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Water and Wastewater Services in Appalachia

In his classic 1940s study of Beech Creek (actually Clay County) in eastern Kentucky, the central part of Appalachia, James S. Brown noted,

> All streams are polluted, and the people of the area get water from springs and shallow wells. These are sometimes inconvenient distances from the house and often go dry in summer, making even longer trips for drinking water necessary. Some, but not all, families had privies; others just went in the bushes.[14]

This image of an area where each family fended entirely for itself in obtaining drinking water and disposing of wastewater, frequently with awful results for families and the collective good, persisted through the era of the Great Society and Volunteers in Service to America and endures today. In truth, it is not dead for the most distressed communities in the Appalachian Highlands and the most remote rural residents, those at the "head of the hollow."

On the other hand, many people in the region now are served by modern, centralized systems for water and wastewater, and their problems are different: how to maintain and operate the systems efficiently and how to raise capital for periodic major investments and repairs. So, as with almost everything about Appalachia, presenting a single picture of how water and wastewater services are delivered is at best misleading. One must delve deeper to see the different types of service delivery, their distribution, and their accompanying problems.

Drinking Water

Households in Appalachia rely primarily on community water systems or individual wells for their drinking water.[15] However, several parts of Appalachia report having incomplete plumbing, an indication that households in these areas may have no access

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[14] James S. Brown, *Beech Creek: A Study of a Kentucky Mountain Neighborhood* (Reprint, Berea, Ky.: Berea College Press, 1988) 27.

[15] A "community water system" is a "public water system" (that is, a system providing water to the public for human consumption) that "serves at least 15 service connections used by year-round residents of the area or that regularly serves at least 25 year-round residents." Safe Drinking Water Act, 42 U.S.C. § 300f(16) (2004).

to drinking water at their residences. The highest percentages of households without complete plumbing are in Kentucky, Pennsylvania, and West Virginia. Cameron County, in Pennsylvania, has the highest proportion of its population without indoor plumbing, at 23 percent.[16] This compares with about 1 percent of households nationally without complete plumbing in 2000.

Although the majority of Appalachia's population (75 percent) is served by community water systems, wells still are the predominant source of water in many areas of the region. In parts of western North Carolina and western Virginia, less than 25 percent of the population is served by community water systems (see Figure 2-1).

The technologies and the treatment systems used by community water systems vary, depending on the type and the quality of source water, the age of the facility, and the size of the facility. Systems that treat surface water use a variety of physical and chemical processes, including sedimentation, filtration, and disinfection. Many in Appalachia and across the country have modified their disinfection systems over the last decade to meet more stringent regulations. Some still depend on the traditional method, chlorination. Others have implemented new systems, such as ozonation.

Groundwater systems are common throughout Appalachia. In general, they employ simpler treatment systems than surface water systems do. The typical small groundwater system in a community includes wells, pumps, and facilities for disinfection but not for filtration or sedimentation.

The well systems of individual households have some similarities with community systems. Normally, though, they do not have disinfection processes, making the protection of private wells even more important.

Many states in Appalachia have made expansion of coverage by a community water system a policy priority. As a result, over the last fifteen years, the region has seen significant gains in the number of people served by community water systems to 74 percent of the population, but still lags significantly behind national coverage (85 percent of the population) (see Figure 2-2) [17].

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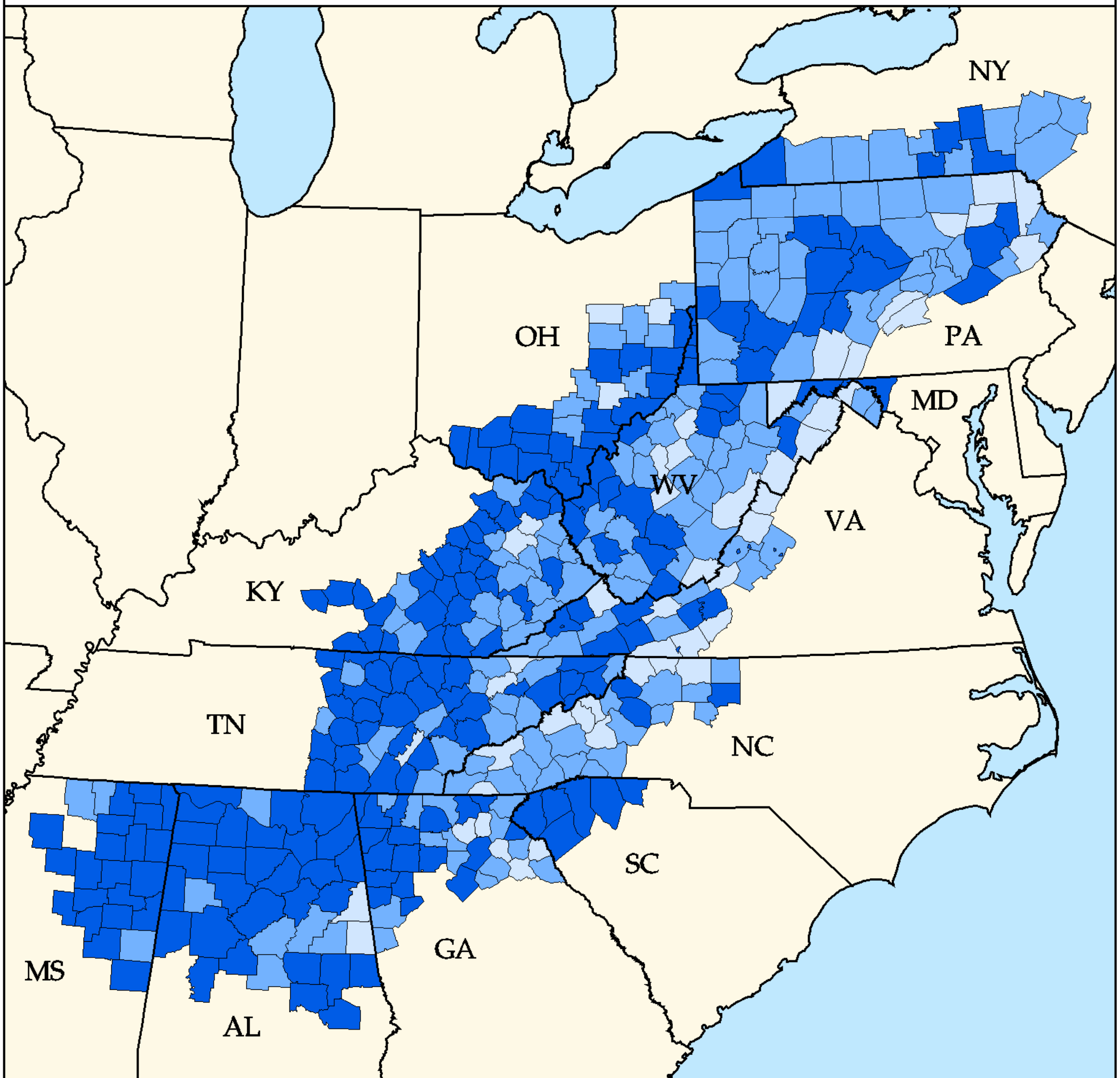
[16] Census Bureau, Census 2000, Summary File 3, Table H47.

[17] U.S. Geological Survey, Water Use Data 2000, county-level data, available at water.usgs.gov/watuse/data/2000/index.html.

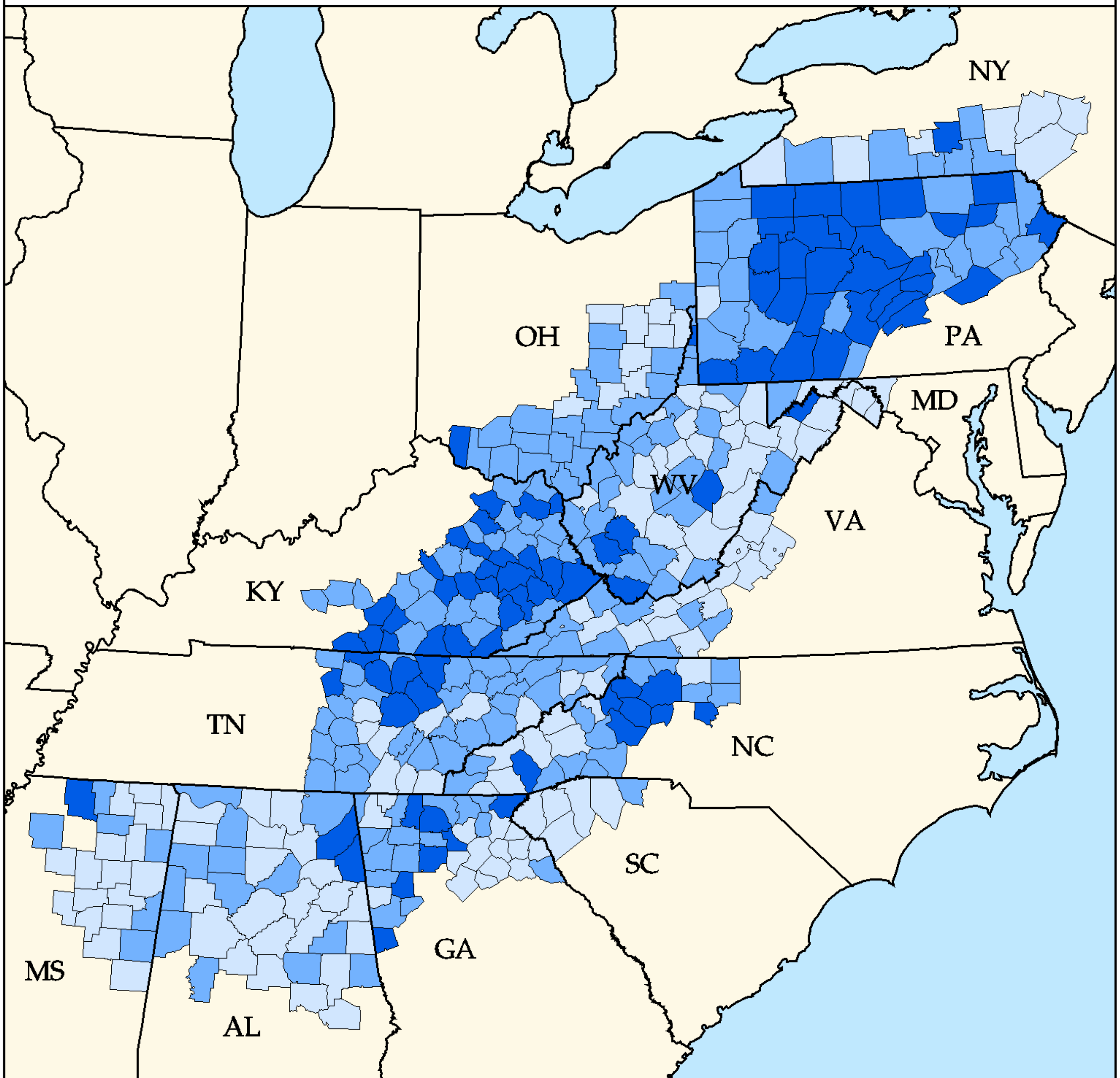
Figure 2-1. Percentage of Appalachian Population with Public Water Service, 1995



Data Source: U.S. Geological Survey, Water Use 1995
County Data Files, available on water.usgs.gov/watuse/spread95.html.
Data compiled by UNCEFC using
'PS-TOPop' and 'TotalPop' fields.

Less than 33%
33 through 67%
More than 67%

Figure 2-2. Increase in Percentage of Population with Public Water Service, 1985-1995



Data Source: U.S. Geological Survey, Water Use 1995 County Data Files, available on water.usgs.gov/watuse/spread95.html (data compiled by UNCEFC using 'PS-TOPop' and 'TotalPop' fields), and Water Use 1985 County Data Files, available on water.usgs.gov/watuse/wudl.county.ascii.html (data compiled by UNCEFC using 'po-total' and 'ps-popto' fields).

- Less than 1%
- 1 through 20%
- More than 20%

A little less than 10 percent (5,234) of the nation's 54,064 community water systems are in Appalachia (see Table 2-1). Fourteen percent of the nation's medium-sized systems (those serving 3,301–10,000 people) are in the region, compared with only 6 percent of the nation's very large systems (those serving more than 100,000).

Table 2-1. Community Water Systems in Appalachia and U.S.

	Community Water System (CWS) Classification: Population Served per CWS					
	Very Small 500 or less	**Small 501–3,300**	**Medium 3,301–10,000**	**Large 10,001–100,000**	**Very Large > 100,000**	**Total**
Number of CWSs in Appalachia	2,621	1,586	644	363	20	5,234
Percentage of CWSs in Appalachia	50	30	12	7	0	100
Percentage of CWS–served population in Appalachia	2	12	19	44	23	100
Number of CWSs in U.S.	31,688	14,149	4,458	3,416	353	54,064
Percentage of CWSs in U.S.	59	26	8	6	1	100
Percentage of CWS–served population in U.S.	2	8	10	37	44	100
Percentage of U.S. CWSs in Appalachia	8	11	14	11	6	10

Source: Data from Environmental Protection Agency, SDWIS, database for 4th quarter, fiscal year 2003, frozen in January 2004; downloaded from www.epa.gov/OGWDW/data/pivottables.html and compiled by UNCEFC

Nationally, 242 million people (85 percent of the country's population) obtain their water from community systems.[18] Most receive it from large or very large community systems (those serving more than 10,000 people).[19] Seven percent of the nation's systems serve 81 percent of the people who are served by such systems (see Table 2-1).

In 1995, seventy-five percent of the Appalachian population was served by community water systems. Thus the region was more dependent on onsite water systems than the nation as a whole was.

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[18] U.S. Geological Survey, Water Use Data 2000, county-level data, available at water.usgs.gov/watuse/data/2000/index.html.

[19] Environmental Protection Agency, *2000 Community Water System Survey* (Washington, D.C.: EPA, December 2002), available at www.epa.gov/safewater/cwssvr.html.

Furthermore, other aspects of water provision are significantly different in Appalachia. For example, the average service size of a community water system in Appalachia (3,800 people) is smaller than the average service size of all U.S. community water systems (4,900 people). Typically, smaller size means higher unit costs.

Certain subregions of Appalachia, notably the Highlands of the Blue Ridge (with 1,937 people per community water system) and the Appalachian Plateaus (with 3,396 people per community water system), tend to have even smaller facilities, with corresponding difficulties obtaining the economies of scale achieved elsewhere in the country. In general, the Appalachian portions of each state tend to be served by smaller systems than the non-Appalachian portions. For example, the average size of a water system in the Appalachian region of Ohio is 43 percent the average size of a system in the non-Appalachian region, in terms of population served.

More people (33 percent) in Appalachia are served by small and medium-sized systems (those serving 10,000 or less) than people in the nation (20 percent) are. Compared with the rest of the country, far fewer people are served by very large systems. Nationally the 353 largest water systems (those serving more than 100,000 people) provide water to 44 percent of the community water population. In Appalachia the 20 largest systems provide service to 23 percent of the community water population.

Kentucky, which has made reducing its number of small community water systems a priority, tends to have fewer systems than most other Appalachian states.[20] New York, North Carolina, and Pennsylvania have an abundance of small systems. Chautauqua County, New York, currently has 76 systems, and Buncombe County, North Carolina, 57. Every Appalachian county has at least 1 system. Fifty counties have 1 or 2, and thirty-six counties have more than 30. (For the number of systems in each Appalachian county, see Figure 2-3.)

Operating and capital costs correlate with the size of a community water system.21 In general, the smaller the system, the higher the costs. They also correlate with the type of community water system. Such systems fall into three general categories based on their source of water: groundwater, which they treat and then distribute; surface water, which they treat and then distribute; and water (either ground or surface) that they purchase from another system and then distribute. (For the distribution of community

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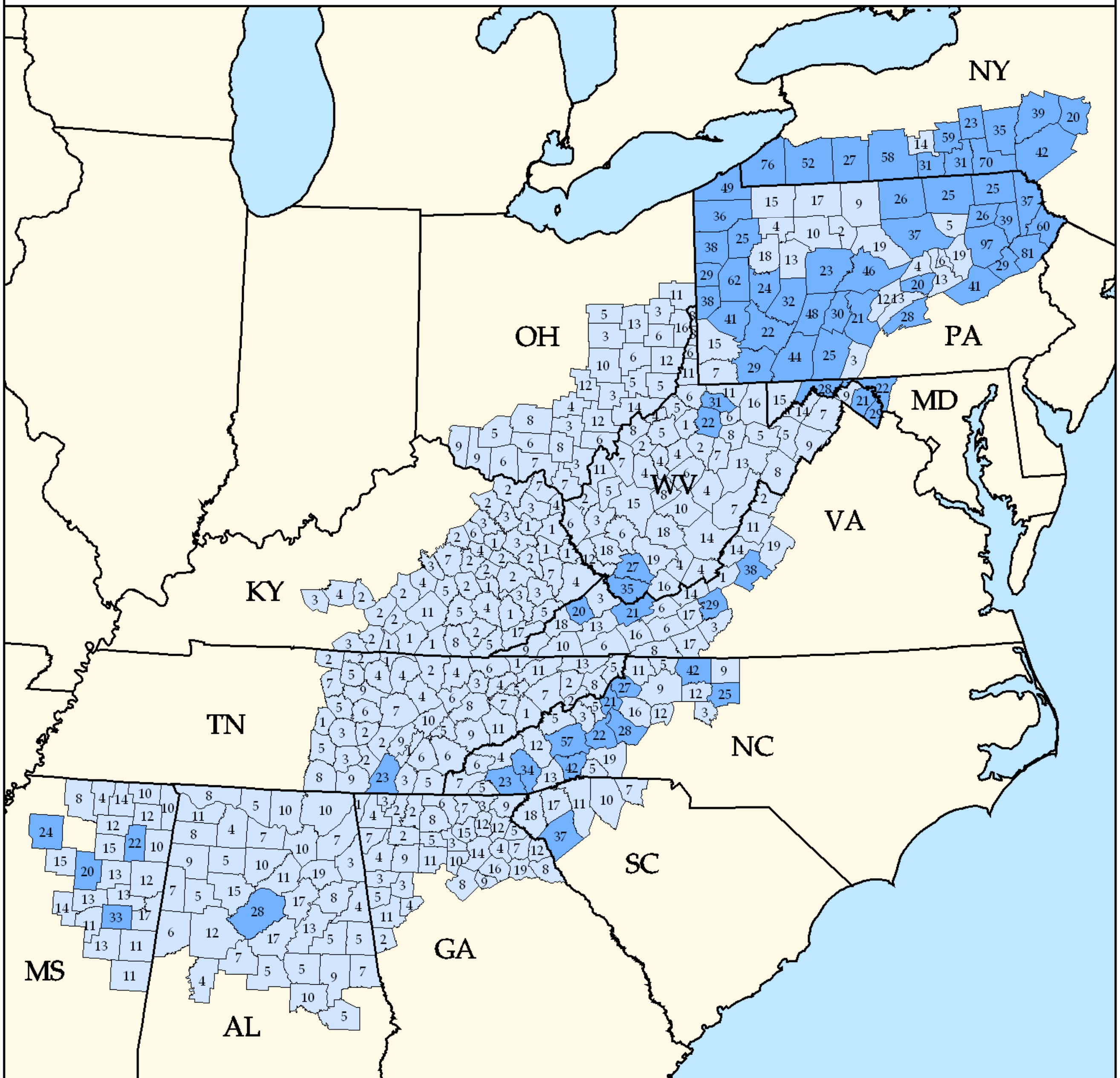
[20] Staff of Kentucky Infrastructure Authority, telephone conversations with authors, Fall 2004.

[21] Environmental Protection Agency, *Drinking Water Infrastructure Needs Survey: Second Report to Congress* (Washington, D.C.: EPA, 2001).

Figure 2-3. Number of Community Water Systems in Appalachia



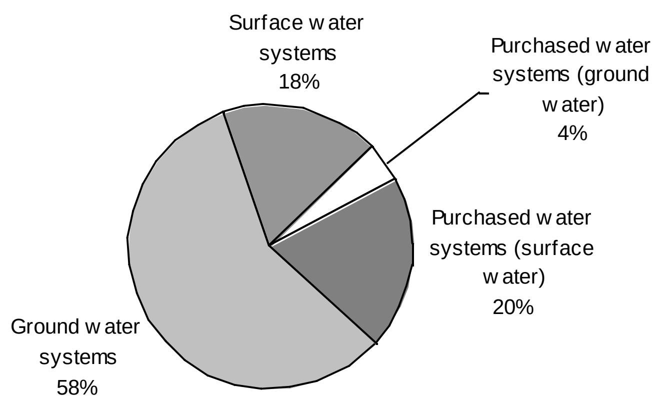
Data Source: Environmental Protection Agency,
Safe Drinking Water Information System database
for 4th quarter fiscal year 2003 frozen in January 2004,
downloaded from www.epa.gov/OGWDW/data/pivottables.html
and compiled by UNCEFC. Noncommunity water systems are
excluded. There were 5,234 community water systems in
Appalachia in January 2004

Fewer than 20

20 or more

water systems and the population served in Appalachia by source of water, see Figures 2-4 and 2-5.) Systems that rely on surface water tend to have significantly higher operating and capital costs than systems that treat groundwater or systems that purchase water. Nationally, 11 percent of the community water systems rely primarily on surface water, 74 percent on groundwater, and 15 percent on purchased water. In Appalachia, the corresponding proportions are 18 percent, 58 percent, and 24 percent. On the whole, 68 percent of the national population is served by the 22 percent of systems that receive their water (purchased or not) from surface sources. In Appalachia, 82 percent of the population served by community water systems is served by the 38 percent of systems that receive their water from surface sources.

Figure 2-4. Community Water Systems in Appalachia, by Source of Water

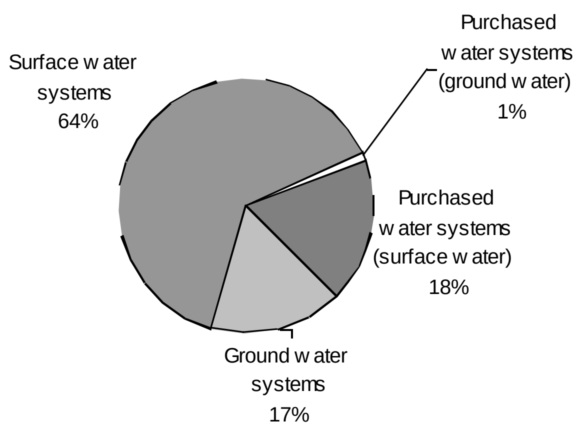


Source: Data from Environmental Protection Agency, SDWIS, database for 4th quarter, fiscal year 2003, frozen in January 2004; downloaded from www.epa.gov/ OGWDW/data/pivottables.html and compiled by UNCEFC. Noncommunity water systems are excluded. There were 5,234 community water systems in Appalachia in January 2004.

In sum, community water systems in Appalachia tend to face higher operating and capital costs than the national average because of their smaller size and their greater reliance on surface water.

The water treatment facilities that serve the population of Appalachia range in size from small groundwater systems that treat several thousand gallons per day with packaged chlorinators, to large surface-water treatment plants, such as a facility in Pittsburgh, Pennsylvania, that treats 117 million gallons per day (and serves 250,000 customers).

Figure 2-5. Appalachian Population Served by Community Water Systems, by Source of Water



Source: Data from Environmental Protection Agency, SDWIS, database for 4th quarter, fiscal year 2003, frozen in January 2004; downloaded from www.epa.gov/OGWDW/data/pivottables.html and compiled by UNCEFC. Noncommunity water systems are excluded. Percentages total to 100% of Appalachian population that is served by community water systems.

Water systems may be owned by public government organizations, such as municipalities, counties, and special government districts, or by private (nongovernment) organizations. Private owners fall into several categories, ranging from for-profit water companies to not-for-profit corporations to ancillary organizations that provide water as a secondary responsibility. Although a slight majority of systems in the United States are owned by nongovernment private entities, the size of most of these systems is small, so the majority of the U.S. population gets its water from public systems.

Forty-seven percent of the community water systems in Appalachia are privately owned and operated. They serve 18.3 percent of the community water population (compared with 15 percent of the U.S. community water population served by privately owned and operated systems).

In several Appalachian states, the number of private systems and the percentage of the population served by private systems are much higher. For example, in Ohio and West Virginia, 67 percent and 34 percent, respectively, of the community water population are served by private systems. In Alabama, only 2.1 percent of the community water population is served by private systems. North Carolina leads Appalachia in percentage of private systems, with almost 80 percent of the 482 community water systems in Appalachia in private hands. However, these systems serve only 14.6 percent of the state’s community water population.

On a county basis, 65 percent of Appalachian counties (268) have less than 10 percent of their community water population served by private systems (see Figure 2-6). Pockets of high coverage by private systems occur in Ohio, northeast Pennsylvania, and West Virginia. Only 12 of the 104 Appalachian counties in the southern states of Alabama, Georgia, Mississippi, and South Carolina have more than 10 percent of their community water population covered by private systems.

The type of ownership can have a significant impact on how systems are managed and regulated. Different ownership models result in different eligibilities for funding sources, different financial incentives, and different governance structures. Under the Safe Drinking Water Act Amendments of 1996, privately owned and operated community water systems have access to Drinking Water State Revolving Funds (DWSRFs).[22] However, many states, such as North Carolina, have state laws that prohibit making those funds available to private for-profit systems.[23] The U.S. Department of Agriculture's Water and Waste Disposal Loans and Grants Program is available to nonprofit private systems but not to investor-owned systems.

The institutional models for, responsibilities of, and regulations regarding government-owned water systems are primarily established at the state level. Thus they vary across Appalachia. In West Virginia, government systems include municipalities, counties, and public service districts. All these systems must submit their financial statements to the state's Public Service Commission. Public service districts also must have their rates and charges reviewed and approved by the commission. In North Carolina, government systems include municipalities, counties, and several regional models, including water and sewer authorities and sanitary districts. These systems must have their financial statements reviewed by the North Carolina Local Government Commission, but they have autonomy over their rate-setting practices.

In some states, such as Kentucky and West Virginia, regional government utility models have become increasingly important as systems have consolidated. These models have influenced how systems have evolved over the last few years in a number of Appalachian states. Models in Kentucky, for example, have facilitated the growth of larger regional systems. In North Carolina the number of districts has been relatively constant, and municipalities are the main government service providers. In 2002 there

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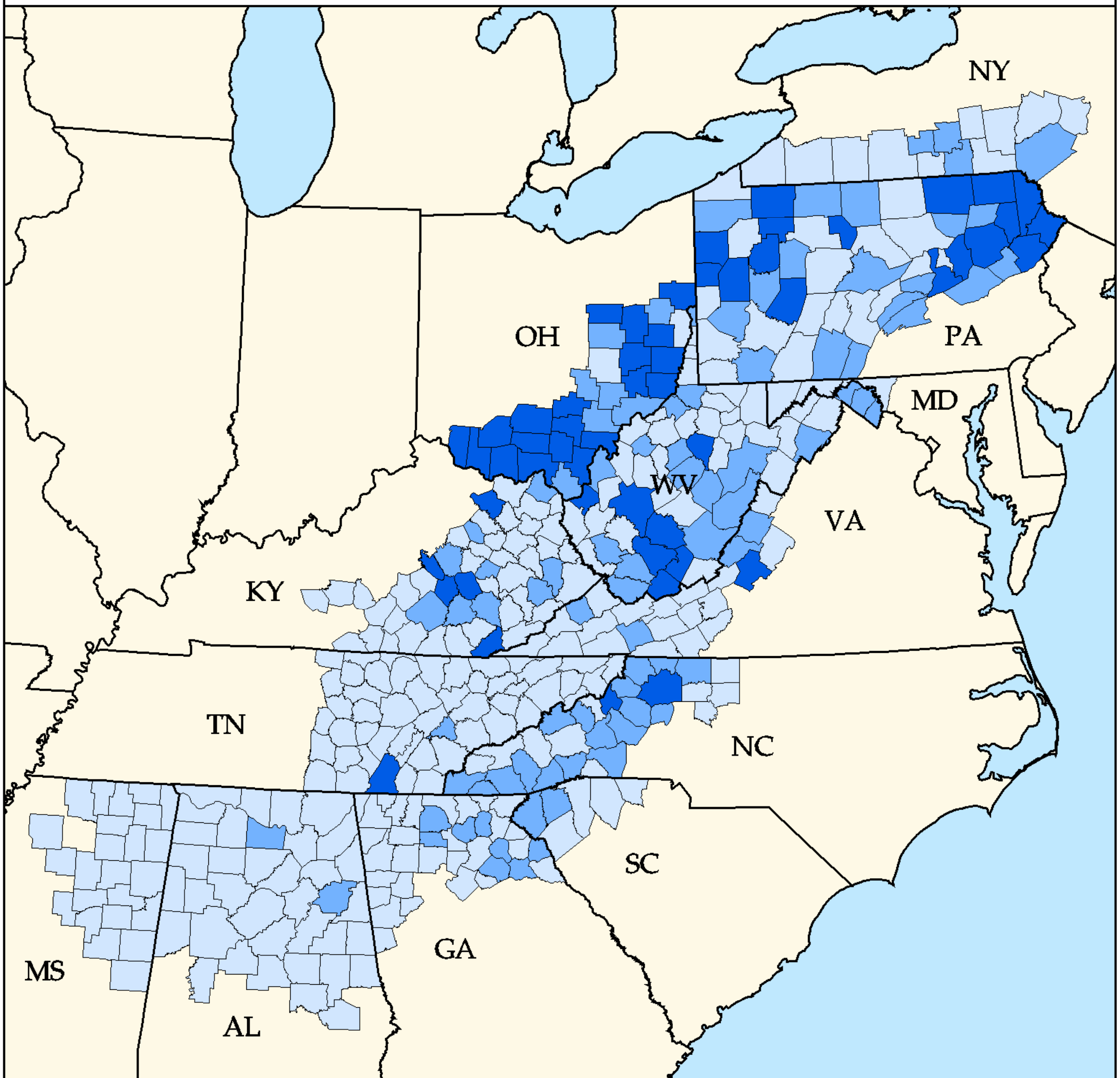
[22] Safe Drinking Water Act Amendments of 1996, 42 U.S.C. § 300j-12(a)(2).

[23] See N.C. Gen. Stat. § 159G-3(2) ("applicants" are restricted to local government units or nonprofit water corporations that exist solely to provide community water or wastewater services and are eligible for funding from the Rural Utilities Service of the U.S. Department of Agriculture).

Figure 2-6. Percentage of Appalachian Community Water Population Served by Private Systems



Data Source: Environmental Protection Agency, Safe Drinking Water Information System database for 4th quarter fiscal year 2003 frozen in January 2004, downloaded from www.epa.gov/OGWDW/data/pivottables.html and compiled by UNCEFC. Noncommunity water systems are excluded.

Less than 10%
10 through 50%
More than 50%

were 1,357 special government districts and authorities in Appalachia providing water and wastewater services (see Table 2-2). Pennsylvania has more than half of these districts.

Table 2-2. Number of Special Government Districts and Authorities in Appalachia

	Water Supply	Sewerage	Sewerage and Water Supply— Combination of Services	Total
Pa.	226	419	127	772
W.Va.	112	52	43	207
Tenn.	122	—	12	134
Ala.	76	—	4	80
Ky.	52	1	6	59
Ga.	15	—	14	29
Ohio	14	6	4	24
S.C.	14	3	4	21
Va.	4	7	3	14
N.C.	4	3	2	9
Miss.	1	1	2	4
Md.	1	1	2	4
Total	**641**	**493**	**223**	**1,357**

Source: Census Bureau, Governments Integrated Directory of the 2002 Census of Governments, available at www.census.gov/govs/www/gid2002.html. Data on special district governments downloaded and compiled by UNCEFC using Type 4 and Function Codes 91 (Water Supply), 80 (Sewerage), and 98 (Sewerage and Water Supply – Combination of Services).

Several studies have gathered data on the age and the condition of community water systems across the country. An EPA survey suggests that large systems tend to have a higher percentage of older pipe than small systems do (see Table 2-3).

Table 2-3. Percentage of Pipe in Each Age Category, by Ownership

Ownership Type	System Service Population Category								
	100 or less	101–500	501–3,300	3,301–10,000	10,001–50,000	50,001–100,000	100,001–500,000	Over 500,000	All Sizes
Public Systems									
Percentage of Pipe that is:									
Less than 40 years old	76.3	81.5	81.1	77.6	76.2	65.2	61.4	54.9	72.6
Between 40 and 80 years old	23.6	18.3	17.5	18.4	19.7	26.9	29.2	35.8	22.4
More than 80 years old	0.1	0.1	1.4	4.0	4.2	7.9	9.4	9.3	5.0
Observations	18	72	173	135	122	88	160	40	808
Private Systems									
Percentage of Pipe that is:									
Less than 40 years old	92.4	92.8	98.7	96.2	95.8	86.6	56.5	67.7	92.9
Between 40 and 80 years old	7.6	7.2	1.3	3.3	3.1	12.0	34.1	23.8	5.8
More than 80 years old	0.0	0.0	0.0	0.6	1.1	1.4	9.4	8.5	1.3
Observations	137	94	31	19	21	12	14	5	333
All Systems									
Percentage of Pipe that is:									
Less than 40 years old	90.6	88.3	85.7	84.3	81.4	70.2	60.9	56.3	78.0
Between 40 and 80 years old	9.4	11.7	13.3	12.9	15.3	23.4	29.7	34.4	18.0
More than 80 years old	0.1	0.1	1.0	2.8	3.4	6.4	9.4	9.2	4.0
Observations	155	166	204	154	143	100	174	45	1,141

Source: Reprinted from Environmental Protection Agency, *Community Water System Survey 2000*, vol. 2, *Detailed Tables and Survey Methodology* (Washington, D.C.: EPA, December 2002), 68, available at www.epa.gov/safewater/consumer/pdf/cwss_2000_volume_ii.pdf.

Note: The table reports the percentage of pipe on average in each age category in the nation. It is not the percentage of pipe per system.

Wastewater

Appalachia's methods of disposing of wastewater are as diverse as the region's cultural and economic environment. In many areas, households still discharge untreated waste directly into streams ("straight-piping"). For example, in 1990 in Madison County, North Carolina, 7 percent of the households surveyed used some type of straight-pipe system.[24] At the other end of the spectrum, Greenville, South Carolina (and surrounding areas connected to the Mauldin Road treatment plant of the Western Carolina Regional Sewer Authority), provides advanced tertiary treatment to the waste that it collects from residents before discharging the waste into Hollow Creek.

Treatment of drinking water is largely a physical and chemical process. In contrast, treatment of wastewater involves using biological systems. Wastewater treatment "chains" include settling and clarifying processes (primary treatment) and reduction of the biological and pathogen contents (secondary treatment) by exposing the wastewater to microorganisms and oxygen. Small communities often rely on "package plants," which involve primary and secondary treatment within a compact physical space. For facilities ending treatment at the secondary level, the treated effluent is disinfected and absorbed into the surface or discharged into a body of water. All discharging facilities are regulated at the federal and state level. Secondary treatment has a limited impact on problem nutrients such as phosphorus and nitrogen, so many communities now must employ advanced or tertiary treatment to reduce nutrient levels before discharge.

Wastewater is delivered from households to centralized treatment facilities through sewer systems, which include "collector lines" through neighborhoods and major "interceptor lines" that serve as the backbone of the system. Aging sewer systems throughout the country and in Appalachia often have "inflow" and "infiltration" problems that involve rain water entering the sewer system through cracks and improperly designed manholes. Inflow and infiltration problems can lead to sewer overflows and overwhelmed treatment facilities, if not corrected. In some parts of the country, sewer systems were intentionally designed to collect rain water in addition to wastewater. These combined-sewer-overflow (CSO) systems now are granted permits by the EPA, and under the permits they must be modified or separated at huge expense to the system owners.

Small household systems that use septic tanks have self-contained treatment facilities on their property. Wastewater is typically collected in a tank that allows solids to separate out, provides some biological treatment, and allows relatively clear wastewater to be absorbed into the ground through a drainage facility. Like centralized systems,

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[24] Estimates from Census Bureau, Census 1990, Summary File 3, Tables H23, H24.

these systems may develop problems, ranging from septic tanks that get clogged because they are not emptied of solids, to drainage fields that lose their absorptive capacity and discharge clear but pathogenic effluent, which bubbles onto the surface. In many parts of Appalachia, space or soil constraints limited what households could install, and some individual systems are nothing more than a straight pipe that runs directly to a stream.

How one characterizes wastewater disposal depends on one's perspective. People in households without indoor plumbing may view the world as divided into "flushing" and "not flushing." Environmentalists may believe that the degree (or lack) of treatment is the most important variable. Regulators may explain the wastewater universe by whether or not a system discharges to surface water. The variation in wastewater systems and the lack of national data on them make quantifying the differences between Appalachia and the United States as a whole significantly more difficult than it is for water systems.

The last time that individual households were asked to indicate whether or not they were connected to a public sewer system was during the 1990 Census. About 75 percent of U.S. households reported being served by public sewers, versus 52 percent of Appalachian households. At the county level, sewerage coverage in Appalachia ranged from 2 percent in Bland County, Virginia, to 89 percent in Ohio County, West Virginia. In 1990, coverage was lowest in the Blue Ridge area of Appalachia and in eastern Kentucky (see Figure 2-7).

The lack of public sewers in Appalachia is not a problem in itself, in fact the use of well designed and maintained onsite systems such as septic tanks are considered by many to be a more appropriate and cost effective means of wastewater treatment for many rural communities.[25] Unfortunately, surveys of existing septic systems continue to suggest that many onsite systems are improperly designed and more prone to failure than centralized sewers.[26]

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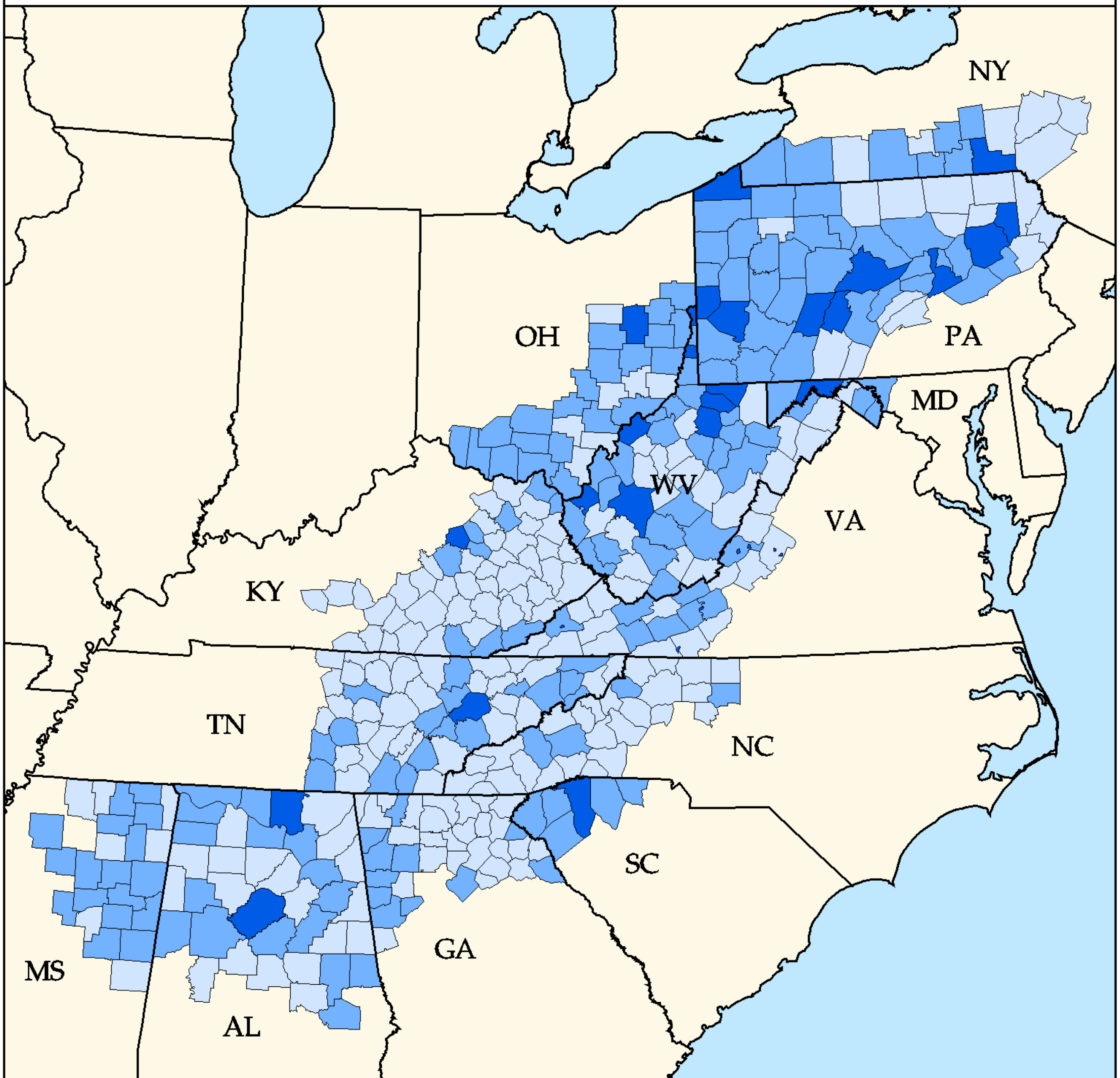
[25] Craig Lindell, Decentralized Wastewater Management, *Public Management* 87:6, 33-35 (July 2005).

[26] National Environmental Services Center, *A Summary of the Status of Onsite Wastewater Treatment Systems in the United States During1998: National, Regions I through X*, (Morgantown, WV: National Small Flows Clearinghouse, 2001).

Figure 2-7. Percentage of Applachian Population with Public Sewer Service, 1990



Data Source: Census 1990 Summary Tape File 3
Tables H23 and H24.

Less than 33%
33 through 67%
More than 67%

Documenting the prevalence of public sewers or conversely the prevalence of onsite systems remains a major challenge. Regulatory (and documenting) responsibility for onsite systems normally rests with county health departments with little accurate data aggregation done at the state, let alone national level. The US EPA maintains coverage data for centralized systems that suggests current centralized wastewater coverage (50 percent) have not changed that much since the 1990 Census (52 percent). However, when the EPA data is used to analyze coverage for specific counties, the limits of the more recent EPA data becomes apparent with many Appalachian counties appearing to have more people covered by centralized systems than are reported to live in the county.[27]

EPA reports data on publicly owned wastewater treatment facilities by the current flow rate at the facility (see Table 2-4). Eleven percent of the nation's wastewater treatment facilities are in Appalachia. Only 29 percent of the Appalachian population whose wastewater is centrally collected have facilities that treat more than 10 million gallons per day, compared with 52 percent for the United States as a whole. In other words, the larger treatment facilities outside Appalachia connect more people per facility than those in Appalachia do. Appalachia accounts for 34 percent of the national facilities that treat less than 10 million gallons of sewage per day. The smallest treatment facilities (constituting 79 percent of all facilities) collect sewage from only 26 percent of the connected Appalachian population.

Table 2-4. Publicly Owned Wastewater Treatment Facilities, by Flow Rate, 2000

Flow Rate (in MGD)	0.001–0.1	0.1–1.0	1.0–10	10–100	> 100	Total
Number of treatment facilities in Appalachia	550	871	354	27	1	1,803
Percentage of treatment facilities in Appalachia	31	48	20	1	0.1	100
Percentage of population receiving collection from treatment facilities in Appalachia	4	22	45	22	7	100
Number of treatment facilities in U.S.	6,583	6,462	2,665	487	46	16,255
Percentage of treatment facilities in U.S.	40	40	16	3	0.3	100
Percentage of population receiving collection from treatment facilities	2	12	32	37	17	100

[27] Environmental Protection Agency, *Clean Watersheds Needs Survey 2000 Standard Report – Facilities in Operation*, available at http://cfpub.epa.gov/cwns/populationp.cfm. Data on population presently served by publicly owned wastewater treatment facilities currently in operation compiled and analyzed by UNCEFC. County population estimates were obtained from Census 2000 Summary File 1 Table P1.

Flow Rate (in MGD)	**0.001–0.1**	**0.1–1.0**	**1.0–10**	**10–100**	**> 100**	**Total**
in U.S.						
Percentage of U.S. treatment facilities in Appalachia	8	13	13	6	2	11

Source: Data from Environmental Protection Agency, *Clean Watersheds Needs Survey 2000* (Washington, D.C.: EPA, 2003), compiled by UNCEFC.

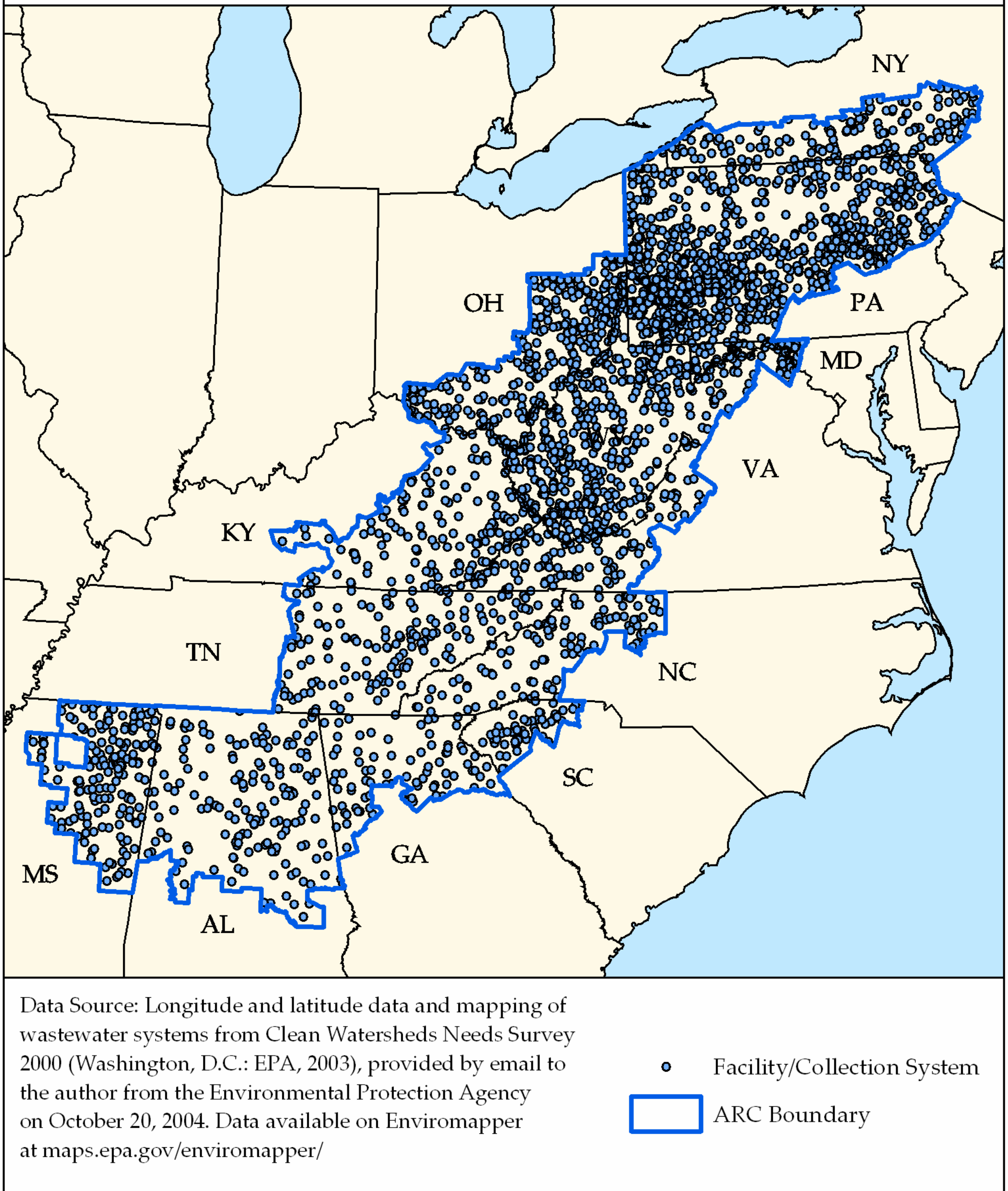
Note: MGD = millions of gallons per day.

More than 4,000 facilities (both in operation and planned) are in the CWNS database for Appalachia (see Figure 2-8). Each state is responsible for identifying the facilities that are entered into this database, and the choice of facilities to include varies from one state to another. Despite this limitation, the map helps illustrate the areas of Appalachia that are served or will be served by community wastewater systems.

Despite the expansion of wastewater systems in some areas of Appalachia, septic tank systems still are abundant. In 1990, households in the region were as likely to have a septic tank as they were to be connected to a public sewer system. Four million households in the region used septic tank systems in that year. (For the number of septic tanks per square mile for counties in Appalachia, see Figure 2-9.)

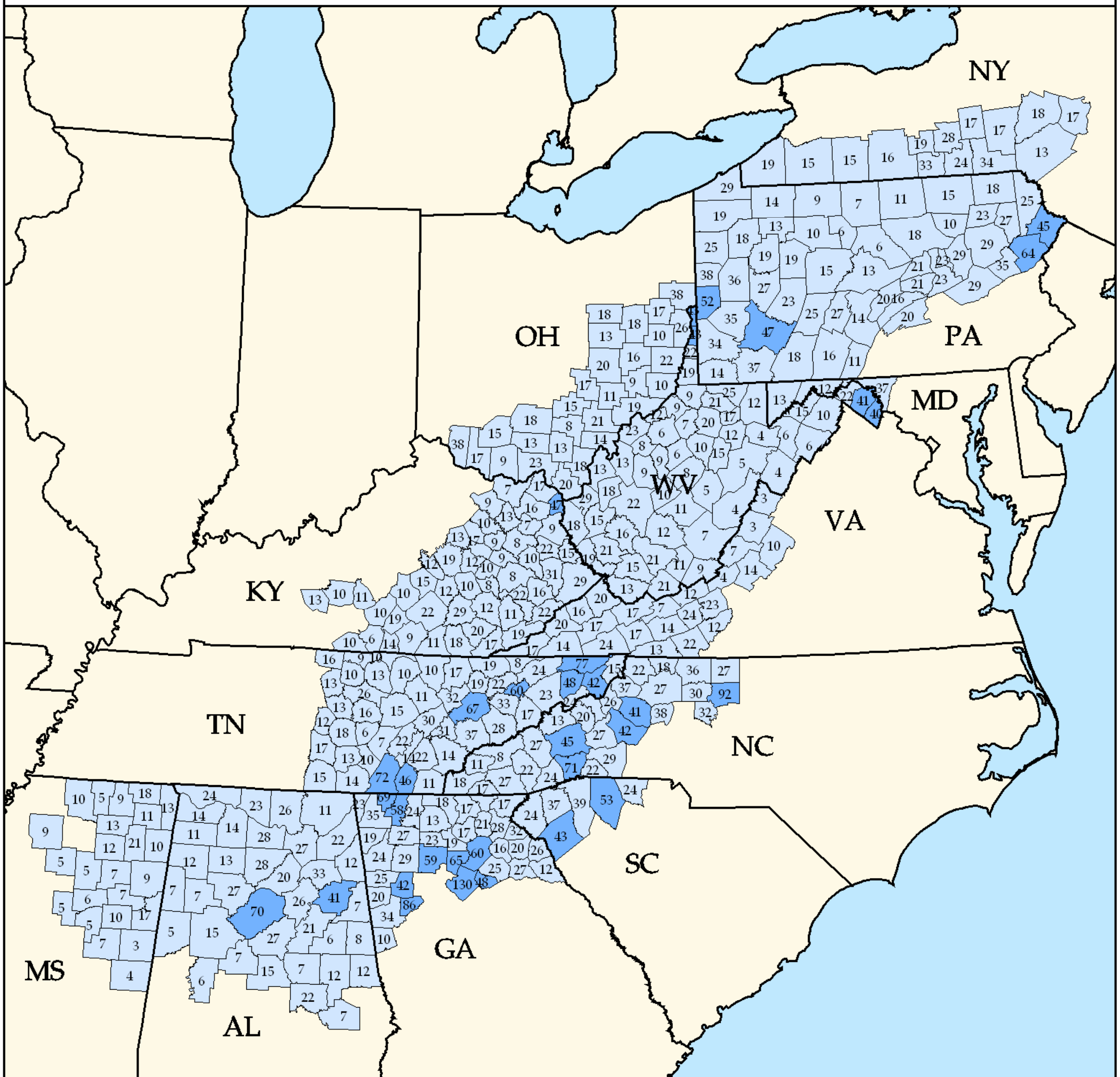
In 1990, about 70 percent of the counties in Appalachia had more than 50 percent of their households served by onsite systems such as septic tanks or unlined systems commonly referred to as "cesspools" (see Figure 2-10). These systems served more than 75 percent of households in counties along the Blue Ridge and in the Valley and Ridge areas, from northern Georgia to southwestern Virginia (see Figure 2-11).

Figure 2-8. Treatment Facilities and Collection Systems in Appalachia, 2000



Data Source: Longitude and latitude data and mapping of wastewater systems from Clean Watersheds Needs Survey 2000 (Washington, D.C.: EPA, 2003), provided by email to the author from the Environmental Protection Agency on October 20, 2004. Data available on Enviromapper at maps.epa.gov/enviromapper/

Figure 2-9. Number of Septic Tanks Per Square Mile in Appalachia, 1990

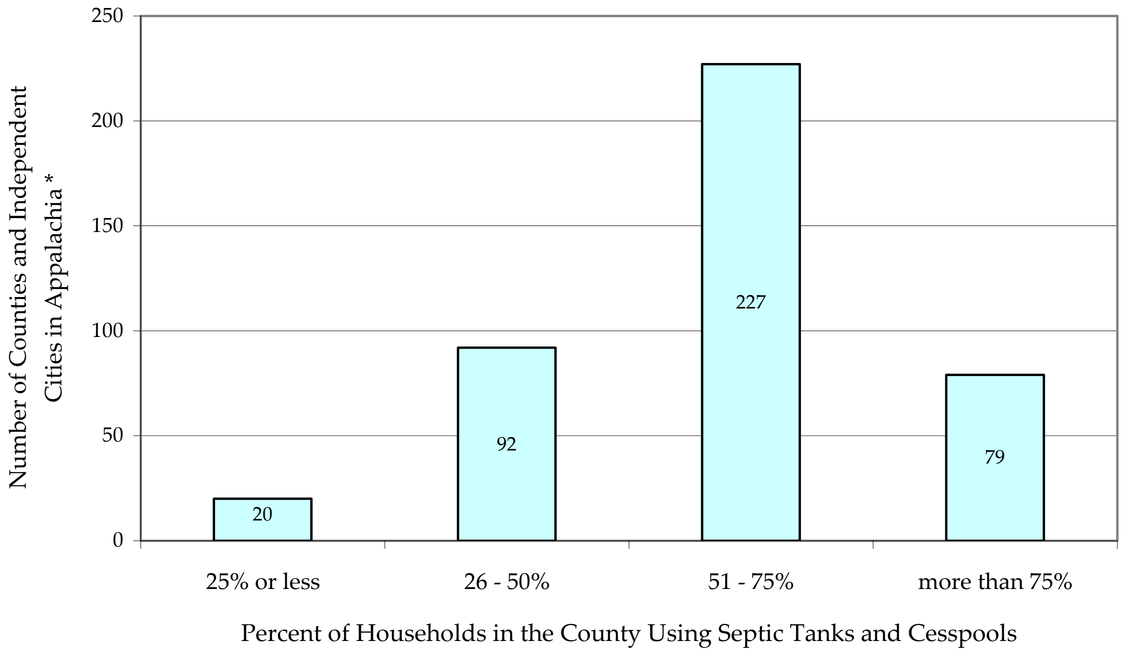


Data Source: Census 1990 Summary Tape File 3
Tables H23, H24

Fewer than 40

40 or More

Figure 2-10. Percentage of Appalachian Households Using Septic Tanks and Cesspools, 1990



Source: Data from Census Bureau, Census 1990, Summary File 3, Tables H23 and H24.

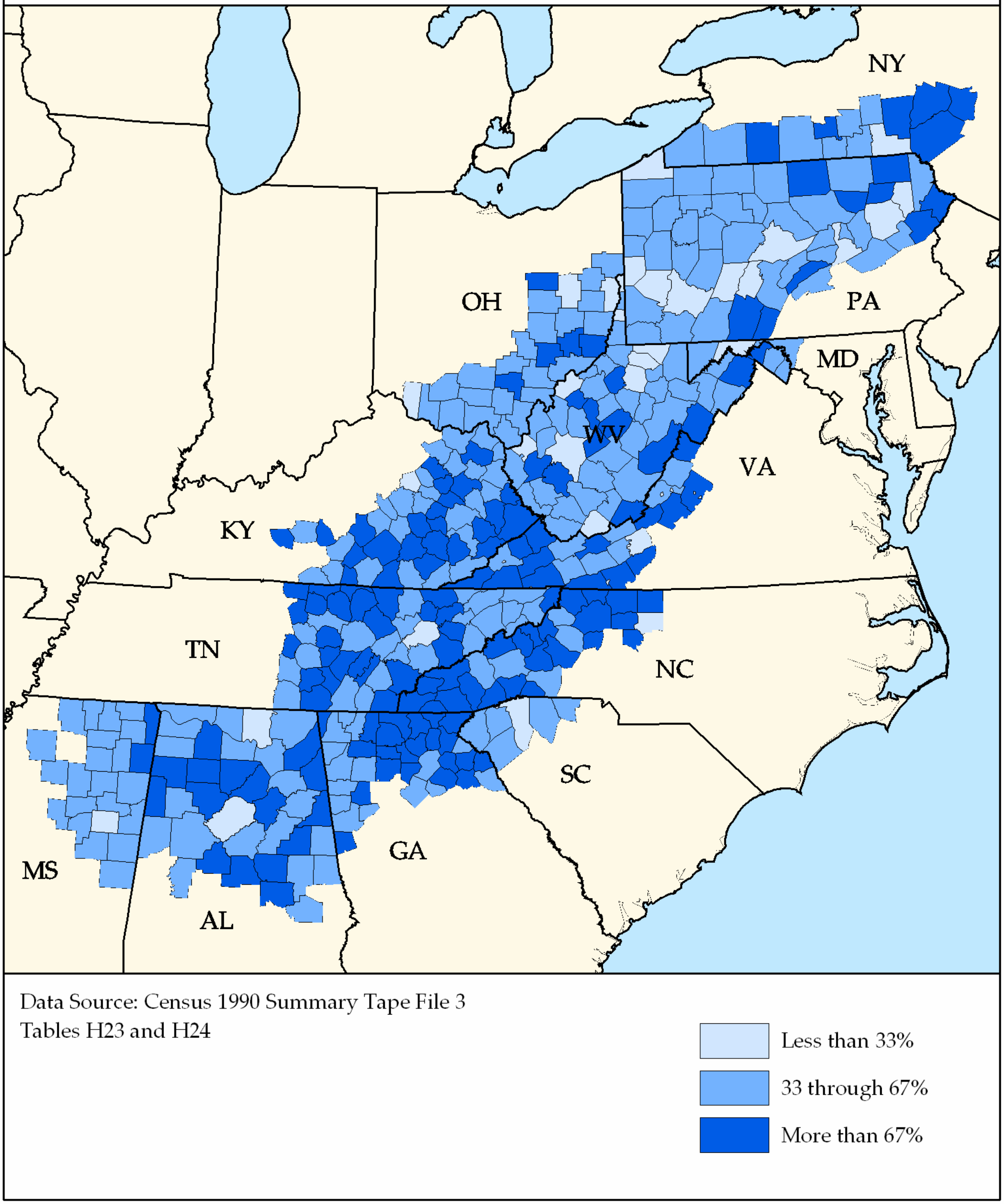
* Eight Virginia Independent Cities are analyzed separately, totaling to 418 counties and independent cities in Appalachia.

Ambient Water Quality

"You are what you drink." The connection between health, drinking water, and the quality of raw water used for drinking is quite clear. In most cases the quality of bodies of water receiving discharge is the primary factor that dictates wastewater treatment requirements. Some of the highest-quality and most outstanding resource waters in the eastern United States are in Appalachia. This is not surprising, given the abundant precipitation, the remaining forest cover, and the headwaters location of most Appalachian streams.

High-quality, high-quantity water is reflected in the diversity of water-dependent species, both amphibians and fish. "The southern Appalachians are a world center of diversity for salamanders and have 68 species of a unique group of lungless salamanders that evolved in this region of well-oxygenated streams and high rainfall,"

Figure 2-11. Percentage of Households in Appalachia Using Septic Tanks and Cesspools, 1990



Data Source: Census 1990 Summary Tape File 3
Tables H23 and H24

write Peter White and colleagues.[28] Appalachia is a major contributor to the southeastern United States’ status as the richest region for diversity of freshwater fish of any temperate area of comparable size in the world.[29]

However, as White and his colleagues point out, this diversity is largely attributable to the numerous, narrowly restricted endemic species in a lot of the headwater streams. Many of these species depend on very good water quality and are accordingly threatened by changes in the environment that might not be as significant in ecologies involving larger, downstream bodies of water. Thus White and his colleagues find a much higher percentage of species endangered or threatened in Appalachia than in other parts of the Southeast (see Table 2-5).

Table 2-5. Endangered or Threatened Species, by Region

Faunal Region	Percent of Species Endangered or Threatened
Southern Appalachians	18.3
Interior Plateau	11.4
Atlantic Slope	7.1
Lower Appalachicola River basin	6.3
Lower Mississippi River	6.0
Lower Mobile River basin	4.9
Peninsular Florida	4.1

Source: From Peter White et al., *Environments of the Southeast* (Delray Beach, Fla.: St. Lucie Press, n.d.), available at biology.usgs.gov/s+t/SNT/noframe/se130.htm.

Some writers, including noted critic of the Appalachian mining industry Harry M. Caudill, have viewed Appalachia’s abundance and high quality of water as great assets.[30] Appalachia is home to the headwaters of almost all the important rivers of the eastern United States (see Figure 2-12). Thus whatever happens to Appalachian waters has major consequences for the nation as a whole.

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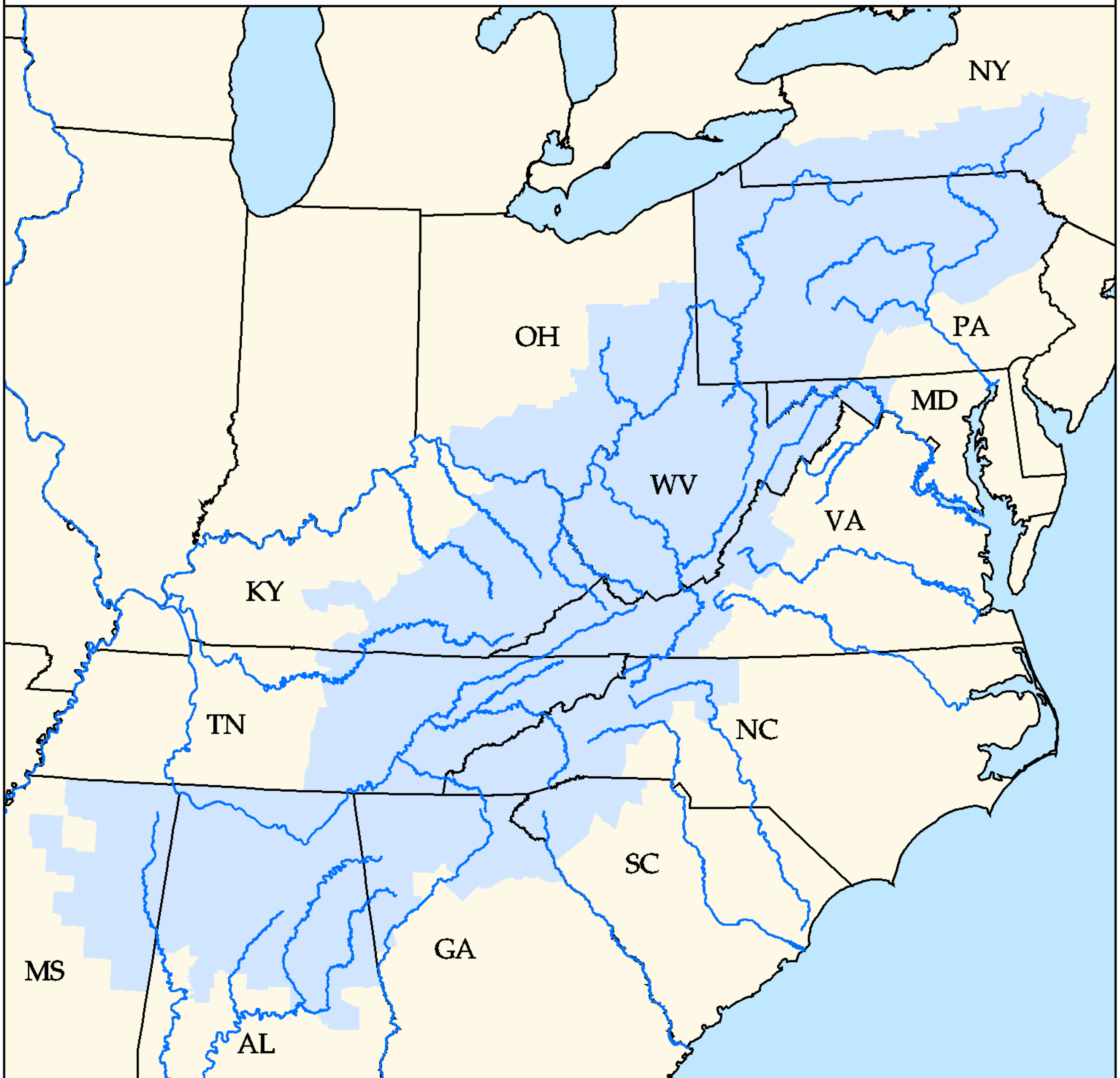
[28] Peter White et al., *Environments of the Southeast* (Delray Beach, Fla.: St. Lucie Press, n.d.), available at biology.usgs.gov/s+t/SNT/noframe/se130.htm.

[29] *Ibid.*

[30] See Harry M. Caudill, *The Watches of the Night* (Boston: Little, Brown, 1976), 253–54, on water as the future of the region.

Figure 2-12. River Basins of Appalachia



Data Source: Provided by by Jeff Levy of the Bluegrass Area Development District on May 24, 2005

Appalachian River

Appalachia also is home to some serious problems with ambient water quality. Recent reports submitted by the Appalachian states to EPA, as required by Section 305(b) of the Clean Water Act of 1972, contain lists [required by Section 303(d)] of water segments in each state that are too polluted to attain their designated use (swimming, fish consumption, drinking, aquatic life, and other purposes). The Section 303(d) list is updated in even years. The Section 305(b) reports have serious limitations, but given that the United States has no real national accounting of the extent and the costs of water pollution, they are a reasonable second-best assessment. If a state deems a water body to be impaired and includes it in the Section 303(d) list, that water body certainly has some significant water-quality problems. West Virginia serves as a good example of problems with water quality. All the river basins in West Virginia are in Appalachia, and they drain the Appalachian Plateaus province, except for rivers on the east and northern borders of the state. West Virginia's 2004 Section 303(d) list identifies 878 impaired streams, covering approximately 6,170 stream miles. The most common impairments of water quality still are those related to mine drainage, bacterial contamination, and acid rain. Mine-drainage streams often are impaired by acidity (low pH) and/or elevated concentrations of metals, including iron, aluminum, and manganese. Many of these streams also fail tests of biological integrity (ability to support aquatic life).

Mercury deserves special mention. Aerial deposition of mercury is a national problem but one with special significance for Appalachia. Mercury contamination in fish tissue at levels above health standards is found in every state, and a recent EPA study found detectable levels in every single fish sample taken during a broad national sampling effort.[31] All the Appalachian states have issued fish consumption advisories for mercury, especially for pregnant women and for children.

One of the major sources of this pollution is combustion of coal—hence the special significance for Appalachia, especially its coal-producing areas. The Appalachian states collectively accounted for 44 percent of the United States' reported atmospheric emissions of mercury and mercury compounds in 2002. Of the top 100 electric utilities emitting airborne mercury, 28 were in Appalachia. The total reported emissions of mercury from these 28 sources in 2002 equaled 15,643.6 pounds.[32]

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[31] See EPA's study website, at www.epa.gov/waterscience/fishstudy, for updated information. The first two years of data are analyzed by the U.S. Public Interest Research Group in *Reel Danger: Power Plant Mercury Pollution and the Fish We Eat* (August 2004), available at cta.policy.net/reports/reel_danger/reel_danger_report.pdf.

[32] Data from Environmental Protection Agency, Toxic Release Inventory 2002, available at www.epa.gov/tri/tridata/tri02, compiled by UNCEFC.

Environmental Characteristics Influencing Service

Water quality in Appalachia—and therefore the cost of providing water and wastewater services—is intrinsically linked to the region's physical environment. Without an understanding of the physical environment's attributes, fully assessing the current and future challenges for water and wastewater service is impossible. The physiographic province map (Figure 1-2) includes shaded relief showing topography in Appalachia. The region includes all the mountain areas of the eastern United States that are south of New England. Also, it extends into piedmont terrain on the east and into interior plains on the west and the south. Topology, geology, soils, precipitation, and groundwater are intimately related. Ultimately they are important to consideration of a region's comparative advantages, disadvantages, and costs in delivery of water and wastewater services. Appendix F discusses these environmental factors in detail by physiographic province. The remainder of this chapter provides an overview of the interplay of these characteristics in Appalachia and offers some specific illustrations in the various provinces.[33]

Most of the environmental factors in Appalachia lead to higher costs, especially in the Highlands. Subsurface conditions often are hard rock, making installation and repair of pipes relatively expensive. Groundwater typically occurs in fractures of bedrock, rather than in large, deep aquifers that are predictable in yield and depth. Frequently, soils are thin and unsuitable for onsite waste systems. Slopes are pervasive and often steep, sometimes requiring more and larger pumps and leading to a dispersed population, as settlements concentrate linearly along river bottoms.

Appalachian water quality suffers disproportionately from acid rain, especially of sulfates. The acid water can be buffered for drinking. However, it takes a toll on the region's aquatic life.

Other airborne pollutants, such as mercury (discussed earlier), are potentially more serious in the region than they are nationally. Further, there are areas of elevated, naturally occurring radionuclides in the groundwater. The mercury, the radionuclides, historically rapacious extractive industries, and widespread inadequacies in wastewater handling all contribute to significant water-quality problems in the region.

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[33] Most of the information in this chapter on geology and its consequences for the water resources of Appalachia is extracted from Henry Trapp Jr. and Marilee A. Horn, *Atlas of the United States: Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, West Virginia* (Washington, D.C.: U.S. Geological Survey, 1997), chap. 730-L (available at capp.water.usgs.gov/gwa/gwa.html), along with related information from other authors of the U.S. Geological Survey's atlases for the relevant physiographic regions, including chapter 730-K for the Appalachian Plateaus and chapter 730-G for the southern portions of the Appalachian Plateaus as well as the Atlantic and Interior Plains.

On the positive side of the ledger, the region receives ample precipitation, and as the headwaters area for the entire eastern United States, it faces fewer problems with upstream contamination than communities in the lower Piedmont, Coastal Plain, and Mississippi River corridor face. The corollary of this fact, though, is that the quality of Appalachian waste treatment is linked directly to the costs and the risks of surface water treatment downstream, in the rest of the eastern United States.

Another positive environmental factor is that the soils support an abundance—indeed, a huge diversity—of plant life, notably trees, both hardwoods and softwoods. Where the forest cover has been restored since its historic clearing from 1870 to 1930, or where it has expanded as a result of the reduction in grazing on ridges, the canopy and the riparian vegetation help stabilize soils and minimize suspended sediment in rivers and streams.

The Appalachian Plateaus province provides a good illustration of the interplay of environmental features and drinking water and wastewater service. The province is characterized by high, sharp ridges, low mountains, and narrow valleys. In the more southerly part of the province, geological processes have produced long, steep ridges running parallel from southwest to northeast. Elevation of the Highlands ranges from 1,000 to 4,500 feet, with a few peaks higher. Local relief generally ranges from 1,000 to 2,500 feet. The bedrock is overlain by residuum, colluvium, and alluvial material. Sandstone and some of the tougher carbonates hold up most of the upland portions; weaker carbonates and shale underlie most valleys.

Most of the precipitation that falls on the Plateaus moves quickly down the slopes, rather than sinking into the typically thin soils. Thus there is not as ample a bedrock aquifer as there is in the Valley and Ridge province.

The chemical quality of water in the freshwater parts of the bedrock aquifers is variable but usually satisfactory for municipal supplies and other purposes. Most of the water in the upper parts of the aquifers is not greatly mineralized and is suitable, or can be made suitable, for most uses. However, fresh groundwater generally circulates only to shallow depths. In much of the area, saline water or brine is not far below the land surface. Around Pittsburgh for example, wells drilled deeper than 100 feet below the level of the nearest major stream often yield saline water.

In southwestern Pennsylvania the rocks nearest the surface are mostly coal-bearing formations that consist of sandstone, shale, conglomerate, clay, coal, and minor limestone. The sandstones are the most productive aquifers, although coal beds and limestones also yield water. The limestones, however, are thin compared with those of the Valley and Ridge province.

In the Appalachian Plateaus, active, underground mining of coal disturbs the natural system of groundwater flow. Mines use artificial drains to dispose of unwanted water. Mines can create new fractures and thus increase the permeability of the soil. When the drains are effective, they can lower the regional water table, and the directions of groundwater flow can change in some cases until flow moves across former groundwater divides into adjoining basins. Groundwater tends to flow toward mines, which usually have pumps removing water from them. Adverse effects of mine drainage on well yields are greatest where the mines are not much deeper than the bottoms of the wells and where vertical fractures connect the aquifers and the mines. Abandoned mines can collapse. This causes fracturing of the rocks that overlie the mine and also may leave a depression on the land surface.[34]

Land Use and Land Cover

The fecund forest of Appalachia has been noted since the days of the earliest European visitors. For example, botanist John Banister wrote in 1680,

> This is a Country excellently well water'd & so fertile that it does or might be made yield anything that might conduce to the pleasure or necessity of life..[35]

As recently as 1902, James Wilson, a trained observer, noted that

> remote from the railroads the forest on these mountains is generally unbroken from the tops of ridge and peak down to the brook in the valley below, and to-day it is in much the same condition as for centuries past.[36]

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[34] Trapp and Horn, *Atlas of the United States*, chap. 730-L.

[35] John Banister, Letter to Dr. Robert Morison, reprinted in *The Height of Our Mountains: Nature Writing from Virginia's Blue Ridge Mountains and Shenandoah Valley*, eds. Michael Branch and Daniel Philippon (Baltimore: Johns Hopkins Press, 1998).

[36] James Wilson, Report on the Forests and Forest Conditions of the Southern Appalachian Region (Washington, D.C.: Government Printing Office, 1902), reprinted in *The Height of Our Mountains: Nature Writing from Virginia's Blue Ridge Mountains and Shenandoah Valley*, eds. Michael Branch and Daniel Philippon (Baltimore: Johns Hopkins Press, 1998),. Wilson was secretary of agriculture under Presidents McKinley, Roosevelt, and Taft. He personally visited the region and indicted the forestry practices then under way, in text and photographs.

With the coming of the railroads from 1870 to 1930, though, the forests of the region were nearly all cut. This clear-cutting had profound negative effects on water quality and quantity—namely, huge losses of already rare topsoil, and devastating floods.[37]

Woody cover across the region may be increasing. However, some experts believe that forest cover peaked in the 1960s and now is declining because of changes in the frequency of fires and the aging and demise of old-field pine that colonized many abandoned farms across the region in the mid and late nineteenth century.[38] Timber is an integral component of the region's water-quality system.

Summary

As with everything else about Appalachia, simple generalizations about water quality are impossibly misleading. There are areas of high-quality water and water uses in the eastern United States, and there are areas so contaminated by decades of uncontrolled discharges that the prospect for cleanup at any foreseeable time is grim.

What is perhaps most important to an understanding of water and wastewater funding in the region is that most expressed needs for capital spending account minimally, if at all, for the costs of watershed restoration. If Appalachia is ever to attain Harry Caudill's vision of a region that would use its water to draw urbanites and their money from all over the eastern United States, much more funding will have to be found to improve ambient water quality.

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[37] See Ronald D. Eller, *Miners, Millhands, and Mountaineers: Industrialization of the Appalachian South, 1880–1930* (Knoxville: University of Tennessee Press, 1982); Ronald L. Lewis, *Transforming the Appalachian Countryside* (Chapel Hill: University of North Carolina Press, 1998); Ronald L. Lewis, "Railroads, Deforestation, and the Transformation of Agriculture in the West Virginia Back Counties, 1880–1920," in *Appalachia in the Making: The Mountain South in the Nineteenth Century*, eds. Mary Beth Pudup, Dwight B. Billings, and Altina L. Waller (Chapel Hill: University of North Carolina Press, 1995), 297–320; John Alexander Williams, *Appalachia: A History* (Chapel Hill: University of North Carolina Press, 2002).

[38] Peter White et al., *Environments of the Southeast* (Delray Beach, Fla.: St. Lucie Press, n.d.), available at biology.usgs.gov/s+t/SNT/noframe/se130.htm.

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