

POPULATION CHANGE AND MARCELLUS SHALE DEVELOPMENT

THE MARCELLUS IMPACTS PROJECT REPORT #1



Executive Summary

Rapid natural resource development has been associated with population increase due to the opportunities generated by greater economic activity. Population growth in areas of Marcellus Shale natural gas development may be driven by an influx of workers in the natural gas and ancillary industries, as well as the arrival of family members of these workers and other individuals attracted to expanding job opportunities and improved business prospects. Therefore, it is anticipated that more Marcellus Shale development may be associated with an increase in population or, in those areas with long-term population decline, a reduction in population loss.

This report examines changes in population size as well as age and gender composition in the four study counties across two regions: Greene and Washington in southwestern Pennsylvania, and Bradford and Lycoming in north central Pennsylvania. These counties have experienced some of the highest Marcellus Shale unconventional natural gas development in terms of the number of wells drilled. Neighboring counties are examined because new development activities and services often extend beyond the counties in which active drilling occurs. Analyses consider three points in time: 2000, 2005/07, and 2010. County-level aggregate data and estimates from the U.S. Census of Population and Housing (2000 and 2010) and the American Community Survey (ACS 3-year estimates, 2005-2007) are used. Findings indicate that:

- **Pennsylvania and Study Counties:** Pennsylvania gained residents over the past decade, especially since 2005/07. Population change varied notably across the four study counties: in the southwest, Washington County gained residents while Greene experienced accelerating decline; in the northern tier, Lycoming's population loss slowed while Bradford experienced a turnaround with population growth occurring at the same time as Marcellus Shale development.
- **Regions:** The northern tier region experienced net population loss from 2000 to 2005/07, but this was more than compensated for by net gain from 2005/07 to 2010. In contrast, the southwest region experienced net loss over both periods of the decade.
- **Level of Development:** The patterns of population change over the decade and across counties in the state of Pennsylvania vary and show little relationship to the extent of unconventional natural gas development in the Marcellus Shale. Other changes in addition to Marcellus activity are influencing patterns of population change.
- **Limitations:** Data limitations, especially at the county level, preclude a full exploration of the impact of Marcellus Shale development on population change because the Census and ACS data do not capture individuals who live in temporary housing. Initial qualitative evidence (see report #5 on housing) underscores the need to pay attention to those residing in temporary housing when considering effects of Marcellus Shale development.

Overall, the Census and ACS data comparisons presented here indicate that patterns of population change varied across the four study counties, and that the associations with Marcellus Shale development are not clear. Trajectories of change diverge notably even though all four places had relatively high levels of Marcellus activity. The relationship of population change to Marcellus activity is not clear or consistent. It is unclear at this time how population flows related to Marcellus Shale development interact with other trends affecting population change.

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This project was sponsored by a grant from the Center for Rural Pennsylvania, a legislative agency of the Pennsylvania General Assembly.

The Center for Rural Pennsylvania is a bipartisan, bicameral legislative agency that serves as a resource for rural policy within the Pennsylvania General Assembly. It was created in 1987 under Act 16, the Rural Revitalization Act, to promote and sustain the vitality of Pennsylvania’s rural and small communities.

Information contained in this report does not necessarily reflect the views of individual board members or the Center for Rural Pennsylvania. For more information, contact the Center for Rural Pennsylvania, 625 Forster St., Room 902, Harrisburg, PA 17120, telephone (717) 787-9555, email: info@rural.palegislature.us, www.rural.palegislature.us.

About This Project:

The Marcellus Shale Impacts Project chronicles the effects of shale-based energy development in Pennsylvania by focusing on the experiences of four counties with significant extraction and production activity – Bradford, Lycoming, Greene, and Washington counties. The project examines social and economic changes in these counties within the context of regional and statewide trends. A series of nine reports describes the research results as follows: (1) population, (2) health, (3) education, (4) youth, (5) housing, (6) crime, (7) local government, (8) local economy, and (9) agriculture.

Study Counties

Bradford, Lycoming, Greene, and Washington counties are studied in this project. They have experienced some of the highest levels of Marcellus Shale development in Pennsylvania, yet they have diverse populations, histories, economic bases, and geographic locations. These differences allow comparisons that facilitate understanding of the potential effects of Marcellus Shale development across the commonwealth and by region. The regional comparisons are defined based on adjacency to the four study counties. The northern tier contains 12 counties: Bradford, Lycoming, and the 10 neighboring counties of Clinton, Columbia, Montour, Northumberland, Potter, Sullivan, Susquehanna, Tioga, Union, and Wyoming. The southwest region consists of six counties: Greene, Washington, and the four neighboring counties of Allegheny, Beaver, Fayette, and Westmoreland.

All four study counties are classified as rural by the Center for Rural Pennsylvania with population densities of less than 284 people per square mile.

Table 1 offers an overview of selected characteristics from 2000 for the four study counties as well as counties in the surrounding region and the state. These data provide important context for understanding differences between the counties and regions prior to Marcellus Shale development. As Table 1 shows how the counties and regions differ across indicators. In the northern tier, Lycoming's population was nearly twice that of Bradford's, and Lycoming County had a slightly higher unemployment rate than Bradford County. The percentage employed in mining was very small in 2000 in both northern tier counties, although a larger percentage of people were employed in the industry in Bradford (0.6 percent) than in Lycoming (just 0.1 percent). The two counties had comparable median household incomes.

In the southwest, the differences between Greene and Washington are more pronounced. Greene had the smallest population of the four counties (40,672) and 6.7 percent of employed individuals in the county were working in mining. The unemployment rate (9.2 percent) was more than 3 points above the state's average (5.7 percent), and the median household income (\$41,972) was well below average for the region (\$52,004) and the state (\$55,460). In contrast, the median household income in Washington County was just over \$10,000 higher than in Greene. Only 1.3 percent of the employed work in mining and the unemployment rate was notably lower (5.3 percent).

The two counties of the southwest had more diversified economies than counties of the northern tier. In Bradford and Lycoming, the same three industries (Manufacturing, Health Care and Social Assistance, and Retail Trade) employed around half the population (52.4 percent and 47.4 percent, respectively (Census 2000). In contrast, just over one-third of the working population in Greene County worked in the same three industries (Health Care and Social Assistance, Retail Trade, and Educational Services). Washington's top three industries (Manufacturing, Health Care and Social Assistance, Retail Trade, and Manufacturing) employed 41.7 percent of the working population.

Table 1. Pre-Marcellus characteristics of study counties in 2000

	Population	People per square mile	% employed in Mining	% Unemployed	Median Household Income (adjusted for inflation to 2012 values)
Northern Tier*	47,968	83	0.6%	6.0%	\$47,071
Bradford	62,761	55	0.6%	5.5%	\$48,451
Lycoming	120,044	97	0.1%	6.3%	\$47,038
Southwest*	370,881	505	1.8%	6.6%	\$47,901
Greene	40,672	71	6.7%	9.2%	\$41,972
Washington	202,897	237	1.3%	5.3%	\$52,004
Pennsylvania	12,281,054	274	0.3%	5.7%	\$55,460

The northern tier region contains 12 counties: Bradford, Lycoming, and the 10 neighboring counties of Clinton, Columbia, Montour, Northumberland, Potter, Sullivan, Susquehanna, Tioga, Union, and Wyoming. The southwest region consists of six counties: Greene, Washington, and the four neighboring counties of Allegheny, Beaver, Fayette, and Westmoreland. Source: Social Explorer Tables (SE), Census 2000, U.S. Census Bureau and Social Explorer. * County average includes study counties.

Marcellus Shale Activity

Table 2 shows the number of unconventional wells drilled in the Marcellus Shale each year in the six Pennsylvania counties with the highest total number of wells drilled between 2005 and mid-year 2013 (Pennsylvania Department of Environmental Protection).

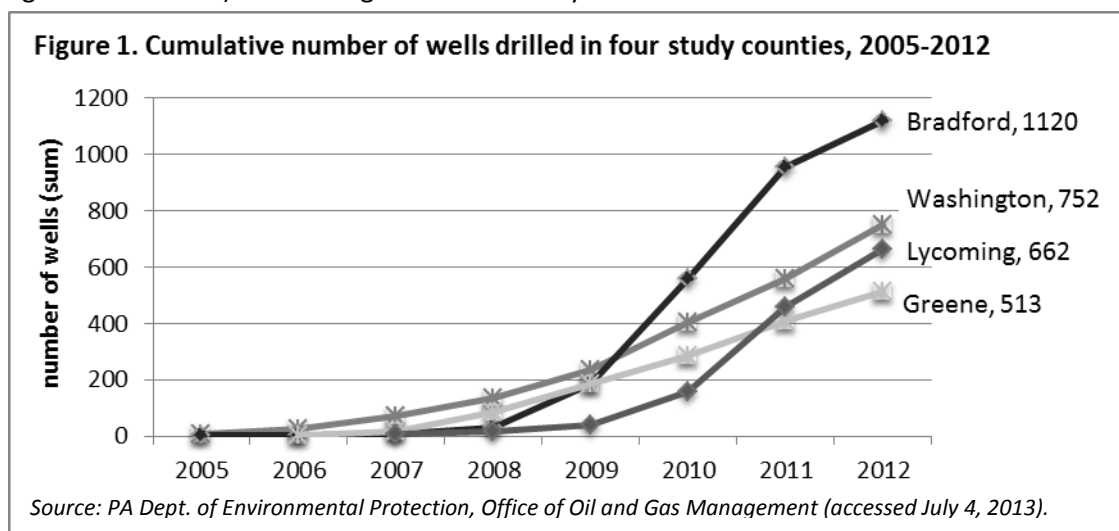
Table 2. Six counties with the most wells drilled and wells drilled each year, 2005-2013*

county name	2005	2006	2007	2008	2009	2010	2011	2012	2013* mid-year	Total, by county
Bradford⁺	1	2	2	24	158	373	396	164	66	1186
Washington⁺	5	19	45	66	101	166	155	195	120	872
Tioga	0	1	0	15	124	273	272	122	13	820
Lycoming⁺	0	0	5	12	23	119	301	202	89	751
Susquehanna	0	1	2	33	88	125	205	191	102	747
Greene⁺	0	2	14	67	101	103	121	105	54	567
Total wells drilled in top six counties:										4943

Source: Pennsylvania Department of Environmental Protection, Office of Oil and Gas Management. *Data through June 30, 2013 (accessed July 4, 2013); ⁺Study counties.

The four study counties have experienced significant Marcellus Shale well drilling and account for half (3,376) of the 6,833 unconventional wells drilled in the commonwealth. The two counties located in the southwest, Washington and Greene, experienced more well development through 2008 than the other counties. Bradford County experienced significant growth starting in 2009. Despite the late start, Bradford County quickly surpassed all other Pennsylvania counties with nearly 400 new wells drilled in 2011, for a total of 1,186 by June 30, 2013. Lycoming similarly experienced more new drilling activity in 2011 than occurred in the southwest and had the highest number of new wells drilled in 2012.

Figure 1 shows the cumulative number of wells drilled from 2005 to 2012 in each of the study counties. Although some wells may no longer be in production by 2012, and some have not yet been put into production, the lines reveal overall trends in the counties and across regions. The northern tier counties (Bradford and Lycoming) had steeper increases in the past 3 years, whereas those in the southwest (Washington and Greene) had more gradual but steady increases in the number of wells drilled.

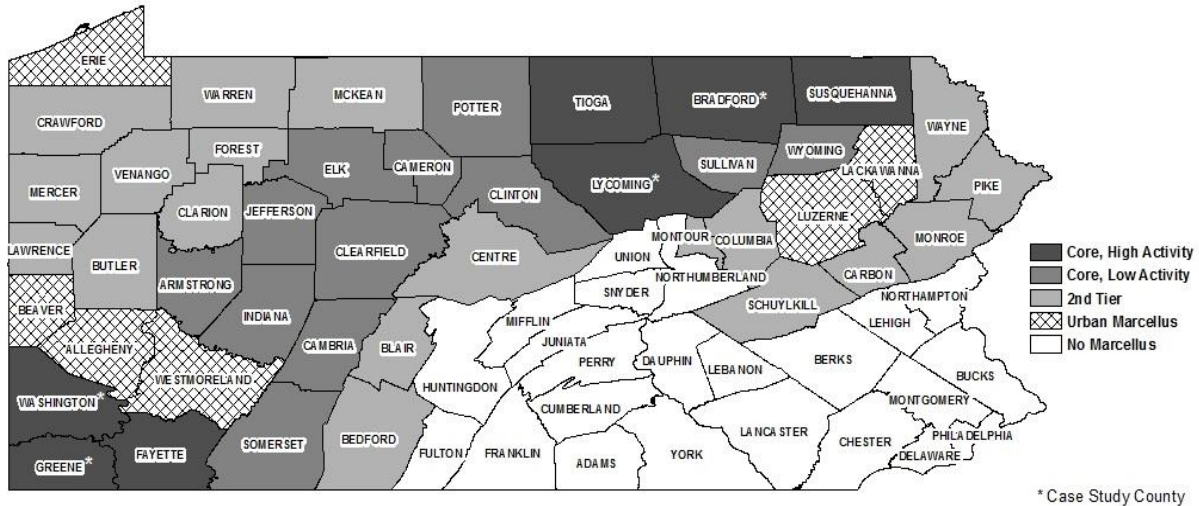


In 2012, the pace of new drilling slowed in Bradford and Lycoming, likely due to the declining price of natural gas. In contrast, drilling in Greene and Washington counties in 2012 was on par with the previous year. This may be because gas in southwestern Pennsylvania tends to be “wet” gas, meaning it contains more marketable compounds (liquid natural gases such as butane and propane) that can generate higher revenues than “dry” natural gas (i.e. methane) alone. Even so, mid-year figures suggest that new drilling activity across all four counties in 2013 may be comparable to 2012. A table listing well counts for all counties in Pennsylvania is in Appendix A.

Classifying Counties by Marcellus Shale Activity

To further understand the effects of Marcellus Shale activity, the analyses compared counties based on their level of Marcellus Shale activity using a five-category county typology. The typology was created by combining several definitions based on estimated shale value and actual development activity, including publicly available maps of the thickness, depth, and thermal maturity of the shale (McLaughlin et al., 2012). This typology also differentiates urban counties because the population and economic dynamics in these counties are fundamentally different from that of rural counties.

Figure 2. Marcellus Shale Typology



Typology based on the number of unconventional wells drilled through September 2012

In Pennsylvania, the number of wells is highly concentrated in a small number of counties. There are 7 counties (including the four study counties) that account for 90 percent of the total number of wells drilled through June 30, 2013. These 7 counties are classified as “core” counties with high drilling activity, and are shaded with the darkest gray in Figure 2. The other four typology categories are: “core” counties with low drilling activity, 2nd tier counties (with lower quality shale and limited drilling activity), urban counties with potential or some Marcellus Shale development, and those counties with no Marcellus Shale. For a full description of the typology, see Appendix B.

Population and Marcellus Shale Development

After briefly defining change and data sources, the next two sections describe population change for the northern tier and the southwest, respectively, presenting information on population numbers and changes of the sex and age distributions within the study counties from 2000 to 2010. The analysis then focuses on population change by typology, comparing overall rates of drilling across the five-county Marcellus Shale Activity typology. Understanding population change that accompanies Marcellus Shale development is critical, as shifts in population size and characteristics influence demand for social and public services, retail stores and services, infrastructure, and housing.

Measuring Population Change

To assess population change, the analysis used county-level data from the decennial censuses (2000 and 2010) and three-year population estimates from the American Community Survey (ACS) for 2005 – 2007, also collected by the U.S. Census Bureau. Population change over time was calculated within and across counties, for the northern tier and southwest regions of Pennsylvania, and for Pennsylvania overall.

Population change is measured as the average annual change per 1,000 residents. The formula used to calculate population change is:

$$\left(\frac{(\text{population at time 2} - \text{population at time 1})}{\text{population at time 1}} \right) \times 1000 = \text{population change}$$

years between time 1 and time 2

When using the 3-year population estimates from the American Community Survey, the middle year is used as the basis for calculating the number of years in a period. For the 2005/2007 ACS data, 2006 is the middle year. For example, Greene County had a population of 40,672 in 2000 and 39,717 in 2005-2007. The average annual population change between 2000 and 2005/7 may be calculated as:

$$\left(\frac{(39,717 - 40,627)}{40,627} \right) \times 1000 = -3.9 \text{ residents per 1,000 population}$$

6 years

This formula is used to calculate population change because the time periods between data points are different; one examines population change between 2000 and 2010, the second time period is 2000 to the midpoint of 2005/07, and the third is 2005/7 to 2010. This formula ensures that all population change measures are standardized to reflect the average change for a single year in each time period.

What is the U.S. Census? The U.S. Constitution mandates that a census be taken in the U.S. every 10 years. This is required to determine the number of seats each state is entitled to in the U.S. House of Representatives and to aid in allocating funds from federal programs. In addition to counting the population for different geographic areas and scales, the Census collects information from every household related to age, gender, race, ethnicity, housing, and household type.

What is the American Community Survey? The American Community Survey (ACS) is conducted every year and provides more up-to-date and detailed information than is collected through the decennial Census. Instead of contacting every household, as is done for the Census, a randomly selected sample of about 3.5 million households is sent a questionnaire each year. Data reported at the county or municipal levels are aggregated across 3 or 5 years, depending on the size of the population (a longer time frame is used for areas with smaller populations to protect confidentiality of the respondents.) The ACS includes questions that were asked on the Census of Population and Housing prior to 2010 (the 'long form'), including education, employment, economic status, and housing characteristics. These questions are no longer asked on the decennial Census.

More information about the U.S. Census and ACS can be found at <http://www.census.gov>.

Table 3 provides an overview of population change in Pennsylvania, the four study counties, and regional comparisons. Pennsylvania experienced overall population growth between 2000 and 2010, gaining more than 400,000 residents over the decade. Yet the state's average annual rate for the decade (3.4 residents per 1,000 population) was around one-third lower than that for the total U.S. population, which increased by 9.7 residents per 1,000 (data not shown; U.S. Census SF 1 files, 2000, 2010). The contrasts are even greater when looking at shorter time periods. From 2000 to 2005/07, Pennsylvania's population growth of 1.6 residents per 1,000 lagged far behind the U.S. population growth rate (10.3 per 1,000). The state's growth, however, almost quadrupled from 2005/07 to 2010, as Pennsylvania added six residents per 1,000 population each year. This corresponds to the beginning of Marcellus drilling and development in the region. It also brings the state's rate closer to the U.S. annual rate, which slowed to 8.4 residents per 1,000 from 2005/07 to 2010.

Table 3. Population change in Pennsylvania, by study counties and region, 2000-2010

	Population			Avg. Annual Rate of Change ^a		
	2000	2005/7	2010	2000-2005/7	2005/7-2010	2000-2010
Pennsylvania	12,281,054	12,400,959	12,702,379	1.6	6.1	3.4
Northern Tier^b	532,741	525,508	538,354	-2.3	6.1	1.1
Bradford	62,761	61,626	62,622	-3.0	4.0	-0.2
Lycoming	120,044	117,311	116,111	-3.8	-2.6	-3.3
adjacent counties (total)	349,936	346,571	359,621	-1.6	9.4	2.8
Southwest^c	2,225,284	2,153,833	2,142,168	-5.4	-1.4	-3.7
Greene	40,672	39,717	38,686	-3.9	-6.5	-4.9
Washington	202,897	205,302	207,820	2.0	3.1	2.4
adjacent counties (total)	1,981,715	1,908,814	1,895,662	-6.1	-1.7	-4.3

Sources: U.S. Census Bureau, 2000 Census, 2005-2007 ACS 3-Year Estimates, 2010 Census.

^a Measured as average change in number of residents per 1,000 population for each year in period. Midpoint of 3-year estimates, 2006, is used to determine number of years in period.

^b Northeast Marcellus region includes 12 counties: the two study counties (Bradford and Lycoming), adjacent counties: Clinton, Columbia, Northumberland, Susquehanna, Tioga, Union, Wyoming, and three counties (Montour, Potter and Sullivan) that were excluded in this analysis because their population counts were too small to be estimated in the 2005/7 ACS data.

^c Southwest region includes six counties: two study counties (Greene and Washington), and four adjacent counties: Allegheny, Beaver, Fayette, and Westmoreland.

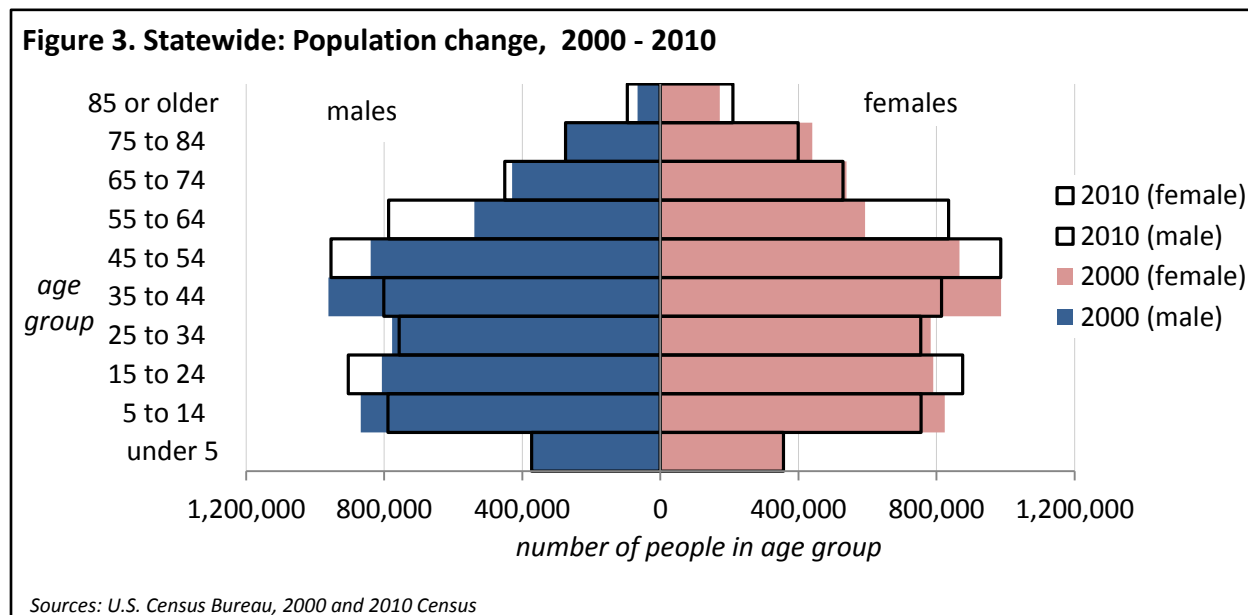
The northern tier Marcellus region experienced a small net gain of approximately 5,600 residents, as the population loss from 2000 to 2006 was slightly less than the gain from 2006 to 2010. The populations of Bradford and Lycoming together represent around one-third of those who live in northern tier counties included here, although Lycoming's population is nearly twice as large as that of Bradford. Bradford lost over 1,000 residents from 2000 to 2006, but regained nearly the same number from 2006 to 2010, for a decade-long average rate of change that is close to zero. In contrast, Lycoming's population shrank from 2000 to 2010. Both of these study counties had lower-than-average population growth rates when compared to adjacent counties, the northern tier region, and the statewide rate of change. Lycoming's loss of nearly 4,000 residents over the decade is particularly striking given the surrounding regional and state contexts, although the rate of loss was less pronounced from 2006 to 2010 (2.6 percent) than the loss earlier in the decade (3.8 percent).

In comparison to the northern tier, the southwest lost approximately 83,000 residents from 2000 to 2010, although the rate of loss was slower in the second half of the decade (1.4 residents per 1,000 compared to 5.4 per thousand). Washington and Greene County populations combined are just over 10 percent of the population in the region, but there are more than five times as many people residing in Washington (207,820 versus 38,686 in 2010) as in Greene County. The pattern of population loss in Greene, which lost nearly 2,000 residents, roughly mirrored that of the adjacent counties overall, although the period with the greatest rate of loss was 2006-2010 (6.5 residents per 1,000). In sharp contrast, Washington County experienced population growth, adding nearly 5,000 residents during the decade (2000 to 2010).

Population Composition

Change in the age and sex composition of a population can shed light on the reasons for growth or decline in a population. Figure 3 presents the population "pyramid" for the state of Pennsylvania. The

solid bars represent the number of males (to the left) and females (to the right) in each age group (shown on the left axis) in the year 2000. The clear bars represent the number of people in 2010. Ages where the clear bar extends beyond the solid bar have larger populations in that age group in 2010 than in 2000. For example, the number of people ages 15 to 24 was larger in 2010 than 2000 for both males and females. The clear bars for ages 15 to 24 in 2010 are slightly larger than the solid bars for ages 5 to 14 in 2000, which suggests some in-migration to Pennsylvania during the decade at that age group.



There is also a prominent “bulge” between the ages of 45 and 64 in 2010 (ages 35 to 54 in 2000), reflecting the baby boom generation, and relatively smaller percentages of elders and children.

Population Change across the Northern Tier

The northern tier of Pennsylvania has been the site of some of the most rapid Marcellus Shale development and highest production levels of natural gas. In examining associated population change, the analysis compared Pennsylvania overall, the northern tier region, the study counties of Bradford and Lycoming, and the counties adjacent to them.

The northern tier region population grew by 1.1 residents per 1,000 population from 2000 to 2010 (See Table 3). This was slower growth than for the state overall (3.4 residents per 1,000). The 10-year growth rates, however, obscure the fact that after experiencing population loss from 2000 to 2005/7, the northern tier actually gained an average of six residents per 1,000 population each year from 2005/7 to 2010, comparable to the state’s population growth rate (also at 6.1 per 1,000 population). This pattern of population loss in the first part of the decade to growth in the latter part of the decade was also found in Bradford County and in six of seven adjacent counties – four of which also experienced Marcellus Shale activity. Only Lycoming County experienced population loss from 2005/7 to 2010.

Table 4. Population Change in the Northern Tier, 2000-2010

	Population			Avg. Annual Rate of Change ^a		
	2000	2005/7	2010	2000-2005/7	2005/7-2010	2000-2010
Northern Tier^b	532,741	525,508	538,354	-2.3	6.1	1.1
Bradford	62,761	61,626	62,622	-3.0	4.0	-0.2
Lycoming	120,044	117,311	116,111	-3.8	-2.6	-3.3
Adjacent (total)	349,936	346,571	359,621	-1.6	9.4	2.8
Clinton ^c	37,914	37,234	39,238	-3.0	13.5	3.5
Columbia ^c	64,151	64,661	67,295	1.3	10.2	4.9
Susquehanna ^c	42,238	41,389	43,356	-3.4	11.9	2.6
Tioga ^c	41,373	40,838	41,981	-2.2	7.0	1.5
Wyoming ^c	28,080	27,881	28,276	-1.2	3.5	0.7
Northumberland	94,556	91,214	94,528	-5.9	9.1	0.0
Union	41,624	43,354	44,947	6.9	9.2	8.0
County average across Northern Tier	59,193	58,390	59,817	-1.6	7.3	2.0
Pennsylvania	12,281,054	12,400,959	12,702,379	1.6	6.1	3.4

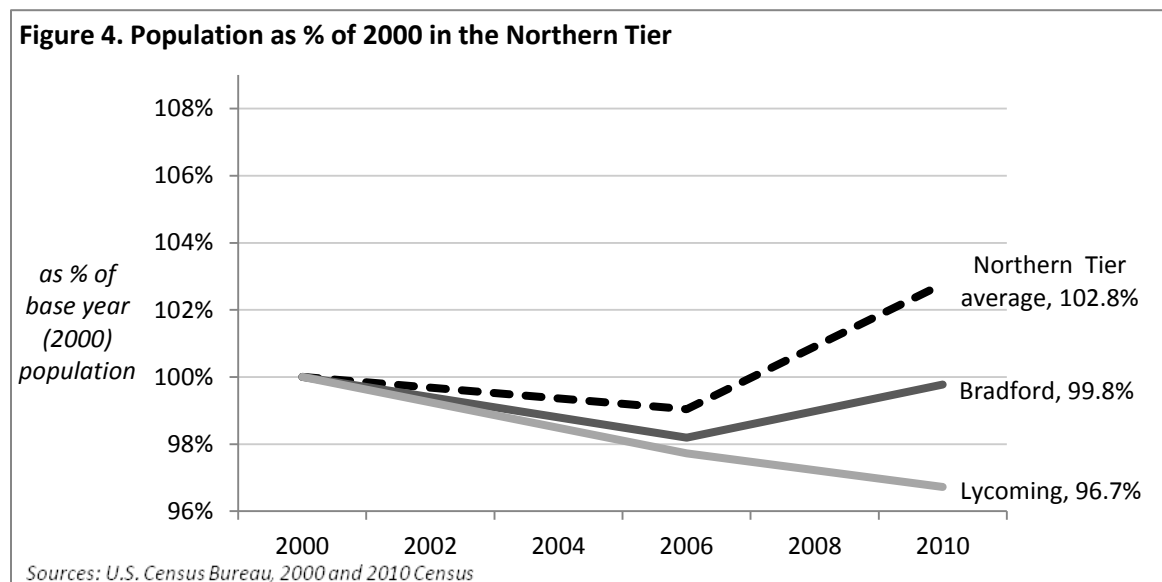
Sources: U.S. Census Bureau, 2000 Census, 2005-2007 ACS 3-Year Estimates, 2010 Census

^a Measured as average change in number of residents per 1,000 population for each year in period. Midpoint of 3-year estimates, 2006, is used to determine number of years in period.

^b Includes 12 counties. Three counties (Montour, Potter and Sullivan) were excluded in this analysis because their population counts were too small to be estimated in the 2005/7 ACS data.

^c County also experienced Marcellus Shale drilling activity during this time period.

Figure 4 shows the patterns of population change over time for the northern tier (dashed line) and Bradford and Lycoming counties. County-level population counts are shown as a percentage of the county population in 2000. The average county in the the northern tier grew in population size to nearly 3 percent higher in 2010 than in 2000.



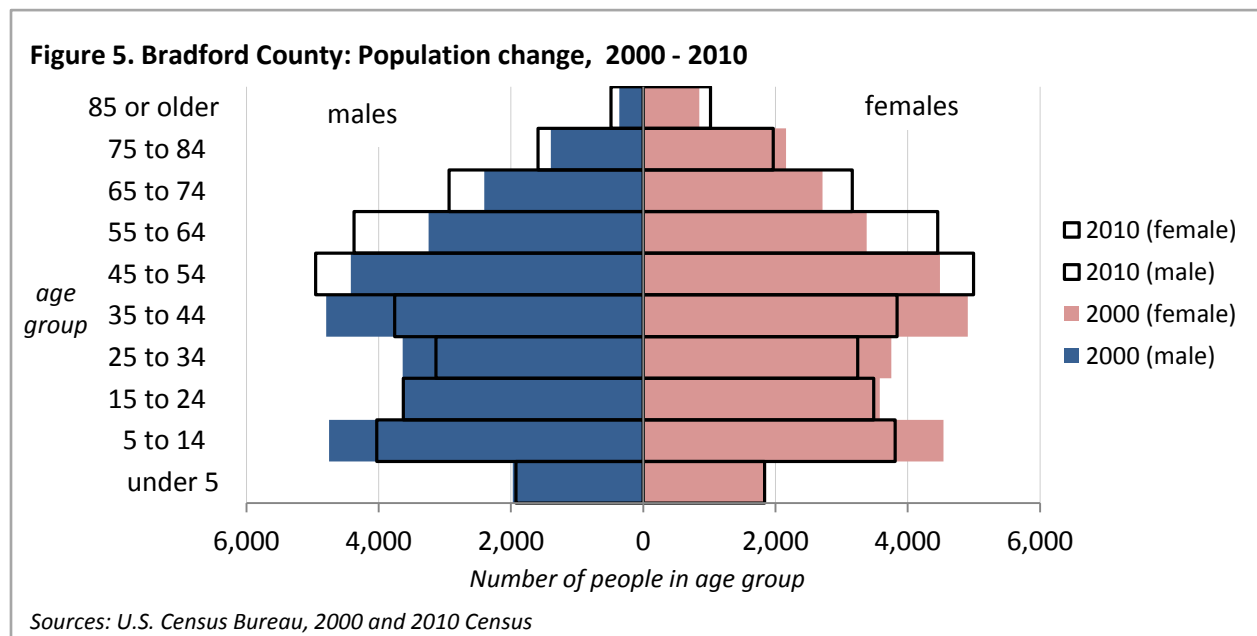
The population in Bradford County declined only slightly by just 0.2 percent, as it lost 139 residents between 2000 and 2010. This minor change overall masks a dramatic swing from population loss in the first half of the decade and relatively faster population growth in the latter half when development of the Marcellus Shale increased rapidly. Bradford County lost an average of 3 residents per 1,000 population per year between 2000 and 2006; the county gained 4 residents per 1,000 population per year from 2006 to 2010. The smaller population size of Bradford County makes smaller changes in the numbers of people coming into or leaving the area more readily observable in calculated rates of change. One hundred workers moving to Bradford County will result in a larger rate of change than the same number moving to Lycoming County. This is consistent with the likely larger influence of an influx of the same number of people on services and activity in Bradford than Lycoming County.

Swings in population change were not as dramatic in Lycoming County (Figure 4). Population decline slowed (from 3.8 to 2.6 per 1,000 population per year) from the beginning to the latter half of the decade, but it did not reverse course as occurred in Bradford County. As a result, Lycoming County lost about 4,000 residents, or 3 percent of its population from 2000 to 2010. Lycoming was the only county in the northern tier region to experience population loss in both periods, which, as shown in the next section, was a pattern more commonly found in the southwest region.

With the exception of Lycoming County, most counties in the northern tier experienced overall population growth over the decade. Growth was faster at the end than at the beginning of the 10-year period. Two counties in the northern tier region – Columbia and Union – experienced population growth throughout the decade (Table 3). Union County gained 8 residents per 1,000 population over the decade, and Columbia County gained 4.9 per 1,000 population. The average annual rate of population growth of the counties in the northern tier was 2 residents per 1,000 population.

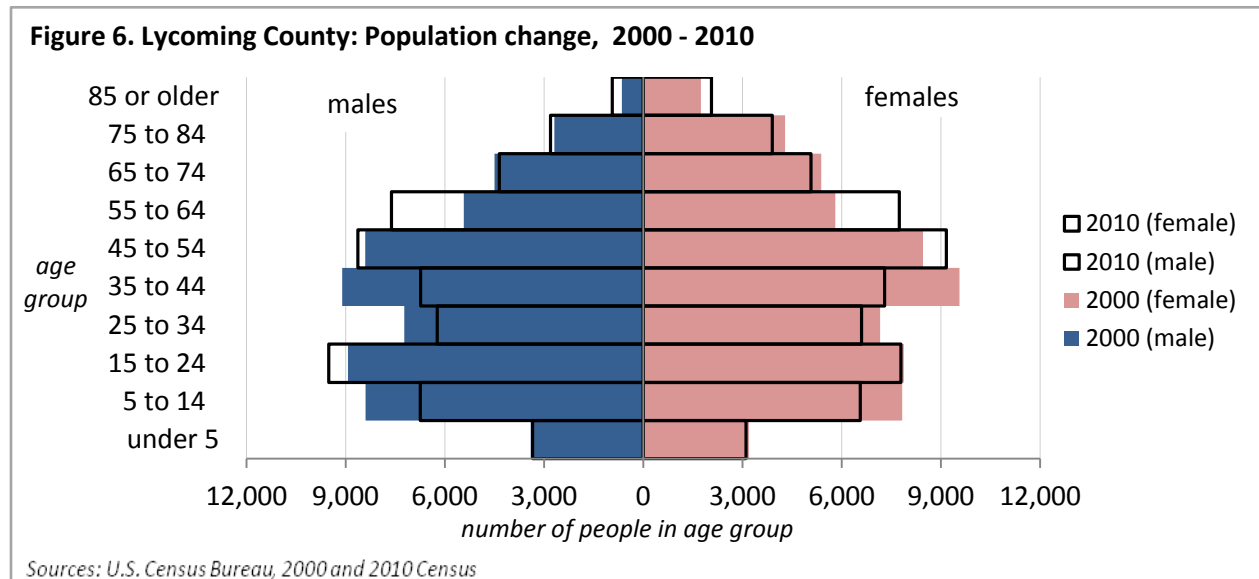
Change in Population Composition in the Northern Tier

The population pyramids of Bradford, Lycoming, and the northern tier are presented in Figures 5 through 8. They show a pattern similar to that of the U.S. as a whole, which includes the prominent “bulge” between the ages of 45 and 65, reflecting the baby boom generation. As earlier, the colored bars represent the share of the population in an age group in 2000. The clear bars represent the share of the same age group in 2010.



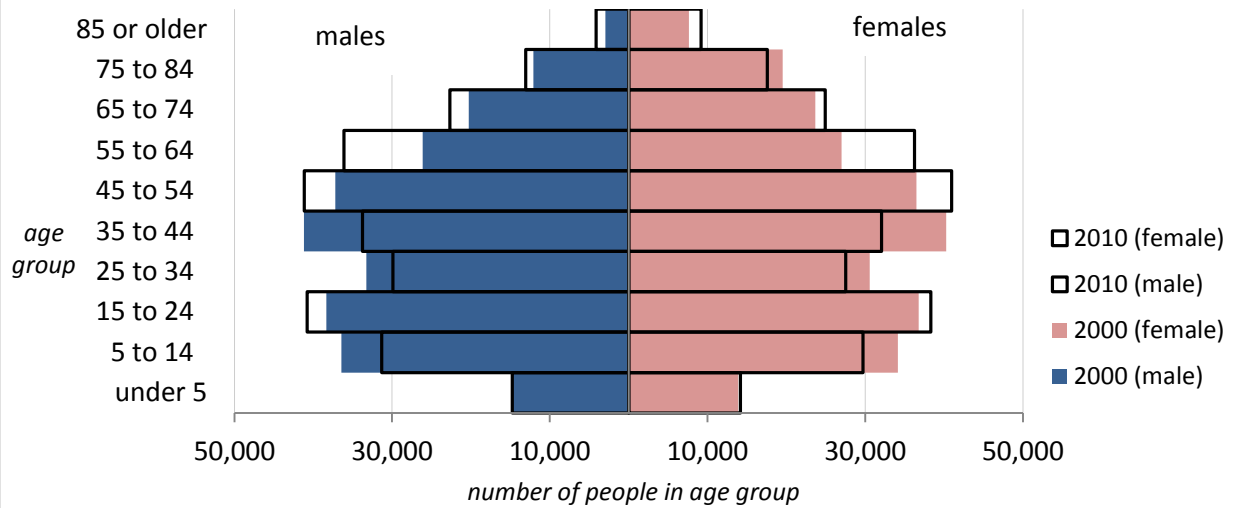
As Figure 5 illustrates, the population in Bradford County became relatively older across the decade, which is typical of rural counties across the U.S. This is indicated by relatively wider solid bars in younger age ranges (i.e., larger share of younger ages in 2000) and relative wider clear bars in older ages (i.e., greater share of older residents in 2010). The growth in the 15 to 24 age group that was seen statewide was not observed in Bradford County. The solid bars for ages 5 to 14 in 2000 were much larger than the clear bars for ages 15 to 24 in 2010, revealing notable out-migration from the county, especially among families with children.

The population pyramid for Lycoming County in Figure 6 reveals a slightly different pattern than in Bradford. Out-migration occurred at older ages, as the number of people in the 15 to 24 age group in 2000 was much larger than the 25 to 34 age group in 2010. In Lycoming County, the age 15-24 male population became relatively larger, but the age 15-24 female population did not. Housing availability could be related to these differences, as male workers arriving to work in Lycoming County may have more housing options within the county than workers in Bradford (who may seek accommodations in neighboring counties instead).



Change in the age structure for the region as a whole, illustrated in Figure 7, shows that older adolescents and young adults (15 to 24 years old) increased their share of the population in the region in the midst of population aging. This pattern is consistent with the statewide trend at most age groups (Figure 4), although the 25-to-34 year-old age group shrank from 2000 to 2010 (and it did not at the statewide level).

Figure 7. Northern Tier: Population change, 2000 - 2010



Counties included: Bradford, Lycoming, Clinton, Columbia, Northumberland, Susquehanna, Tioga, Union, Wyoming.
Sources: U.S. Census Bureau, 2000 and 2010 Census

This descriptive analysis indicates that population aging continues to be a major factor in the northern tier counties of Pennsylvania. However, most counties experienced overall population growth across the decade, with general decline in the first half and growth in the second half of the decade. These changes were accompanied by a growing share of young adults (particularly men) that parallels rapid growth in Marcellus development. Although correlated in time, it is difficult to isolate population change due to particular industrial activity such as development of the Marcellus Shale. This is especially true when job growth and economic activity in that industry generate growth of peripheral industries and may encourage family settlement. Other demographic and economic phenomena unrelated to Marcellus development, of course, also confound relationships between development of an industry and population change. Of particular notice is the coincidence of the recession and development of the Marcellus Shale. While the recession officially began December 2007 and ended June 2009, more recent statistics continue to reflect slow economic activity (U.S. Bureau of Labor Statistics). Further analysis is needed to understand how population change is related to development of the Marcellus Shale and other events, such as the recession.

Population Change across the Southwest

Table 5 shows population change in the southwest region of the state. Unlike the northern tier, the region experienced population loss through the entire decade. The rate of loss was much higher in the early part of this decade (-5.4 residents per 1,000 population between 2000 and 2005/2007) but slowed during the latter part of the decade (-1.5 per 1,000 population between 2005/2007 and 2010).

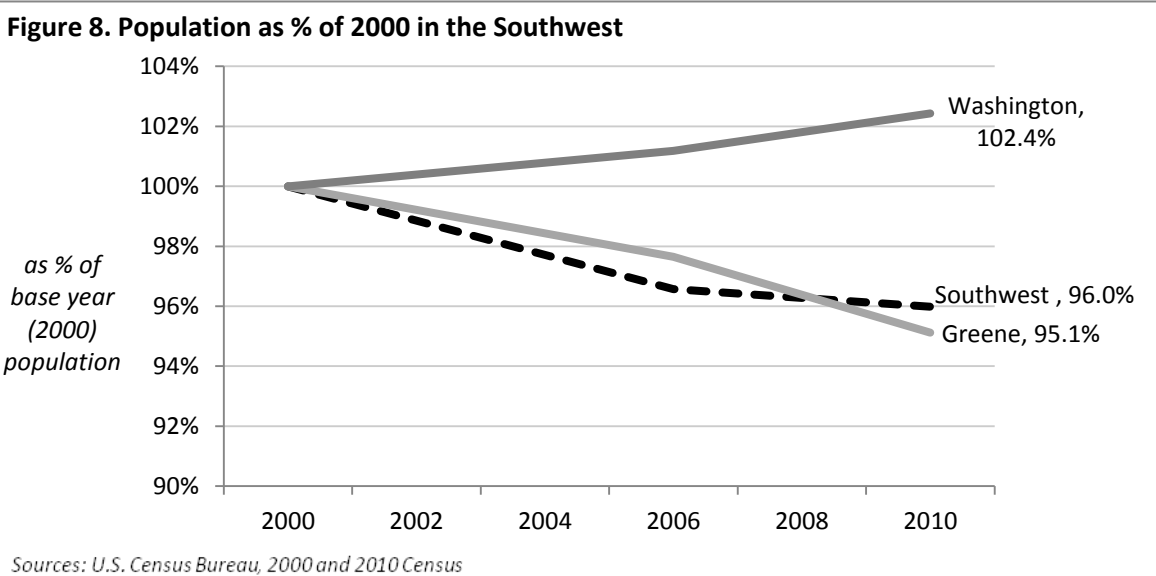
The pattern of population loss in the southwest was very different from statewide population increase during the decade. It also contrasts with the turnaround of the northern tier, which had early population loss (2000-2005/7) followed by population increase from 2005/7-2010. Another important difference is the contribution of the study county populations to overall trends. Whereas Lycoming and Bradford together constitute nearly one-third of the entire population in the northern tier, the combined populations of Greene and Washington represent just one-tenth of the population in the southwest Marcellus region.

Table 5. Population change in the Southwest, 2000-2010

	Population			Avg. Annual Rate of Change		
	2000	2005/7	2010	2000-2005/7	2005/7-2010	2000-2010
Southwest	2,225,284	2,153,833	2,142,168	-5.4	-1.4	-3.7
Greene	40,672	39,717	38,686	-3.9	-6.5	-4.9
Washington	202,897	205,302	207,820	2.0	3.1	2.4
Adjacent counties only (total)	1,981,715	1,908,814	1,895,662	-6.1	-1.7	-4.3
Allegheny	1,281,666	1,226,174	1,223,348	-7.2	-0.6	-4.6
Beaver	181,412	174,189	170,539	-6.6	-5.2	-6.0
Fayette	148,644	144,962	136,606	-4.1	-14.4	-8.1
Westmoreland	369,993	363,489	365,169	-2.9	1.2	-1.3
County average across Southwest	701,167	677,108	672,972	-4.8	-4.0	-4.5
Pennsylvania	12,281,054	12,400,959	12,702,379	1.6	6.1	3.4

Sources: U.S. Census Bureau, 2000 Census, 2005-2007 ACS 3-Year Estimates, 2010 Census.

Figure 8 shows the populations of the southwest counties, with the region’s average and the two study counties. Greene County’s population declined throughout the decade with the rate of decline actually accelerating in the latter half of the decade. Greene County lost almost 4 residents per 1,000 population per year at the beginning of the decade, and, by the end of it, the rate of decline accelerated to more than 6 people per 1,000 population per year. Over the 10-year period, the loss was 4.9 people per 1,000 per year. While the county lost only 2,000 residents across the decade, this is a relatively large share – about 5 percent – of its small population.



Population change in Washington County followed a pattern very different from the southwest region, but similar to the state. The county population increased across the decade, but growth appears to have increased slightly in the latter half of the decade when drilling activity increased. On average, the county added an additional two residents each year between 2000 and 2006 for every 1,000 residents in 2000; however, the rate of growth increased to about 3 residents per 1,000 population per year in the last 4 years of the decade. Over the decade, population growth was 2.4 residents per 1,000 population per year, for an increase of about 2.4 percent of the 2000 population.

Recent research shows that Marcellus activity may be affecting population change in counties adjacent to those with high drilling activity (Kelly, 2012). Greene and Fayette counties hug the southern border of Pennsylvania, while Beaver, Westmoreland, and Washington counties are adjacent to Allegheny County and the City of Pittsburgh. The counties adjacent to Greene and Washington counties, which include Allegheny, Beaver, Fayette, and Westmoreland counties, all experienced significant population decline across the decade. But overall, the decline for these counties as a group slowed by the end of the decade from a loss of 6.1 per 1,000 before 2006 to 1.7 residents per 1,000 population from 2006 to 2010. Over the decade, the population loss was 4.3 residents per 1,000 population (about 4 percent of the 2000 southwest population), a substantial loss compared to the overall gain in the state of 3.4 residents per 1,000 population.

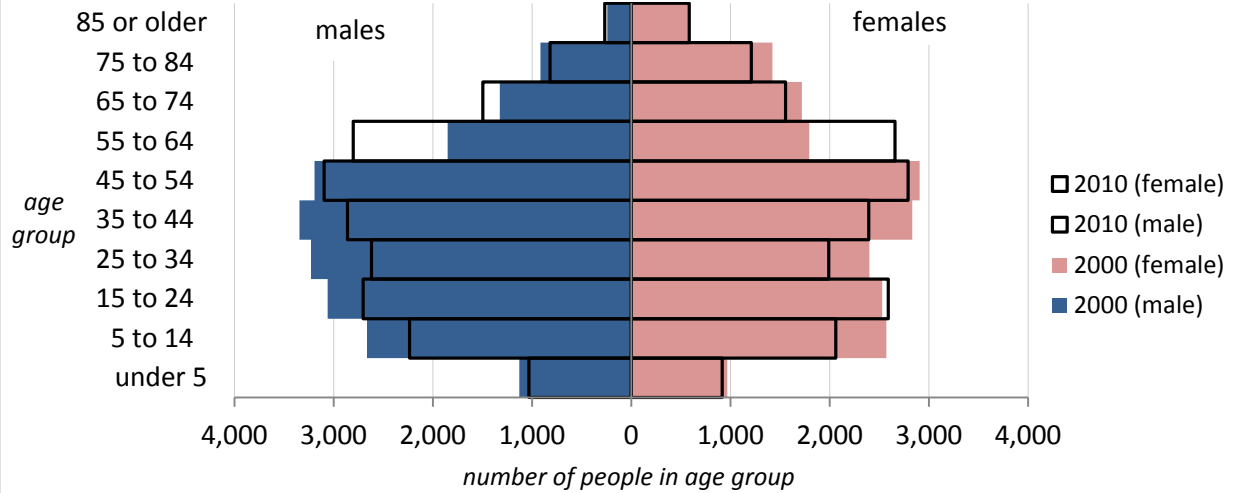
What is noteworthy about the adjacent counties is the variation in population change. Allegheny, Beaver and Westmoreland counties experienced population losses early in the decade, with a slight slowing of population loss in Beaver County in the latter part of the decade. In Allegheny County, population loss from 2006 to 2010 dropped to 0.6 residents per 1,000 population and in Westmoreland County, the population grew by 1.2 residents per 1,000 population. Fayette was similar to Greene, although its population loss was even more pronounced. In the 2000 to 2005/7 period, Fayette County lost 4.1 residents per 1,000 population. In the latter part of the decade, that loss had more than tripled to 14.4 residents per 1,000 population.

Change in Population Composition in the Southwest

Figures 9 through 11 show changes in the age and sex composition of Greene and Washington counties, and the southwest region overall. The population in Greene County generally ages across the decade. This is typical of rural counties across the United States in which young adults leave to acquire higher education and higher paying jobs in metropolitan areas. Population aging is indicated by relatively wider solid bars in younger age ranges (i.e., larger percentage of younger residents in 2000) and relatively wider clear bars in older ages (i.e., greater percentage of older residents in 2010).

There are a few exceptions in Greene County. First, it appears that women older than 65 years became a relatively smaller percentage of the female population. Female aging was concentrated among women transitioning into their late 50s and early 60s. Second, the number of women ages 15 to 24 years old was actually slightly higher in 2010 than in 2000, although this was not seen for men. An increase in young-adult women in combination with a decline in the percentage of young-adult men is not what one would expect in the context of growing Marcellus drilling activity, in which men are the largest share of the workforce. However, the scale shows that the number of men in the younger age groups was actually quite a bit higher in 2000 than for women, i.e. there were more than 3,000 men ages 15 to 24 but only 2,600 women.

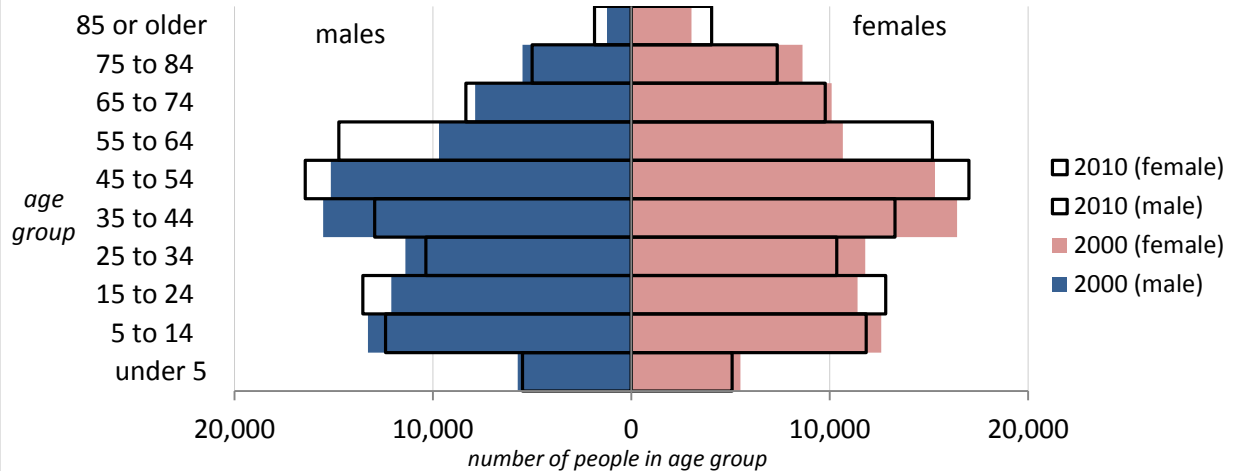
Figure 9. Greene County: Population change, 2000 - 2010



Sources: U.S. Census Bureau, 2000 and 2010 Census

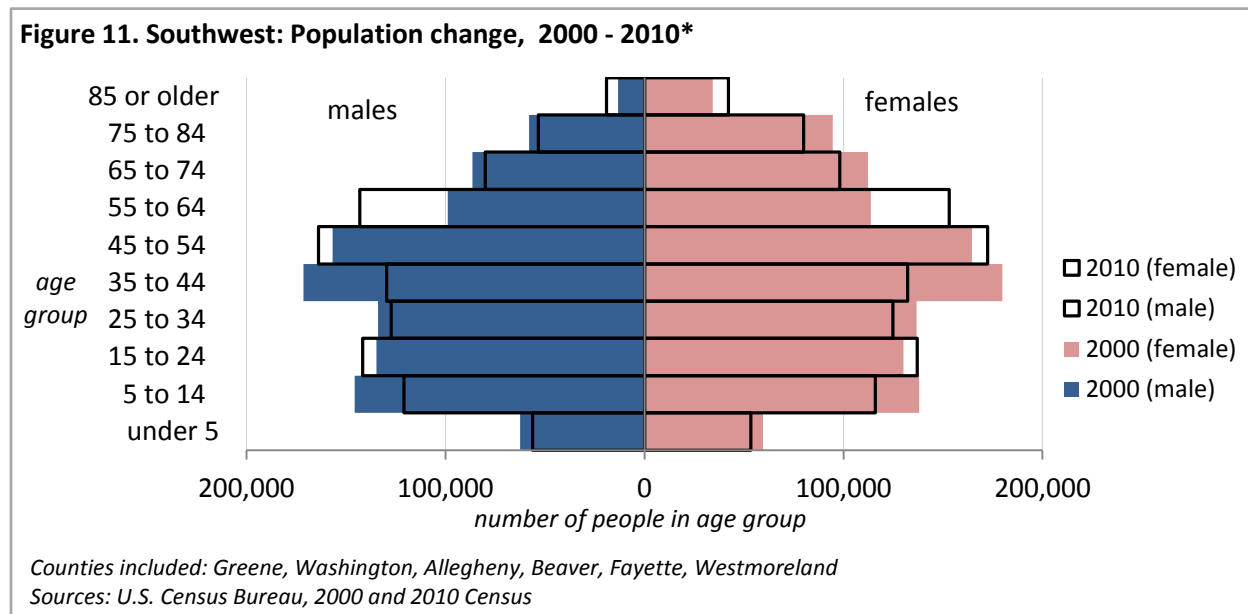
The population pyramid for Washington County in Figure 10 shows a similar pattern to Greene at older ages. One major difference, however, is that Washington County experienced a slight increase among young-adult men and women in the 15 to 24 year age range (who were ages 5 to 14 in 2000) that did not occur in Greene County. Further exploration, such as examining changes in employment patterns in multiple industries by gender, may reveal why fewer young adults left Washington County and some in-migration was also observed. Changes in college enrollment or job opportunities for young adults, for example, could partially explain this trend.

Figure 10. Washington County: Population change, 2000 - 2010



Sources: U.S. Census Bureau, 2000 and 2010 Census

Change in the age structure for the Southwest region as a whole, illustrated in Figure 11, shows a pattern similar to Washington County.



Overall, population aging continues to be a major factor in population change in southwest Pennsylvania. Why Greene County experienced continued population loss as drilling activity increased remains an open question that survey data or interviews may better address; it is, however, consistent with the main trend of population loss in the southwest. Washington, in contrast, had population growth throughout the decade. Growth in the number of individuals ages 15 to 24 suggests that more people are staying, or that out-migration of young adults is balanced by in-migration of others. This may indicate demand for young workers with a high school diploma or technical college certificate, such as might be expected in the energy and related industries. It is unclear from this analysis, however, if the increase in men and women between the ages of 15 to 24 is due to members of this age group migrating into the region, staying in the region at higher rates, or a combination of the two. In addition, it is difficult to isolate population change due to particular industrial activity such as development of the Marcellus Shale, especially in counties close to a metropolitan area with a diversity of industries. For example, Washington County has both a prominent shale-based energy industry and is also close to the metropolitan center of Pittsburgh. Here, economic cycles affecting various industries fluctuate, making the reasons for change in county population difficult to determine.

Population Change by Marcellus Shale Activity

One final comparison is done using the five-county typology presented earlier in this report. As noted, the four study counties are all considered to be “core” counties with high drilling activity. To understand how population change differs across the counties in the categories of the typology, we examine population counts and calculate the average annual rate of change for the 2000 to 2005/7, 2005/7 to 2010, and 2000 to 2010 periods (see Table 6).

The average annual rate of change figures in Table 6 show the fastest growth in population in Pennsylvania counties occurred among those *without* Marcellus Shale. These largely are counties in southeastern Pennsylvania; their high population growth rates, 6.8 residents per 1,000 population per year, drive up the statewide rates. The 2nd tier Marcellus counties, those with less economically valuable shale but with limited or no drilling activity, experienced the second highest rate of population growth

over the decade, adding 4.2 residents per 1,000 population per year between 2000 and 2010. Some of these counties are in northeast Pennsylvania and have experienced strong population growth; however, 2nd tier counties also include those in the northwest, which have experienced slow or declining populations.

Table 6: Population Counts and Change in Population by Marcellus Typology Categories

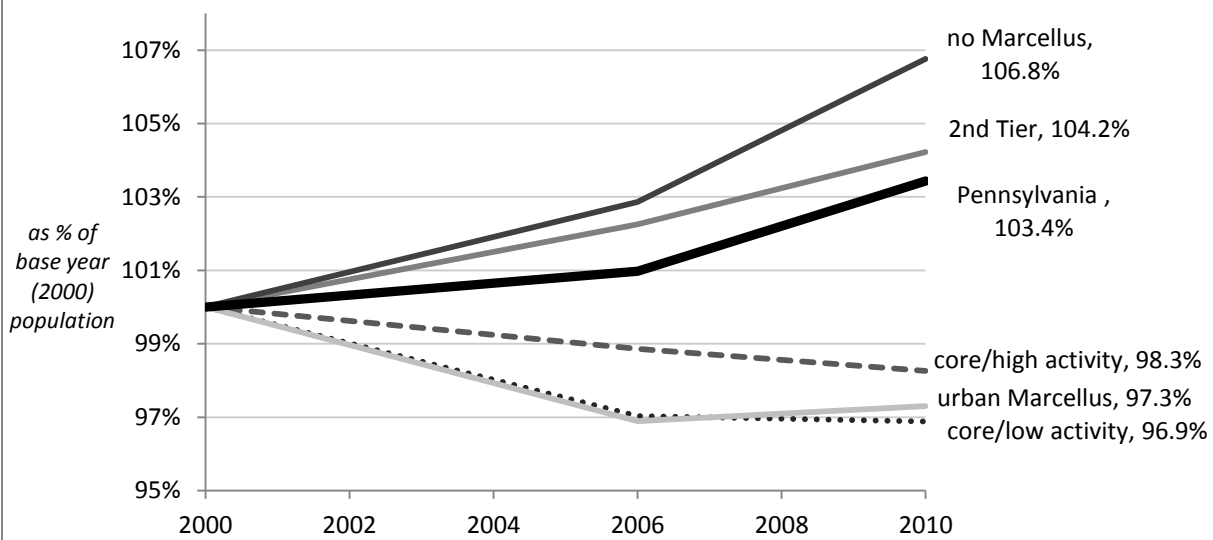
	Average Annual Rate of Change					
	2000	2005/7	2010	2000-2005/7	2005/7-2010	2000-2010
Core / High Activity	658,629	651,145	647,182	-1.9	-1.5	-1.7
Core / Low Activity	625,038	606,470	605,544	-5.0	-0.4	-3.1
2nd Tier	1,489,400	1,522,906	1,552,317	3.7	4.8	4.2
Urban Marcellus	2,646,459	2,564,165	2,574,977	-5.2	1.1	-2.7
No Marcellus	6,793,475	6,987,849	7,252,561	4.8	9.4	6.8
Pennsylvania	12,281,054	12,400,959	12,702,379	1.6	6.1	3.4

Sources: U.S. Census Bureau, 2000 Census, 2005-2007 ACS 3-Year Estimates, 2010 Census.

The number of people living in core counties with low drilling activity declined during this decade (loss of 3.1 residents per 1,000 population per year), which is a rate of loss comparable to the urban Marcellus category (-2.7 residents per 1,000 population per year). It should be noted, however, that the loss was greatest in the first half of the decade for both areas. The core, high-drilling activity counties also lost population, although the rate of loss was about half as large. Except for the core counties, the 2005/7 to 2010 period showed more robust population growth compared to the 2000 to 2005/7 period. In the core counties, the rate of population loss slowed at the end of the decade.

Figure 12 further illustrates these trends, showing the influence of population growth in the 2nd tier and the no-Marcellus categories on the statewide trend. Population loss was lower across the area in core counties/high-drilling as there were 2 percent fewer residents in 2010 than in 2000. This compares to closer to 3 percent less in the urban Marcellus area and core counties with lower drilling, which may suggest that development could be associated with a slowing of population loss.

Figure 12. Population growth by 5-county typology category (as % of 2000)



Sources: U.S. Census Bureau, 2000 and 2010 Census

Summary and Implications

Overall, the Census and ACS data comparisons presented here indicate that patterns of population change varied across the four study counties, and that the associations with Marcellus Shale development are not clear. Trajectories of change diverge notably even though all four places had relatively high levels of Marcellus activity. Washington was the only one of the four counties to experience net population increase over the decade, with the population growing by more than 2 percent from 2000 to 2010. Despite its location in the southwest, this pattern of growth was more similar to counties in the northern tier. Greene County lost nearly 5 percent of its 2000 population by 2010. The southwest is thus home to both counties that were outliers on population change.

In the northern tier, Bradford’s population dipped in the first half of the decade. The loss, however, was nearly compensated for with population growth from 2005/7 to 2010 for a net decade change of close to 0. Lycoming, in contrast, lost nearly 3 percent of its population during the decade. Bradford and Lycoming were both atypical because the region experienced an increase of nearly 3 percent of the population from 2000 to 2010. The relationship of population change to Marcellus activity is not clear or consistent.

Bradford County is therefore the only county that experienced significant population growth coincident with Marcellus development, which may have contributed to the turnaround from loss (2000-2005/7) to gain (2005/7-2010). This turnaround was mirrored across the northern tier; population loss in Lycoming was not consistent with the region trend. Among our study counties, Bradford had the most wells drilled (by far) by the end of 2010, with more than 550 wells drilled from 2005 to 2010. This compares to just over 400 in Washington, less than 300 in Greene, and just over 150 in Lycoming (Table 1). It is possible that more years of data are needed to fully understand these trends, as natural gas development occurred more evenly across these four counties from 2011 to 2012.

Washington’s population growth did increase during Marcellus Shale development, but this pattern of increase was a continuation of the pattern since 2000. The analysis suggests that long-term trends in

population growth or loss are not easily changed by the introduction of one industrial activity. Although Greene and Lycoming counties both experienced significant development of wells, population decline continued throughout the decade (although Lycoming County's population decline was at a slower rate between 2005/2007 and 2010).

The analysis of all Pennsylvania counties differentiated by level of Marcellus activity indicates no clear relationship between population growth and Marcellus development overall. Net population growth during the decade was only observed in the areas *without* Marcellus Shale development (which had nearly 7 percent more residents by 2010) and across 2nd tier counties (which had more than 4 percent more residents by 2010 and little to no drilling activity). These increases thus drove up the statewide total: Pennsylvania's population in 2010 was more than 3 percent larger than in 2000.

Turning to the other three categories, population loss occurred across core counties and in urban Marcellus areas, which all lost between 2 to 3 percent of residents from 2000 to 2010. What this masks, however, is that the population loss (2 percent) in the core/high activity area was lower than the population loss (3 percent) in core/low activity area. This is consistent with what would be expected with Marcellus Shale development. Further analysis of migration (moves across county, state, or national boundaries) and industrial employment change would shed additional light on explanations for population trends in different parts of the commonwealth.

It is also important to note that Bradford and Greene counties are the most rural of the four study counties with small populations of about 63,000 and 38,000, respectively, in 2010. Population change (growth or decline) in places with low populations, while small in actual numbers, can have significant impacts on public services, infrastructure, and economic opportunities.

There are some important limitations that need to be considered in understanding the implications of this analysis. First, the Census and the ACS are based on surveys of households at a particular point in time. Individuals, such as those working for gas companies or their subcontractors (including drilling or hydraulic fracturing companies) and living in temporary housing (e.g., RV parks, campgrounds, hotels), will not be captured as residents in these data. These individuals are most likely to be counted at their permanent addresses, which may be elsewhere in Pennsylvania or out-of-state. As the energy industry seems to be transitioning toward moving workers to the region and/or hiring more local workers, the Census and ACS are more likely to capture these individuals as residents in future years. Additional research is needed to understand how to effectively count temporary workers and understand their impacts on public services within a community. See report #5 in this series on housing for additional evidence and resident perceptions of this issue.

Aggregate trends shown here do not indicate how the increases or decreases occur, as the population counts are a result of a combination of in-migration, out-migration, and retention of current residents. Although the focus is on in-migration related to economic opportunities created by Marcellus Shale development, it is unclear how these key drivers interact to create the aggregate changes in population shown here. An increase in workers moving to an area may displace low income families. The increase in the share of males ages 15 to 24 in some of the study counties does suggest a possible influx of working age young males. Displacement of one population group by another is not captured in the rates of population change, but is suggested in the population pyramids in some areas.

Finally, it is unclear at this time how population flows related to Marcellus Shale development interact with other trends affecting population change. These trends are often specific to each region within the state, such as in-migration of residents from New York and New Jersey to northeastern Pennsylvania or long-term trends of population loss in large urban areas and western Pennsylvania. Construction of casinos in the southwest may have increased job opportunities and attracted construction workers. An

analysis with data through 2012 could provide a more complete picture of population change across levels of drilling activity. Further research is needed to describe the components of change in the population – the extent of in-migration and out-migration that occurs – and the characteristics of the movers. This information would be helpful in identifying the flows of people into and out of counties experiencing development of Marcellus Shale.

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Appendix A: Unconventional Wells Drilled by County and Year, 2005-2013

county name	2005	2006	2007	2008	2009	2010	2011	2012	2013*	Total, county
Bradford[†]	1	2	2	24	158	373	396	164	66	1186
Washington[†]	5	19	45	66	101	166	155	195	120	872
Tioga	0	1	0	15	124	273	272	122	13	820
Lycoming[†]	0	0	5	12	23	119	301	202	89	751
Susquehanna	0	1	2	33	88	125	205	191	102	747
Greene[†]	0	2	14	67	101	103	121	105	54	567
Westmoreland	1	0	4	33	39	49	59	42	22	249
Fayette	0	2	6	20	57	44	54	43	12	238
Butler	0	3	12	11	10	35	35	69	44	219
Armstrong	0	3	2	7	19	36	35	44	26	172
Clearfield	0	0	1	6	24	39	58	19	2	149
Wyoming	0	0	0	0	2	24	71	15	25	137
Clinton	0	0	0	4	9	35	39	10	1	98
Sullivan	0	0	0	0	0	22	19	27	5	73
Potter	0	0	8	6	8	36	11	1	0	70
Elk	1	1	6	8	6	16	22	1	3	64
McKean	0	2	1	5	7	22	19	5	3	64
Centre	0	0	1	4	7	41	8	2	0	63
Indiana	0	0	0	5	6	7	21	2	0	41
Jefferson	0	0	0	3	3	7	15	9	0	37
Allegheny	0	0	0	1	3	0	5	13	8	30
Lawrence	0	0	0	0	0	0	2	16	8	26
Beaver	0	0	0	0	1	1	5	17	2	26
Somerset	0	0	1	0	7	4	7	5	1	25
Clarion	0	0	3	1	3	3	10	4	0	24
Forest	0	0	0	0	5	1	0	12	4	22
Cameron	0	0	0	3	2	3	7	0	0	15
Mercer	0	0	0	0	0	0	0	5	3	8
Cambria	0	0	0	0	2	1	3	1	0	7
Blair	0	0	0	0	0	4	2	0	0	6
Venango	0	0	0	0	0	0	2	3	0	5
Warren	0	0	2	0	0	0	1	1	1	5
Wayne	0	0	0	1	0	4	0	0	0	5
Columbia	0	0	0	0	0	1	2	0	0	3
Crawford	0	0	0	0	0	0	0	3	0	3
Lackawanna	0	0	0	0	1	0	1	0	0	2
Luzerne	0	0	0	0	0	2	0	0	0	2
Bedford	0	0	0	0	0	1	0	0	0	1
Huntingdon	0	0	0	0	0	1	0	0	0	1
Total, by year	8	36	115	335	816	1598	1963	1348	614	6833

Source: Pennsylvania Department of Environmental Protection, Office of Oil and Gas Management.

*Data through June 30, 2013 (accessed July 4, 2013). [†]Study counties.

Appendix B. Marcellus Activity County Typology Definitions for Pennsylvania^a

Category	Geological Definition	Activity level	Counties
Core Counties with High Drilling Activity^b (N=7)	More than 50 percent of the land area is in the core Marcellus formation	Annual average 64 or more Marcellus wells 2005 to 2010	Bradford, Fayette, Greene, Lycoming, Susquehanna, Tioga, Washington
Core Counties with Low Drilling Activity (N=12)	More than 50 percent of the land area is in the core Marcellus formation	Annual average less than 64 Marcellus wells 2005 to 2010	Armstrong, Cambria, Cameron ^c , Clearfield, Clinton, Elk, Indiana, Jefferson, Potter ^c , Somerset, Sullivan ^c , Wyoming
Counties in the Marcellus 2nd Tier (N=19)	1 percent-50 percent land area is in the core <u>and</u> 25 percent or more land area is in the less viable areas (2 nd tier or gray areas in Figure 2)	Not applicable	Bedford, Blair, Butler, Carbon, Centre, Clarion, Columbia, Crawford, Forest ^c , Lawrence, McKean, Mercer, Monroe, Montour ^c , Pike, Schuylkill, Venango, Warren, Wayne
Urban Counties in the Marcellus Shale-- Core or 2nd Tier (N=6)	Marcellus Core or 2 nd Tier <u>and</u> identified as urban by the Center for Rural Pennsylvania	Not applicable	Allegheny, Beaver, Erie, Lackawanna, Luzerne, Westmoreland
Counties with No Marcellus Shale (N=23)	25 percent or less viable Marcellus land area or no Marcellus land area	Not applicable	Adams, Berks, Bucks, Chester, Cumberland, Dauphin, Delaware, Franklin, Fulton ^c , Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Mifflin, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Snyder, Union, York

^aSee McLaughlin, et al. 2012.

^bNote this category includes all four study counties.

^cThese counties are excluded from those analyses that use American Community Survey (ACS) three-year estimates, as their populations are too small to be estimated.

*For more on maps, see the Penn State University Marcellus Center for Outreach and Research (<http://marcellus.psu.edu>) and Dell, Lockshin, and Guber (2008).

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