)

	Temperature change, °F				Precipitation change (−), %			
State	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
New Hampshire	4	5	5	5	Little change	10	10	25–60
New Jersey	4	>4	>4	4	<10–20	10–20	10–20	>10–20
New Mexico	3	5	4	5	15	Slight decrease	Slight increase	30
New York	4	>4	>4	4	<10–20	10–20	10–20	>10–20
North Carolina	3	3	3	3	15	>15	>15	15
North Dakota	4	3	4	4	5	10	20	25
Ohio	3	3	4	3	5–25	25	20	5–25
Oklahoma	2	3	3	4	20	20	Slight increase	Little change
Oregon	4	5	4	5	Slight increase	Light decrease	15	15
Pennsylvania	<4	>4	>4	<4	10	20	50	20
Rhode Island	4	5	5	4	10	10	15	25
South Carolina	3	3	3	3	15	>15	>15	<15
South Dakota	3	3	4	4	10	10	10	20
Tennessee	2–3	<2–3	2–3	2–3	20	30	20	Slight increase
Texas	3	4	4	4	10	10	10	(5–30)
Utah	3–4	5–6	3–4	5–6	10	(10)	30	40
Vermont	4	5	5	5	Little change	10	10	30
Virginia	3	3	4	3	20	20	20	20
Washington	4	5	4	5	Little change	Little change	Little change	10
West Virginia	3	3	4	3	20	20	20	>20
Wisconsin	4	<4	4	4	Little change	15–20	15–20	15–30
Wyoming	4	5	4	6	10	Decrease slightly	10	30

Compiled from USEPA. www.epa.gov/globalwarming/

and increases in runoff from glaciers and ice fields are expected to continue and result in rising ocean levels (see Table 1.4). In some places such as Texas and Louisiana, the effect of rising seas may be made worse by concurrent land subsidence. The world's oceans are expected to rise by nearly 20 in by 2100. Such an increase has significant implications for coastal communities. Will warmer oceans influence hurricane frequency and storm intensity?

TABLE 1.4 Climate and Sea Level Changes in Individual States

State	Temperature change, (−), °F	Precipitation change, %[a]	Sea level change, in[b]	Anticipated sea level change, in, 2000–2100
Alabama (Tuscaloosa)	(0.1)	20	9.0	20.0
Alaska (Anchorage)	3.9	10	—	10.0
Arizona (Tucson)	3.6	20[c]	—	—
Arkansas (Fayetteville)	0.4	20	—	—
California (Fresno)	1.4	20	3.0–8.0	13.0–19.0
Colorado (Fort Collins)	4.1	20	—	—
Connecticut (Storrs)	3.4	20	8.0	22.0
Delaware (Dover)	1.7	10	12.0	23.0
Florida (Ocala)	2.0	—[d]	7.0–9.0	18.0–20.0
Georgia (Albany)	(0.8)	10	13.0	25.0
Hawaii (Honolulu)	4.4	20	6.0–14.0	17.0–25.0
Idaho (Boise)	<1.0	20	—	—
Illinois (Decatur)	(0.2)	20	—	—
Indiana (Bloomington)	1.8	10	—	—
Iowa (Des Moines)	(0.02)	20	—	—
Kansas (Manhattan)	1.3	<20	—	—
Kentucky (Frankfort)	(1.4)	10	—	—
Lousiana (New Orleans)	N/C	5–20	—	—
Maine (Lewiston)	3.4	(20)	3.9	14.0
Maryland (College Park)	2.4	10	7.0	19.0
Massachusetts (Amherst)	2.0	20	11.0	22.0
Michigan (Ann Arbor)	1.1	20	—	—
Minnesota (Minneapolis)	1.0	20	—	—
Mississippi (Jackson)	2.1	20	5.0	15.0
Missouri (Jefferson City)	(0.5)	10	—	—
Montana (Helena)	1.3	(20)	—	—
Nebraska (Lincoln)	(0.2)	10[e]	—	—
Nevada (Elko)	0.6	20	—	—
New Hampshire (Hanover)	2	20	7.0	18.0
New Jersey (New Brunswick)	1.8	5–10	15.0	27.0
New Mexico (Albuquerque)	(0.8)	20	—	—
New York (Albany)	>1.0	20	10.0	22.0
North Carolina (Chapel Hill)	1.2	5	2.0	12.0
North Dakota (Bismarck)	1.3	(10)[f]	—	—
Ohio (Columbus)	0.3	10[g]	—	—

TABLE 1.4 Climate and Sea Level Changes in Individual States (Continued)

State	Temperature change, (−), °F	Precipitation change, %[a]	Sea level change, in[b]	Anticipated sea level change, in, 2000–2100
Oklahoma (Stillwater)	0.6	20	—	—
Oregon (Corvallis)	2.5	20[h]	4.0	6.0
Pennsylvania (Harrisburg)	1.2	20	—	—
Rhode Island (Providence) 12.4		3.3	20	2.0
South Carolina (Columbia)	1.3	20	9.0	19.0
South Dakota (Pierre)	1.6	20[i]	—	—
Tennessee (Nashville)	1.0	10	—	—
Texas (San Antonio)	0.5	(20)	25.0	38.0
Utah (Logan)	1.4	20	—	—
Vermont (Burlington)	0.4	5	—	—
Virginia (Richmond)	0.2[j]	10	12.0	23.3
Washington (Ellensburg)	1.0	20	8.0	19.0
West Virginia (Charleston)	10.0	10	—	—
Wyoming (Laramie)	1.5	(20)	—	—

[a]Change may not address all parts of a given state.
[b]Rate of change historically.
[c]Some parts of Arizona have experienced a 20 percent decline in precipitation.
[d]Precipitation has decreased in the south and the keys and increased in the north and panhandle.
[e]Precipitation has decreased as much as 10 percent in some parts of Idaho.
[f]Except in western Nebraska where precipitation has fallen by 20 percent.
[g]Precipitation has decreased in southern Ohio.
[h]Except leeward side of Cascade mountains where precipitation has decreased by 20 percent.
[i]Except southeastern part of South Dakota where precipitation has risen slightly.
[j]Other parts of Virginia have shown a decrease in temperature.

SOURCE: Compiled from USEPA. www.epa.gov/globalwarming/

Increases in shore and beach erosion should be anticipated along coastlines. Barrier island communities may experience significant losses. Local and state governments will be required to devise strategies for impacted communities that may require significant public expense. Insurance for coastal properties can be expected to rise significantly. Reinsurance companies have predicted catastrophic insurance losses associated with weather to increase to $300 billion worldwide through 2010. Beach replenishment will become an increasingly expensive (Table 1.5), and perhaps futile, effort. Barrier islands should be expected to shift landward in response to deepening oceans. Necessary mitigation methods such as the construction or improvement of existing sea walls

TABLE 1.5 Estimated Cost of Sand Replenishment for a 20-Inch Rise in Sea Level

State	Cumulative costs of shoreline protection, millions of dollars
Alabama	60–200
California	174–3,500
Connecticut	500–3,000
Delaware	34–147
Florida	1,700–8,800
Georgia	154–1,800
Hawaii	340–6,000
Louisiana	2,600–6,800
Maine	200–900
Maryland	35–200
Massachusetts	490–2,600
Mississippi	70–140
New Hampshire	39–104
New Jersey (Long Beach Island only)	100–500 (bulkheads and sea walls)
New York (Manhattan island only)	30–140 (bulkheads and sea walls)
North Carolina	660–3,600
Oregon	60–920
Rhode Island	90–150
South Carolina	1,200–9,400
Texas	4,200–12,800
Virginia	200–1,200
Washington	143–2,300

Compiled from U.S.E.P.A. information.

or bulkheads and the installation of revetments or levees on bayside beaches would add additional costs to the beach replenishment efforts. It is important to note that some of these costs are already being paid. Sea level rise has significant implications for water supply as well. Saltwater encroachment may become a larger problem as coastline communities continue to grow and groundwater use increases. It is expected that as much as 50 percent of the coastal wetlands will be inundated. Louisiana is currently losing 35 mi^2 of wetland each year due to saltwater intrusion.

Rising sea levels will complicate floods of tidal-influenced rivers and streams. Increased storm surges may back up streams and change floodplain characteristics. It has been calculated that a sea level rise of 40 in (1 m) would result in a flood with a frequency of 15 years actually inundating the same area a 100-year flood covered previously. The Federal Emergency Management

Agency (FEMA) estimated that a rise of 12 in and 36 in would increase the area impacted by a 100-year flood from 19,500 mi^2 to 23,000 and 27,000 mi^2, respectively. Damage resulting from these floods would be expected to rise 36 to 58 percent for a 12-in increase and from 102 to 200 percent for a 36-in increase.

Changes in precipitation patterns along the Gulf Coast, central and northern plains, and parts of the midwestern and northeastern United States may experience as much as 10 to 20 percent increase in annual precipitation. The distribution of the precipitation may also change as it arrives in more frequent storms of higher intensity. The more intense storms may result in less infiltration and a greater amount of runoff. The result would be falling groundwater tables, streams, and lakes. The shortened snow season may result in less snowpack in western states and earlier runoff. Reservoirs built to collect runoff for use throughout the year may begin to have a longer service period and experience shortages earlier in more frequent dry years. Earlier runoff may result in lower streams and river flows later in the summer as well. Reduced flows could impact hydroelectric production in some places. More frequent and intense rains in some places will result in increases in storm runoff, erosion, and slope instability. The increase in runoff may require a rethinking of the maximum probable storm (MPS) event in many places. It may require retrofitting of exiting storm water collection and control devices to retain more water and encourage infiltration.

Paradoxically with an increase in precipitation there is expected to be an increase in the number and severity of droughts. Increased temperatures will result in an increase in evaporation and a loss of soil moisture. The loss of soil moisture, and the increased runoff associated with more intense storm events, may result in lower streams and rivers but also warmer streams and rivers. Cold-water fisheries may become endangered in the southern-most ranges. Falling levels in the Great Lakes have already been observed, and it is possible that falling levels could limit commercial traffic in the Saint Lawrence River during certain times of dry years. This may be offset, however, by a longer ice-free season in the Great Lakes.

An increase in carbon dioxide should result in more robust plant growth. Some have observed that this is the "upside" to global climate change and will increase food and fiber production. Other studies have found that as carbon dioxide levels increase, some plants actually reduce the rate of photosynthesis. Still others observe that the increased production of plant mass results in an increase in plant litter, which alters the carbon/nitrogen ratio in the soil, in effect reducing the amount of nitrogen available for plants. The increase in leaf area will also increase the amount of transpiration, which will contribute to the drying of soils.

The implications of climate change may be significant. It is possible that most of the United States will experience an increase in the frequency of precipitation as the amount of rainfall increases and its distribution changes. Increased erosion and perhaps slope destabilization in some places can be expected with an increase in precipitation. Coastal communities may experience an increase in flooding and beach erosion. Flood-prone areas may increase in size as the sea levels rise. Public health officials and communities may become more sensitive to areas of standing water as subtropical and tropical diseases expand their range. Design strategies in impacted coastal communities may provide significant opportunities for innovation and problem solving.

Site planners and designers will have to respond to these climate changes by retrofitting existing facilities and designing new projects. While infiltration will continue to be an important element of site planning, perhaps the wet pond will be less desirable with the spread of the West Nile virus or malaria. Clearly, in their designs and planning, site planners will have to account for the life cycle and habitat preferences of the mosquitoes that transmit such diseases.

Anticipated warming in most places will result in increasing cooling costs for all buildings, including homes. Properly locating a building and plantings on a given site so as to lower energy costs will become even more important. As temperatures increase, plants growing in the extremes of their southern range may be subject to significant heat- and drought-related stresses. Some places may see a shift in species considered to be “native,” particularly those living at the margins of their tolerance.

Figure 1.1 Photograph of a traditional street and neighborhood.

Land Use

Since World War II the growth of the suburbs has been the most important development, and possibly environmental, trend (Fig. 1.1). At the beginning of the twenty-first century more people live in suburbs than in the former urban centers. At the same time, awareness is growing that suburbs as they have evolved are unsustainable, but this knowledge has done little to slow the growth in consumer preference to live in suburban areas. There is a general acknowledgment that cities offer a greater cultural experience, but in general, populations have not started to return to urban areas in significant numbers. In fact, as they vote with their feet and checkbooks, people have shown their preference for suburban living over city living. Builders respond to market demand; they do not create it. Thus changing the trend to urban living will require changing public policy, which is politically difficult, if not impossible. Local ordinances tend to favor low-density development and highways, not parks and higher-density development. It is difficult for planners and designers to influence this suburban growth trend on a site-by-site basis. Instead, planners and designers will have to address the impacts of suburban development through design.

Paradoxically many people living in suburbs seem to prefer what might be considered urban values and character. A survey by the National Association of Home Builders (NAHB) found that those surveyed would prefer to live within walking distance of schools, shops, and community facilities. The study also found that in spite of the standard practices of most ordinances, most people would rather live in a place with narrower streets and more public open space. During the time that American families became smaller by nearly half, new houses have ballooned to more than twice the size. As the population has become older, however, there is an increasing interest in smaller homes. In some metropolitan areas most of the homes built and purchased are townhouses and condominiums (Fig. 1.2). Part of this popularity may be due to the cost of housing in some urban areas, but many of these units are higher-end dwellings located near shopping or social and cultural features of the city.

The southwestern parts of the United States are becoming more popular places to live, and designing for those areas presents significant challenges. The influx of people from more humid parts of the country has brought with it an expectation of life and an esthetic that often is simply out of place in the desert. The southeastern part of the United States is already facing problems with water supply. The native people of these dry places long ago found ways to live that recognized the character of their region. Our culture is faced with learning and acting on the lessons already known by so many, while our footprint is so much larger and deeper. These areas of growth are experiencing significant declines in other environmental indicators such as air quality, biodiversity, and human health. It remains to be seen if we can find the ways to live sustainably and successfully in the desert. Figure 1.3 is an example of good design.

Figure 1.2 Photograph of a contemporary urban neighborhood.

The shift of population to the South and the suburbs leaves many northern cities with declining populations and tax bases, underutilized infrastructure, and the remains of an industrial past that lasted only 50 years in many places. The recognition of brownfield redevelopment opportunities has been important in the last few years for cities and for designers. The challenges of redeveloping brownfields, however, require site designers to confront the impacts of industrial contamination; we can no longer assume a site to be clean and healthy. This requires a different mindset and more than a few new skills. Consequently, design professionals find themselves working on more diverse project teams. The roles of professional boundaries often blur within the context of projects looking for innovative solutions to complex problems.

Sustainable Development Principles

Our culture context for sustainability is in its infancy, but the dialogue is well underway. There are important voices encouraging us not to go back but forward, to solve problems through design. No single set of guidelines has emerged, but there is a growing recognition of the principles that lead to sustainable design and development. The views of leaders such as William McDonough and Emory Lovins are moving into boardrooms and legislatures and are beginning to change the expectations of design professionals.

Figure 1.3 Photograph of a southwestern home.

The definitions of "sustainable development" are too numerous to recount. The phase itself is in danger of becoming another meaningless mantra. Design professionals need to recognize the intellectual and professional challenge presented to them in the need to find a workable balance with nature. This may be the most important time for the design professions since they have emerged. Architects have made important advances in designing green buildings, though the practices are hardly mainstream yet. There are excellent but too few examples of sustainable site development practices.

Sustainable site planning must include considerations of the impact of the site development on the local ecosystem, the global ecosystem, and the future. Principles of green site work encourage the designer to consider the nature of the materials and the flows of energy and materials not only to build the project but to maintain it over its useful life and to dismantle and dispose of it eventually if necessary (Table 1.6). More than just modifying the way storm water is handled, for example, the designer should consider the life cycle costs of the materials being used, the ultimate disposition of the site and the materials, and ways in which any negative impacts can be reduced or mitigated.

The longer the useful life of a building or a site, the longer the environment has to "amortize" the impacts. But designing a site with an extended life span requires the designer to consider future and possibly different uses and to incorporate that thinking into the design. The most sustainable development is