PART SEVEN
Sustainability and the Individual

Issue 24

SUSTAINABLE COMMUNITIES: *SPRAWL VERSUS SMART GROWTH*

KEY QUESTIONS

- How do scientists calculate population growth for a locality?
- What is sprawl, and how can we assess its environmental impacts?
- What are the implications of sprawl?
- How do municipalities deal with storm water?
- What is smart growth and what is it designed to accomplish?
- What are brownfields?

POPULATION GROWTH

> "Sprawl is not evil. In fact, it is good. It is the inevitable result of a free people exercising their cherished, constitutionally protected rights as individuals to pursue their dreams when choosing where to live, where to work, where to educate, and where to recreate."[1]

Population growth at the local level involves not only more people, but also high rates of land conversion, often called "development" The type of residential land conversion most common in the United States is *sprawl.* In this type of development, the amount of land converted from its traditional state (e.g., open space, farmland, forests) to residential and commercial use rises at a much faster rate than the growth of the population. For example, a study of urban growth in the greater Charleston, South Carolina metropolitan area from 1973 to 1994 found that over the twenty-one-year period, the rate of urban land use growth exceeded population growth by a 6:1 ratio.[2]

L. Brooks Patterson is certainly entitled to his opinion, but sprawl is associated with numerous kinds of environmental issues, not the least of which is transport emissions, especially CO_2. In a report done by the World Bank cities were ranked according to their population densities and CO_2 transport emissions per capita per year. Here is a brief snapshot of the findings.[3]

---

[1] The county executive of Oakland Co., MI, L. Brooks Patterson, http://www.oakgov.com/exec/brooks/sprawl.html.

[2] Allen, J., & Kang Shou Lu. Modeling and predicting future urban growth in the Charleston area. The Strom Thurmond Institute for Government and Public Affairs, Clemson University. www.strom.clemson.edu/teams/dctech/urban.html.

[3] *The Economist*, Shoots, greens and leaves; June 16, 2012, p. 69.

City	Population Density/ Hectare	CO_2 Transport Emissions Per Capita/Y*
Atlanta	2.4	7.5
Houston	14	6.2
Melbourne	16	2.5
London	50	1.2
Barcelona	160	1.6
Bangkok	185	0.8
Note: Barcelona and Atlanta have similar populations. *Tonnes		

Question 24-1: Describe the association between urban population density and transport emissions.

Question 24-2: Atlanta's metropolitan area is home to about 5.2 million people. How many tonnes of CO_2 per year could be saved if Atlanta was as efficient as Barcelona, with a similar population?

Prince William County, Virginia, located 35 kilometers south of Washington, D.C. along Highway I-95, has been one of the more growth-oriented entities in its region. From 1940 to 1990, Prince William's population grew at the rate of 4 percent per year. From 1990 to 2000, growth rates decreased to 2.6 percent. Its population in 2010 was 402,000 with a population density of 1,195 persons per square mile.[4] We will use Prince William County as our first case study of local growth. Between 2000 and 2007 alone, 9.4% of the entire county area was developed from open space/forest to commercial/residential structures.

GROWTH IN PRINCE WILLIAM COUNTY

Recall from Issue 1 (page 31) that when a population grows exponentially, the time it takes for the population to double, called doubling time, can be calculated using the formula $t = 70/r$, where t equals doubling time (usually in years) and r is the growth rate expressed as the percentage increase or decrease (for example, a rate of 7%, or 0.07, would be entered as 7). Doubling time is a very useful and practical concept for *projecting* (not *predicting*) and analyzing the implications of growth.

[4] http://quickfacts.census.gov/qfd/states/51/51153.html.

Question 24-3: Population growth from 2000 to 2010 was 43.2%.[5] What then was the average rate of growth over that ten-year period?

Question 24-4: The 2010 population of Prince William County was 402,000. Using the doubling time formula, determine approximately when the population of Prince William County would reach 1 million. Starting with the 2010 population, use the most recent percent annual rate (2000–2010).

Question 24-5: Now, let's apply the doubling time formula to project land-use changes. The area of Prince William County is approximately 9×10^8 m^2. At a 4.3 percent growth rate, when would Prince William County reach a population density of 1 person/100m^2?

Question 24-6: Answer the question again, using an earlier growth rate of 2.6 percent. Compare the two results and state how much more time it would take Prince William County to reach this high density with the lower growth rate.

Question 24-7: Discuss to what extent lowering the growth rate significantly reduces the impact of population growth.

[5] www.pwcgov.org.

IMPERVIOUS SURFACE

Development is an inclusive and somewhat ambiguous term used to refer to all the human-built structures in an area. One major effect of development is the increased amount of *impervious surface.* Impervious surface refers to any surface material that water cannot penetrate. In this section, we will analyze impervious surface as a local population growth issue.

When most people speak of development, they mean subdivisions, commercial buildings (such as offices, shops, and malls), and roads. Most of these buildings have parking areas attached. The parking area can be as small as the driveway of a house or it can be a paved area adjacent to a large mall, covering tens of thousands of square meters. These impervious surfaces collect runoff and prevent it from infiltrating into soils and surface sediment, where rainfall can be stored and natural filtering can often remove some pollutants.

Paved areas, and the vehicles that are parked on them, can contribute significant amounts of pollution to the water. But even if the runoff were to contain no pollution, it still would increase the risk of flash flooding. Local government officials are familiar with these threats and try to design stormwater management systems to handle runoff from development. Most municipal systems consist of a network of pipes that collect runoff from streets and large parking lots and channel it into artificial stormwater detention ponds or into creeks in the vicinity. Sometimes, the runoff pipes carry the water to a sewage treatment plant, where it can be treated before it is discharged into streams.

Stormwater management systems can, but rarely do, incorporate *Better Site Design* principles, including reshaped zoning regulations, increased green space, pervious concrete, vegetated swales and buffers, rain gardens, narrower streets, and even vegetated rooftops.

Although treating runoff to remove pollutants is a good idea, it can cause serious problems during times of heavy runoff. The added runoff from the stormwater system can, and often does, overload the sewage treatment plants, resulting in a mixture of untreated sewage and storm water dumped into waterways. For this reason, many communities design separate systems to transmit sewage and stormwater. Although this is more expensive, it results in much less environmental degradation, especially during floods. Unfortunately, it can also result in polluted water from impervious surfaces contaminating waterways.

Stormwater management systems work only as well as the weakest link in the chain, which simply means that if anything can go wrong, it usually will. Pipes and retention ponds may get clogged with debris or fill up with vegetation and sediment. Storm drains may be too small to handle runoff volumes, and development since construction of the system may overload them. This means that unless local governments take painstaking care in the design and maintenance of stormwater management systems, a costly endeavor that cash-strapped cities often forego, the more development in an area, the higher the risk of flash flooding.

HURRICANES AND TROPICAL STORMS

A hurricane or tropical storm can often dump as much rain on an area in a few hours as the area experiences in several months. Consider this example from Prince William County. The Potomac Mills Mall is one of the largest in the United States, and in 1999 the buildings and parking area together represented 5,675,411 ft^2 of impervious surface.[6]

When the last great hurricane, Agnes, hit the area in June of 1972 and dumped 14 inches of rain on the region in three days, Agnes' effects were described by officials as

[6] Prince William County Department of Public Works (Prince William County did not publish impervious surface data for 2000 and later.)

the Eastern Seaboard's most costly disaster in history. But Potomac Mills Mall hadn't yet been built.

Question 24-8: Assume another Hurricane Agnes-size storm occurs (as it surely will someday) and dumps 14 inches of rain on the region in 72 hours. Assume further that before Potomac Mills Mall was built the land was pasture and forest, which, given the area's subsurface geology, could have absorbed much of the storm's runoff. Calculate the maximum amount of extra runoff Potomac Mills Mall would generate when the next "Hurricane Agnes" hits northern Virginia. Express your answer in cubic feet and liters (1 $ft^3 = 2.83 \times 10^{-2}$ m^3; 1 m^3 = 1,000 L).

Question 24-9: Assume this runoff has to be handled over a 72-hour period. What is the resultant discharge from Potomac Mills Mall in liters per hour? (For comparison, a typical summer flow of the Potomac River is 100 million L/hr.)

Of course, this number represents a maximum value, but it illustrates how development can increase a region's susceptibility to flash flooding. Keep this point in mind while you study the impact of home building on Prince William County's impervious surface in the following section.

HOME BUILDING AND IMPERVIOUS SURFACE

Table 24-1 contains data on housing units and impervious surface for Prince William County from 1940–2010.[7] The area of the county is 222,615 acres or 90,000 hectares.

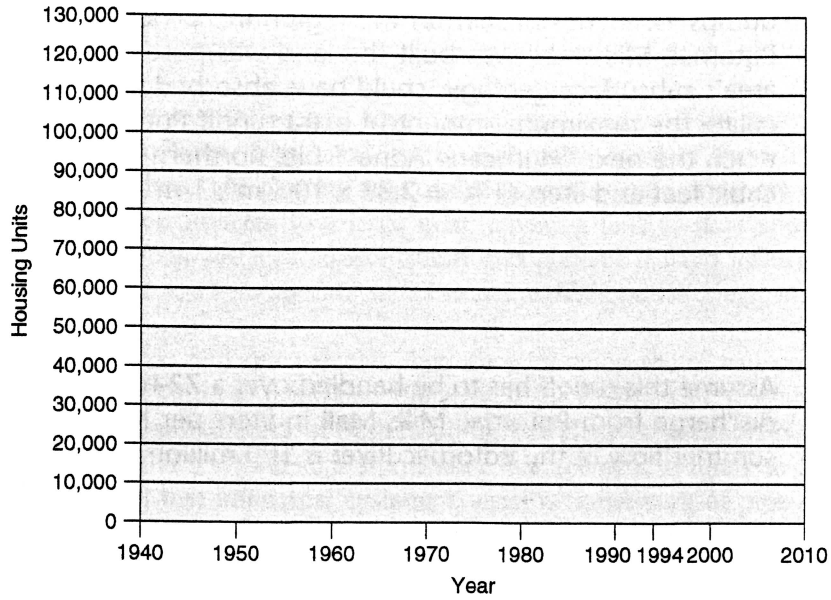
TABLE 24-1 ■ Prince William County's Housing Data Impervious Surface Area[1]

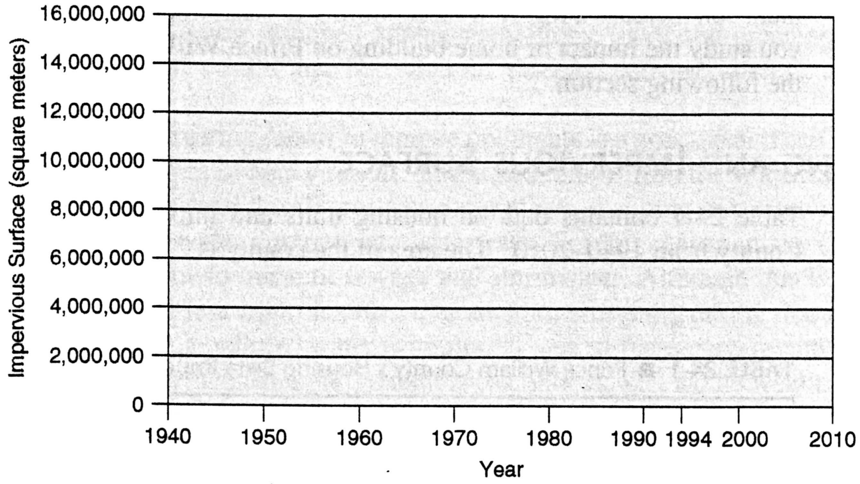
Year	Housing Units	Impervious Surface Area (m^2)	Area of county covered by impervious surface (from housing alone) %
1940	3,545	622,018	0.07
1950	5,755	1,009,850	0.11
1960	13,207	2,317,519	0.25
1970	29,885	5,244,050	0.58
1980	46,490	8,157,855	0.90
1990	74,759	13,107,552	1.45
1994	90,759	15,175,716	1.68
2000	94,570	—	—
2002	108,004	—	—
2005	123,379	—	—
2010	137,115	—	—

[1]Source: Prince William County Department of Public Works.

[7] Prince William County Department of Public Works.

Question 24-10: On the first set of axes below, plot housing units versus time. On the second set, plot impervious surface area (m^2) versus time. (Use data from 1940–2010.) Interpret the graphs.





(To answer the following questions, use the equation, $r = (1/t)\ \ln(N/N_0)$, explained in "Using Math in Environmental Issues," pages 6–8.)

Question 24-11: Calculate average annual growth rates for both housing units and impervious surface area for the period 1940–94. How do they compare?

Question 24-12: Using the growth rate for impervious surface area from 1940 to 1994, project the area of impervious surface as of 2010. How did your calculation compare to your projection?

Question 24-13: Speculate how life would be different in Prince William County if half the county were impervious surface.

Question 24-14: In Question 24-4, we asked you to project when Prince William County's population would reach a density of one person per 100 square meters, which is certainly a very high density. It has been observed that population growth will stop eventually. We can decide when, or we can let math and "nature" take its course. Comment on why no one seems to be planning for extremely high population densities.

Question 24-15: Discuss whether "sustainable growth" is an oxymoron.

Question 24-16: Summarize the main points of this Issue.