

Race, Class, Political Capacity and the Spatial Distribution of Swine Waste in North Carolina, 1982 - 1997

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The emerging national controversy over the socio-economic and environmental impacts of corporate pork production on rural communities raises claims of environmental injustice. Over the past two decades, the US swine industry has undergone a dramatic restructuring, expansion, and vertical integration of its pork production systems throughout North America, locating in peripheral, rural locations like North Carolina where environmental costs can be more easily externalized on to marginalized populations. We examine the relationships between key environmental justice variables—race, class, and local political capacity—and the spatial concentration of swine waste in the Black Belt region of the state and assess, empirically, claims of environmental inequity central to this emerging national issue. Analyzing the growth and concentration of swine production in eastern North Carolina between 1982 and 1997, we find clear cross-sectional and longitudinal evidence that minority communities and localities lacking the political capacity to resist are shouldering the bulk of the adverse economic, social, and environmental impacts of pork industry restructuring. We also find that the relationship between poverty and swine waste concentration varies by region. In the eastern region where 95% of North Carolina's swine waste is produced, we find a strong direct relationship between poverty and concentrated swine waste, while in the rest of the state we find an inverse relationship.

Introduction

Twenty years ago the environmental justice movement emerged onto the American political landscape and continues to raise questions about who pays and who benefits from contemporary policies of economic growth, industrial development, and environmental protection (Edwards 1995; Bullard 1996). More recently, emerging national contention over the socio-economic and environmental impact of agro-industrialization, especially related to pork production, clearly exemplifies these broader issues. By the mid-1980s, most sectors of American agriculture were well into an "industrial" transformation driven by the adoption of integrated production systems, capital intensive technologies, and increasing corporate control. Late to adopt corporate controlled, integrated production systems, the pork industry began to aggressively restructure production processes in the early 1980s and has since integrated itself into a global market

in which pork now accounts for over 40 percent of world animal protein consumption (Furuseth 1997; Thu and Durrenberger 1998: 8). By the late 1990s, the U.S. was producing 10% of the global pork supply and, by exploiting burgeoning markets in east Asia, the Russian Federation, and its NAFTA partners Mexico and Canada, was poised to overtake Denmark as the world's leading pork exporter. A ten-fold increase in pork exports since 1986, coupled with a modest 9.5% growth in pork's share of domestic meat consumption, has driven a sharp increase in the number of hogs produced annually, while over one-half million hog farmers went out of business nationally as their ranks declined from about 650,000 to 120,000 during the period examined here (NPPC 1999).

Hog farms have also changed dramatically since the 1970s when most hogs were raised on multiple-enterprise, crop-livestock farms with an average herd size of 150 hogs that provided an important, but

usually secondary source of farm income (Agricultural Animal Task Force 1996; Furuseth 1997). Today the typical hog farm utilizes confined animal feeding operations (CAFOs) of the sort pioneered by poultry producers and frequently dubbed “assembly line swine” by those wanting to emphasize that swine CAFOs more closely resemble industrial facilities than the traditional farms of the recent past. Swine CAFOs often house in excess of 50,000 head, with operations of over a million head each under development in Utah and Idaho, yet herd sizes of 1,000 - 5,000 are more the norm (Furuseth 1997; NPPC 1999). Hog operations with 1,000 or fewer head comprise 62% of current hog farms, but their market share has steadily eroded in concert with industry restructuring from 32% of all hogs produced in 1988 to only 5% by 1997. Conversely, in 1997, hog operations with more than 5,000 head produced 63% of the nation’s hogs, yet comprised only about 6% of all hog farms (NPPC 1999).

Current pork industry profitability rests in large part on the extraordinary economies of scale generated by recent restructuring and the adoption of new, capital-intensive, production technologies (Rhodes 1995). However, these same economies of scale, in conjunction with the intensifying geographic concentration of pork production, have produced equally extraordinary and troubling “externalities of scale” flowing directly from the downstream economic, social, and environmental consequences of current waste disposal practices (Furuseth 1997). Central to the emerging debate surrounding the recent transformation of pork production are more general questions about the uneven social and spatial distribution of risks and rewards associated with industrial restructuring. Are the “externalities of scale”—socio-environmental impacts—associated with swine waste concentrated in low-income and minority communities? Does local political capacity play a role in explaining the socio-spatial distribution of swine waste externalities? If so, have such patterns intensified over time as pork industry restructuring intensified?

The county level census and agricultural data assembled here document community characteristics and indicators of swine waste production beginning in

1982 when traditional patterns of pork production still held sway, through the period of rapid industry expansion and restructuring, extending to the imposition of a statewide moratorium on new and expanded swine operations in 1997 (Edwards and Ladd 2000). The cross-sectional and longitudinal analyses presented here use an environmental justice framework to investigate the relationships between key environmental justice variables—race, class, and local political capacity—and the spatial distribution of externalities of scale associated with current swine waste disposal practices. Thus, it takes advantage of a unique opportunity to examine empirically claims of environmental injustice in the context of industry expansion and restructuring.

Swine Waste, “Externalities of Scale,” and Environmental Justice

A recent Senate Agriculture Committee report documents that the annual volume of livestock wastes—including pork, poultry and beef—in the U.S. is approximately 130 times greater than annual production of human wastes. Moreover, recent reports indicate that such animal waste is now the largest contributor to pollution in 60% of America’s rivers and streams classified as “impaired” by the U.S. Environmental Protection Agency (U.S. Senate, 1997; Office of Senator Thomas Harkin, 1997; Silverstein, 1999: 30). Nationally, contemporary swine CAFOs produce about 116 million tons of swine excreta and utilize an expanded and refined version of the waste disposal techniques characteristic of small-scale traditional hog farms. In the traditional system, indicative of the beginning of the period examined here, hog waste was collected and used to fertilize commercially viable field crops on the same farm. With reduced herd size and geographic dispersion of hog populations, the waste could essentially be laid on the land with little to no adverse consequences. In current practice, hogs are kept in confinement buildings where their liquid and solid excreta fall through slats in the floor and are periodically flushed away with water forming a liquid slurry. The slurry is then transferred to nearby waste lagoons as much as 25-30 feet deep and several acres in surface area. As needed to keep the lagoon from get-

ting too full, the slurry is applied to sprayfields with large irrigation sprinklers (see Furuseth 1997; U.S. EPA 1998 for more information).

Recent reports estimate that 10 million hogs produce nearly 20 million tons of swine waste in eastern North Carolina alone (Clean Water Network et al., 2000; Silverstein, 1999). However, swine waste is not categorized by the federal EPA as a hazardous or toxic material capable of damaging human health in relatively low doses. Thus, it is exempt from the Clean Water Act and many other environmental regulations that would apply to "point-source" polluters. Yet, the "externalities of scale" inherent in current swine waste disposal practices and its intensifying geographic concentration constitute a potential threat researchers and policy makers have just begun to investigate. What we term "externalities of scale" refers to a constellation of adverse, but not yet fully understood, economic, social and environmental impacts associated primarily with current pork production and waste disposal practices, but not present in the more dispersed, small-scale production practices typical at the beginning of the period examined here. Specifically these include economic impacts like the displacement of small farmers and the loss of property values, health impacts on those who work in or live in close proximity to CAFOs, and broader environmental impacts on air, soil, and ground and surface waters which can indirectly affect human and economic health in surrounding communities (Ladd and Edwards, 2001).

Since the early 1990s, the spatial concentration of corporate owned (vertically integrated) or contracted (horizontally integrated) hog operations in North Carolina has been framed by many environmentalists and minority activists as an environmental injustice. In such cases, people of color and the poor living in rural communities lacking the political capacity to resist are said to shoulder the adverse socio-economic, environmental, or health related effects of swine waste externalities without sharing in the economic benefits brought by industrialized pork production (United Church of Christ 1987; U.S. General Accounting Office 1995; Harris 1994, 1997; Wing et al. 1996; Wing et al. 2000; Wing and Wolfe 2000; Edwards and Ladd

2000). The cross-sectional and longitudinal analyses below assess these claims directly.

Theoretical Issues

In this section, we discuss pertinent issues related to regional differences, race/ethnic discrimination, local political capacity, and market factors in explaining patterns of environmental inequality. Much quantitative environmental justice research has examined residential proximity to hazardous waste streams or traditional industrial facilities, especially those associated with toxic and hazardous substances that are widely believed to harm human health (cf. Mohai and Bryant 1992). The case at hand diverges from existing research in two important respects. First, the restructuring and expansion of pork production sketched above has so thoroughly transformed the industry during the period of our analysis that we treat it as a "new" or emerging industry. Second, swine CAFOs are legally categorized as "farms" rather than "industrial" facilities, and livestock waste is not regulated as a hazardous or toxic material. Thus, they are "non-point source" polluters and exempt from the Clean Water Act and many other environmental regulations that would apply to industrial facilities, hazardous or toxic materials, and other "point source" polluters like municipal sewerage treatment plants (NRDC 2001).

Regional Concentration

The rural and agricultural nature of this emerging industry further differentiates our emphasis from the predominant focus in environmental justice research because the equity issues at stake in the agro-industrialization of swine production in North Carolina stem, in large part, from the historical political economy of North Carolina's eastern coastal plain as a distinct and peripheral region of the state (Roscigno and Tomaskovic-Devey 1994). The concentration of corporate hog farming has followed the path previously paved by cotton, tobacco, and poultry whereby production migrated to the counties of the eastern, coastal plain traditionally dependent on black, and poor white, agricultural labor (Wood 1986). Besides row crops, the region's economy has been dependent upon

extractive industries like fishing, mining, and pulpwood forestry. Beginning in the early 1960s, the region has become home to some textile and light manufacturing as firms began to migrate out of northern industrial states to regions with lower taxes, lower wages, and weaker unions. Much of the region's economy has been controlled by outside interests. Despite improvements in recent years, the coastal-plain of the East remains the most economically distressed and arguably the most politically marginalized area of the state (ProjectEast 1993; RDI 2000). This region, which lies roughly to the east of Interstate 95, is home to just over 2 million people or 31% of the state population, yet in 1990 42% of North Carolina's poor lived in the East. At the beginning of the period examined here (1980), 25 of the region's counties had poverty rates over 20% and in 33 eastern counties blacks comprised more than 30% of the population. The East is also home to 44% of the state's African American residents, more than half (53%) of which are in poverty. In 1990, the region-wide poverty rate was 17.5%, but among African American residents it was 33%.

Eastern North Carolina has been profoundly affected by pork industry restructuring. In 1982 only one North Carolina county lacked commercial hog farms; by 1997, following the period of intensive restructuring examined here, approximately 95% of all swine production had concentrated in the eastern counties of the coastal plain. In light of these strong regional dynamics, the analysis below pays particular attention to region in explaining the distribution of swine waste externalities during the period of industry restructuring and globalization examined here.

Intentional or Institutional Discrimination in Environmental Justice Analysis

In our estimation, two problems characterize much of the recent empirical research on environmental equity relating to the conceptualization of injustice generally and racial discrimination in particular. Feagin (1977) distinguishes between direct and indirect discrimination. In the context of our analysis, direct discrimination would involve conscious and intentional decisions to locate large, CAFO-style hog operations

in minority communities. Hamilton (1995) characterized this definition as a "pure-discrimination model" of environmental racism and a number of environmental equity analysts use this definition (see for example Been 1994). By contrast, another group of analysts adopts a structural conceptualization of environmental racial inequality focusing on institutional processes that constrain, often indirectly, the capacity of minority individuals to resist forms of oppression (see for example Bullard and Wright 1987; Bullard 1990; Stretsky and Hogan 1998). Downey's (1998) replication of Bowen et al. (1995) indicates that similar empirical results lead to contrasting interpretations depending on whether one adopts an institutional, rather than a "pure discrimination," conceptualization. To find evidence of environmental racism in a "pure-discrimination" model, the analysis must demonstrate racist intent (no small task in statistical analysis). However, the presence of environmental injustice does not require a demonstration of intentional discrimination and proponents of 'institutional racism models' do not attempt to explain racially inequitable outcomes in terms of racist intent. They argue, instead, that the normal, non-intentionally discriminatory operation of important social institutions leads to racially inequitable outcomes. Therefore, a racially biased distribution of any environmental hazard is evidence, in and of itself, of environmental racism (Downey 1998: 769-770). For those using a racist intent model, such non-intentional outcomes are often treated as market-related and therefore "incidental" and not constituting discrimination (Been 1994: 17). Here, we adopt a structural and institutional framework to assess discriminatory impacts. Thus, we focus analytical attention on whether or not and to what degree low-income communities and communities of color (regardless of income) shoulder the environmental burdens and risks of recent pork industry restructuring and spatial concentration.

Local Political Capacity

A growing consensus exists among scholars about the factors that account for the emergence of collective action, and hence the capacity of specific localities to mobilize opposition to increasing environ-

mental inequalities. These include elements of political opportunity, as well as access to specific human, social and cultural resources (McAdam, McCarthy and Zald 1996). Difficulties in compiling systematic local data over time on fine-grained indicators of political capacity are daunting and quantitative environmental justice researchers have often relied on voter registration rates (Hamilton 1995). Though clearly not an ideal measure of political capacity, the logic has some merit since structural impediments to voter registration and turnout have traditionally constrained the political capacity of low-income groups and minorities (see Piven and Cloward 1988; Teixeira 1992). This is especially so in the South where for many long-term residents simply being registered to vote is itself the direct result of participation in local political mobilizations (Morris 1984; McAdam 1983). Other researchers have argued that the percent of residents with a college education would be a better measure of potential political mobilization on local environmental justice issues than voter registration rates (see for example, Hird, 1994:130-134). With respect to local collective action potential, "conscience constituents" comprised of sympathetic college educated residents are an important, but not always necessary, resource for local mobilization (McCarthy et al. 1988; McCarthy and Zald 1977).

What this body of research makes clear is that the normal functioning of the American political arena constrains the representation of marginalized, low-income, and minority constituencies, often excluding their concerns from public agenda setting altogether (Gaventa 1980). Following these factors, an environmental justice framework would predict that communities lacking political capacity constitute a path of less resistance and will suffer greater exposures to environmental risks and bear higher costs of externalities than those capable of mobilizing more effectively (Bullard and Wright 1987; Capek 1993). Thus, we expect to find a negative relationship between local political capacity and hog population size (cross-sectional) and hog population growth (longitudinal). Moreover, extending this logic would predict that localities whose political capacity had declined over this

period of restructuring and globalization would be expected to have experienced greater swine population growth.

Data & Measures

The spatial unit of analysis most suitable for empirical environmental justice research has been the subject of some debate and contention because of inconsistent findings and aggregation bias (Anderton 1996). Nevertheless, the county level of analysis is used here because comprehensive, longitudinal swine data is available only at the county level.¹ Thus, the data assembled here enable us to undertake a cross-sectional analysis of the relationship between community characteristics and hog population size at four time points spanning the key two decades of swine industry expansion and spatial concentration. It also enables a preliminary longitudinal analysis of changes in county hog population size during this period of industry restructuring commensurate with the globalization of the pork industry.

The data set used in this research was assembled from county level data compiled in the North Carolina LINC data base and NC Department of Environment, and Natural Resources Division of Water Quality (DWQ) data base on state swine operations. The LINC system combines county-level measures assembled from a wide array of state and federal agencies, including the U.S. Census Bureau, the Census of Agriculture, State Board of Elections, the NC Department of Commerce, and the State Department of Agriculture. The DWQ data are updated quarterly and represents the most reliable source of swine data for the state. State Department of Agriculture data on the number hogs and hog operations by county are used for 1977, 1982, 1987 and 1992. The 1997 swine data come from the October 15, 1997 DWQ quarterly report and reliably represents the state's swine population at the time the current moratorium on new and expanded hog operations went into effect. Because of the moratorium on new and expanded swine operations that went into effect in 1997 but is set to expire in 2003, our data accurately reflects the

current spatial distribution of swine waste in North Carolina (Ladd and Edwards 2001).

Dependent Variables

We use two dependent variables in the analysis presented below. County-level hog population size is used in the cross-sectional analysis, while the preliminary longitudinal analysis examines the percent change in hog population size between 1982 and 1997. We chose to examine patterns of concentration in hog

populations rather than in hog operations in part because we want to shift the analytical focus to inequitable environmental outcomes, rather than individual facility siting decisions. Also, as depicted in Figure 1, mean herd size grew from 187 head in 1982 to 2,109 head in 1997 representing more than a 1000% increase in the waste potential of a typical hog operation over the period studied here. Moreover, contemporary commercial hog operations vary greatly in size. Thus, herd size and, by extension, county-level hog population

Figure 1

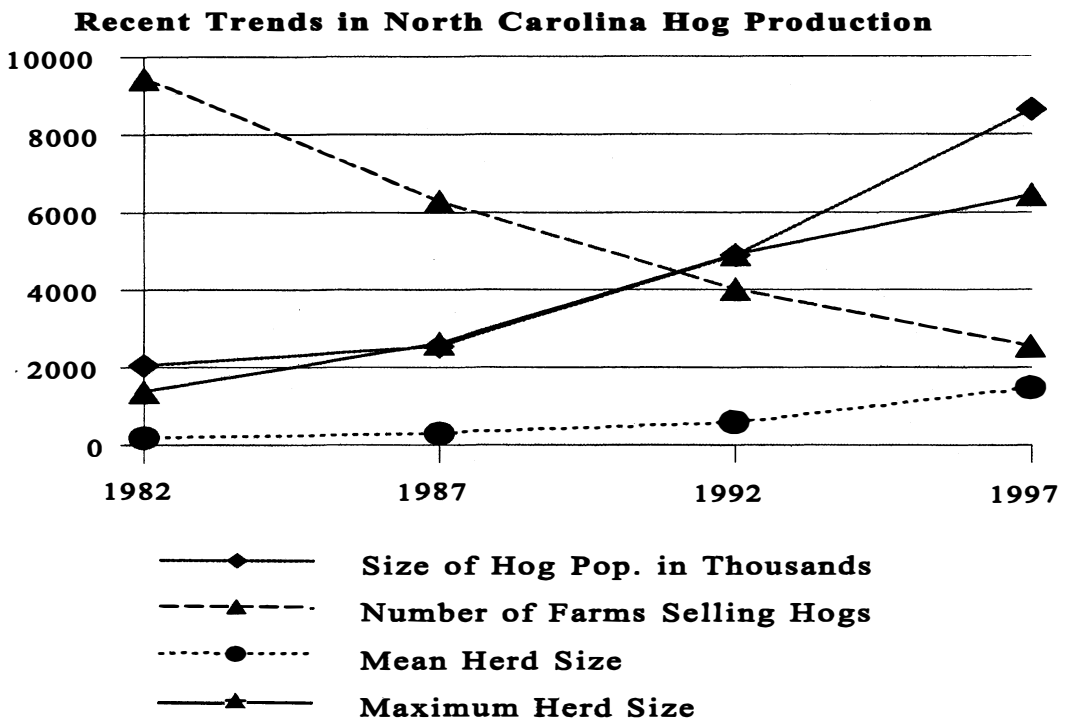


Table 1:
North Carolina County Characteristics and Hog Population
(A Comparison of Eastern to Other Counties)

County Characteristics	All Counties (N=100)		Eastern Counties (N=41)	Other Counties (N=59)	Means Ratio
County Attributes	Mean	(SD)	Mean	Mean	(East/Other)
Hog Population					
Hog Population, 1982	20,471	57,982	40,378	6,637	6.1 **
Hog Population, 1987	25,407	32,875	54,328	7,731	7.0 **
Hog Population, 1992	48,861	161,325	111,378	5,417	20.6 **
Hog Population, 1997	86,221	283,460	203,076	5,017	40.5 **
Environmental Justice					
Percent Not White, 1980	24.8	17.1	36.3	16.7	2.17 **
Percent Not White, 1990	24.5	17.2	35.6	16.8	2.12 **
Percent Residents in Poverty, 1980	13.1	2.0	21.0	15.1	1.39 **
Percent Residents in Poverty, 1990	23.8	4.1	18.5	13.7	1.35 **
Local Political Capacity, 1980	37.9	5.7	35.3	39.7	.89 **
Local Political Capacity, 1992	41.9	5.8	39.6	43.5	.91 **
Control					
Percent Urban, 1980	26.2	24.6	25.3	26.9	.94 ns
Percent Urban, 1990	27.1	24.7	26.3	27.7	.95 ns
Median Property Value, 1980	32,700	6,300	30,100	34,100	.88 **
Median Property Value, 1990	57,600	13,400	54,300	59,800	.91 *
Unemployment, 1977-81	6.6	1.5	7.1	6.3	1.11 **
Unemployment, 1982-86	8.3	2.8	8.6	8.0	1.08 ns
Unemployment, 1987-91	5.2	2.1	5.5	4.9	1.12 ns
Unemployment, 1992-97	5.9	2.4	6.6	5.4	1.22 **
Annual Wages, 1980	10,470	1,490	10,070	10,750	.94 *
Annual Wages, 1990	17,130	2,600	16,210	17,790	.91 **

* $p \leq .05$, ** $p \leq .01$

are more direct and preferable indicators of the environmental externalities and potential risks associated with swine waste than using the number of hog operations.

Hog Population 1982, 1987, 1992, 1997 indicates the approximate number of all commercially raised hogs alive in each county on any given day in each of the years listed.² In 1997, this ranged from zero hogs in some counties to 1.65 million and 2.11 million head in Sampson County and Duplin County respec-

tively. Because the distribution of this variable is so skewed—with a mean 1997 county hog population of 86,221 and a standard deviation of 283,460—the base 10 logarithm is used to reduce skewness in the dependent variable and prevent the analyses from being distorted by the characteristics of outlier counties.

³ In the longitudinal analysis, we examine the percent change in logged hog population size from 1982 when traditional hog farming still prevailed, to 1997 when the current state moratorium went into effect. The

means and standard deviations of variables used in the analyses are presented in the first two columns of Table 1.

Environmental Justice and Control Variables

The environmental justice framework predicts that the externalities of scale associated with the restructuring, expansion, and spatial concentration of pork production would fall disproportionately on lower income counties with higher proportions of nonwhite residents. Moreover, in the longitudinal analysis, such communities are expected to experience intensifying concentrations of swine waste externalities. We use the following two variables to investigate these claims. Percent Not White refers to the percent of each county's population comprised of people of color.⁴ Percent in Poverty measures the proportion of county residents living below the federally established poverty threshold in 1980 and 1990.

As argued above, we also expect the adverse impacts of swine waste externalities to follow a path of least political resistance settling in communities with less capacity to resist.

Thus, given the limitations of currently available local data, we use a proxy indicator of Local Political Capacity that combines the percentage of eligible adults in each county who were registered to vote with the percentage of county residents with a four-year college degree.⁵ Clearly this is a less than ideal measure of local political capacity. A preferred measure would, for example, identify environmental and other issue advocacy organizations in each locality and construct measures of rates of such organizations per 1,000 residents. A similar strategy worked well in Bebbington's (1997) case study analyzing mobilization capacity for sustainable development in the rural Andes. Another strategy would follow the lead of Flora, et al. (1996) who developed measures of "entrepreneurial social infrastructure" in over 1,000 small municipalities as a means of explaining which communities were more or less likely to undertake local economic development initiatives. The prospect of constructing either of these kinds of measures over the 15 year time frame of this analysis is no simple matter. Thus, for the purposes of this analysis we

use the measure described above as an exploratory proxy to see if the results here motivate the data building efforts needed to construct more robust and satisfying measures. In the longitudinal analysis below (Table 4), Change in Political Capacity measures the percent change in Local Political Capacity between 1980 and 1992.

Columns 3 and 4 of Table 1 present the mean values of the variables used in this analysis for the 41 eastern counties and the 59 other counties in the state. The last column presents the means ratio and results of an independent samples T-test of differences between the mean values for each region. Tables 2 – 4 present results from bi-variate and multiple regression analyses. In light of the consistent regional differences, especially related to the key environmental justice variables, we use a dummy coded control to differentiate between the East Region (1) and other (0) counties. To test our expectation about regional differences in the relationship between poverty and swine waste, we constructed an interaction term In-Region Poverty (East * Percent Poverty). Doing this enables us to examine the effects of poverty separately for each region. In the models that contain this interaction term, the main effect for Percent living in poverty represents the effect of poverty outside of the East Region. By contrast the coefficient for In-Region Poverty represents the effect of poverty within the 41 counties of eastern North Carolina.

Population density, often measured as the number of residents per square mile, has been suggested as part of an alternative explanation in environmental justice analyses of hazardous waste site location and residential exposure to toxic releases with mixed results (Kriesel et al., 1996; Yandle and Burton, 1996). Through the period of this study, North Carolina has been one of the fastest growing states in the U.S. with most new population growth concentrated in metropolitan areas and urban municipalities. Thus, counties that have become increasingly urbanized over the last two decades may be less likely to also have either larger or growing hog populations. Thus, we use the percentage of county residents residing in urban areas in 1980 and 1990 to control for Urbanization. We also include additional controls for property values and

Table 2:
Bivariate Regressions (OLS) of Hog Population Size on County Characteristics

County Characteristics ^a	Environmental Justice ^c				Controls ^c		
	Percent Not White	Local Political Capacity	Percent Poverty	East (1 = Yes)	Percent Urban	Median Property Value (\$1,000)	Labor Market Attributes
1982 Hog Population							
Standardized Beta	.62 **	-.53 **	.26 **	.50 **	.16	-.29 **	.01
T Score	7.86	-6.14	2.66	5.67	1.59	-2.96	.04
Adjusted R square	.38	.27	.06	.24	.02	.07	-.01
1987 Hog Population							
Standardized Beta	.55 **	-.47 **	.20 *	.53 **	.12	-.22 *	-.09
T Score	6.55	-5.28	1.98	6.13	1.15	-2.24	-.85
Adjusted R square	.30	.21	.03	.27	.00	.04	.00
1992 Hog Population							
Standardized Beta	.49 **	-.55 **	.16	.49 **	.02	-.28 *	.01
T Score	5.50	9.83	1.60	5.49	.15	-2.90	.12
Adjusted R square	.23	.29	.02	.23	.00	.07	-.01
1997 Hog Population							
Standardized Beta	.60 **	-.54 **	.23 *	.58 **	.00	-.31 **	.13
T Score	7.33	8.55	2.35	7.13	.01	-3.27	1.30
Adjusted R square	.35	.28	.04	.33	.00	.09	.01

labor market attributes. Labor Market combines the average monthly unemployment rate in each county over the sixty months preceding each of the four time points in the analysis with its average annual wages, which reflects total earnings by place of work divided by total full and part-time employment for all industries. Labor Market is coded so that lower scores correspond with a more favorable business climate in terms of lower wages and higher unemployment rates.⁶ Property value measures the median value of owner-

occupied residences in 1980 and 1990 dollars respectively.

Results

Cross-Sectional Analysis

After briefly considering the bivariate regressions presented in Table 2, we examine the results of our multivariate cross-sectional analysis of county-level swine populations. The environmental justice and control variables are measured in 1980 and 1990 and

indicate county level attributes predating our measures of hog population size at each of the four points in time. Standardized coefficients are presented to facilitate comparisons of the relative strength of each variable in explaining patterns of swine waste concentration. Bivariate results for Percent Not White, Local Political Capacity, and Percent Poverty are statistically significant and consistent with environmental justice expectations except for Percent Poverty in 1992. We also find evidence of strong regional effects with East Region, a consistent positive predictor of greater swine waste concentration. Among the control variables, higher Property Values generally predicts smaller hog populations as expected, while Labor Market and Percent Urban evidence no relationship with hog population size.

We turn now to the multivariate cross-sectional analysis presented in Table 3 which identifies county-level attributes associated with subsequent hog population size and thus the concentration of externalities associated with swine waste. Given the relatively small number of cases ($N=100$) in this analysis, we limit our models to a maximum of one predictor for every ten cases (London 1988). Thus, our multivariate analysis uses the following strategy.⁷ For each of the four time periods examined, Model 1 includes our three key environmental justice variables and the dummy coded East Region ($East = 1$). Model 2 then steps in the In Region Poverty interaction to test our hypothesis about a region specific poverty effect and to better assess any changes over time in the ability of race and class to predict subsequent patterns of swine population concentration. In Model 3, we step in three control variables—Percent Urban, Property Values, Labor Market—to assess whether or to what extent the relationships between the primary environmental justice and region variables are altered. In order to facilitate comparisons of the relative strength of different variables in predicting patterns of swine waste concentration, we present standardized Betas in Table 3.

Before examining the results with respect to the specific hypotheses described above, we begin by briefly discussing the fit of our models. First, we note that the adjusted R squares for Model 1 range from .40 to .55 indicating that our base model of environmental justice variables and region explains county-

level hog population size acceptably well. Across the first three time periods examined here, Model 2 improves notably upon Model 1, while the addition of control variables in Model 3 does not notably improve upon the fit of Model 2 in any of the periods examined here.

Local Political Capacity. The environmental justice framework predicts that environmental inequalities of all sorts would follow a path of least political resistance. Commensurate with this we expected to find an inverse relationship between local capacity for political mobilization and swine waste concentration at subsequent points in time. The results for Local Political Capacity are consistent with the path of least political resistance hypothesis across all four time periods examined here. The strength of this effect in Model 1 is consistently enhanced by stepping in the In Region Poverty interaction (Model 2), and generally diminished somewhat by adding the block of control variables (Model 3).

Percent Not White. The environmental justice framework claims that contemporary effects of historic discrimination in conjunction with current processes of institutional and intentional discrimination cause people of color to be more likely than whites to experience environmental inequalities. We expected to find greater concentrations of hog waste in counties with higher proportions of minority residents. Results for Model 1 are consistent with this expectation in each time period examined here. Counties with larger communities of color have larger hog populations and thus have had to absorb intensified externalities of scale from swine waste. However, the relationship between race and poverty and their effects on subsequent hog population size are complicated significantly by regional differences. When the In Region Poverty interaction is stepped in (Model 2), the effect of Percent Not White is reduced to nonsignificance for 1987 and 1992. Yet, in 1997, following the period of greatest hog population growth (1992-1997), Percent Not White remains a significant predictor of swine waste concentration. The effect of Percent not White becomes stronger after stepping in the block of control variables (Model 3).

Poverty and In Region Poverty. Another core environmental justice claim predicts that independent of

Table 3:
Multiple Regression (OLS) of Subsequent Hog Population on County and Hog Operation Characteristics^a

County Characteristics ^b	1982 Hog Population			1987 Hog Population			1992 Hog Population			1997 Hog Population		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Environmental Justice												
Pct. Pop. Not White	.45 ** (3.95)	.24 * (2.13)	.22 ** (1.93)	.37 ** (3.11)	.18 (1.49)	.17 (1.37)	.28 ** (2.58)	.13 (1.07)	.17 (1.29)	.38 ** (3.85)	.28 * (2.60)	.37 ** (3.12)
Local Political Capacity	-.27 ** (-2.85)	-.31 ** (-3.58)	-.28 ** (-2.99)	-.17 + (-1.74)	-.21 * (-2.25)	-.20 * (-1.98)	-.37 ** (-4.24)	-.40 ** (-4.64)	-.42 ** (-3.70)	-.31 ** (-3.86)	-.32 ** (-4.08)	-.28 ** (-2.73)
Percent Living in Poverty	-.08 (-.79)	-.35 ** (-3.08)	-.29 * (-2.20)	-.22 * (-2.00)	-.46 ** (-3.81)	-.43 ** (-3.09)	-.11 (-1.06)	-.30 * (-2.50)	-.28 + (-1.67)	-.14 (-1.50)	-.26 * (-2.38)	-.39 * (-2.42)
Eastern Counties	.16 (1.40)	-1.20 ** (-3.81)	-.99 ** (-3.00)	.36 ** (3.08)	-.87 * (-2.58)	-.73 * (-2.08)	.25 * (2.29)	-.58 + (-1.92)	-.53 (-1.46)	.32 ** (3.31)	-.21 (-.75)	-.12 (-.36)
In Region Poverty												
East * Poverty Rate	—	1.69 ** (4.55)	1.45 ** (3.76)	—	1.53 ** (3.84)	1.36 ** (3.31)	—	1.07 ** (2.91)	.99 * (2.38)	—	.68 * (2.02)	.60 (1.54)
Control Variables												
Percent Population Urban	—	—	.01 (.10)	—	—	-.09 (-.80)	—	—	-.15 (-1.45)	—	—	-.13 (-1.33)
Labor Market	—	—	-.18 + (-1.68)	—	—	-.18 (-1.48)	—	—	-.09 (-.72)	—	—	.02 (.14)
Median Property Values	—	—	-.20 + (-1.83)	—	—	-.14 (-1.12)	—	—	.03 (.17)	—	—	-.05 (-.34)
Adjusted R Square	.45	.54	.55	.40	.48	.48	.42	.46	.46	.53	.54	.55
F Score	21.25	24.66	16.18	17.58	19.05	12.30	18.85	17.95	11.40	28.57	24.40	15.81
Degrees of Freedom	95	91	90	95	91	90	95	91	90	95	91	90

+ $p < .05$ (one-tailed), * $p \leq .05$, ** $p \leq .01$.

^a Coefficients are standardized Betas. Raw T scores in parentheses.

^b 1980 county characteristics are used in the analyses of 1987 hog population, and 1990 characteristics are used for 1992 and 1997.

minority composition or political capacity, low income areas will experience greater environmental inequality than those populated by higher income residents—and our bivariate results (Table 2) are consistent with this expectation. However, the results for percent poverty in a multivariate model (Model 1, Table 3) that includes the three environmental justice variables and region are not consistent with this expectation at any of the four time points. In fact, we find just the opposite in 1987 when higher poverty rates predicted smaller hog populations. However, as discussed above, we expected that the effects of poverty rates on swine waste concentration would be complicated by differing regional dynamics and this expectation proved to be generally well founded as indicated by results for Model 2. Because we have the interaction term for In-Region Poverty in the model, the coefficient for Percent Poverty represents the effect of poverty outside of eastern North Carolina. Thus we see that across all four time points the direct effect of Percent Poverty in Model 2 indicates that outside of eastern North Carolina, where only about 5% of the state's hog population currently exists, higher poverty rates consistently predict smaller swine populations. However, Model 2, which includes the interaction between region and poverty rates, indicates that just the opposite is the case within eastern North Carolina where about 95% of the state's swine waste is currently produced. Within the East, there has been a strong positive relationship between prior household poverty rates and subsequent swine waste concentration as indicated by the results for In-Region Poverty in Model 2. To determine the size of the effect of In-Region Poverty the coefficient for the direct effect of poverty is subtracted from the coefficient for the interaction term. Thus, in eastern counties, the effect of poverty rates on the intensity of swine waste externalities is 1.34 (1.69 - .35), 1.07, .77, and .42 in 1982, 1987, 1992 and 1997 respectively. Thus, swine waste is more concentrated in the poorer counties of the state's poorest region, while outside of the East higher rates of poverty consistently predict smaller swine populations. When examining Model 2 across all four time periods, the in-region poverty effect remains significant, but diminishes steadily in strength as judged by the standardized Beta coefficients. Moreover, when

the three control variables are stepped in (Model 3), the strength of In-Region Poverty effect is also reduced. In 1997 following the period of greatest swine population growth and concentration, In-Region Poverty becomes nonsignificant ($p = .06$, one-tailed) after adding in the additional controls, despite the fact that none of those controls are significant.

Longitudinal Analysis

In Table 4 we present a longitudinal analysis of patterns of intensification in the spatial distribution of swine waste over the period of industry restructuring and globalization. In 1982 traditional patterns of pork production prevailed in North Carolina, but by 1997 total production had increased more than five-fold, the number of hog farmers had declined precipitously, and CAFO-style operations had become the norm with typical herd sizes in excess of 2,000 head. Moreover, all industry growth had occurred in the eastern region where a single vertically integrated, multi-national corporation controls virtually all pork production and processing statewide, reaping substantial profits. To the extent that industry critics are correct in arguing that current profitability is largely "pollution-based," resting on shifting the costs of swine waste externalities to the rural residents of North Carolina, this longitudinal analysis specifies which constituencies have borne an increasing share of these costs.

Model 1 includes key environmental justice variables and the interaction to specify regionally specific effects of poverty on the intensification of swine waste externalities. The results here are broadly compatible with the cross-sectional results presented in Table 3. Counties that began this period of industry restructuring with higher proportions of nonwhite residents experienced swine waste growth (.26) between 1982 and 1997. Similarly, counties with greater political capacity are also shouldering a decreased share of swine waste externalities (-.17). The relationship between poverty rates and swine waste intensification vary by region as they did in Table 3. Outside of eastern North Carolina, there is an inverse relationship (-.37), while within the east where over 95% of the state's swine waste is currently produced, the relationship is positive indicating that poorer counties in the eastern re-

Table 4:
Multiple Regression (OLS) of Hog Population Change on County Characteristics ^a

County Characteristics ^b	Hog Population Change, 1982 - 1997		
	Model 1	Model 2	Model 3
Percent Population Not White	.26 * (2.17)	-.34 ** (-2.72)	.35 ** (2.91)
Local Political Capacity	-.17 + (-1.78)	-.20 * (-2.09)	-.32 ** (-2.96)
Percent Living in Poverty	-.37 ** (-3.00)	-.56 ** (-3.99)	-.53 ** (-3.78)
Eastern Counties	-.08 (-.24)	-.09 (-.26)	-.14 (-.43)
In Region Poverty (Eastern County * Poverty Rate)	.67 + (1.67)	.68 + (1.72)	.70 + (1.81)
Percent Urban	---	-.18 + (-1.68)	-.23 * (-2.08)
Median Property Values	---	-.03 (-.26)	.09 (.69)
Labor Force Attributes	---	.11 (.90)	.12 (.98)
Change in Local Political Capacity (1980 - 1992)	---	---	-.21 * (-2.20)
Adjusted R Square	.44	.47	.50
F Score	15.95	11.75	11.44
Degrees of Freedom	95	92	91

+ $p \leq .05$ (one-tailed), * $p \leq .05$, ** $p \leq .01$.

^a Coefficients are standardized Betas. Raw T scores in parentheses.

^b 1980 county characteristics are used in the analyses of 1987 hog population, and 1990 characteristics are used for 1992 and 1997.

gion have shouldered increasing amounts of swine waste compared to the region's more prosperous counties.

In Model 2, we step in controls for urbanization, property values, and labor market attributes. This block of controls significantly improves the fit of the model to the data and increases the adjusted R square to .47. As expected in a rapidly growing and urbanizing state, counties that were already more urbanized in 1982 experienced declining swine waste concentrations over the subsequent period. However, adding the controls does not alter the pattern of results for the variables previously included in Model 1. In Model 3 we add an additional variable that measures the change in local political capacity between 1980 and 1992. The results indicate that increasing political capacity over the period is associated with decreasing swine waste concentrations (-.21). Model 3 improves significantly upon Model 2 and fits the data acceptably well with an adjusted R square of .50. Based on Model 3, our results offer clear support for the expectations of an environmental justice analytic framework. Counties with larger nonwhite populations saw their share of the state's swine waste increase over this period of industry restructuring. Poorer counties in the East experienced increased concentrations of swine waste, while swine waste levels in poorer counties outside the region saw swine waste levels decrease. Finally, this analysis points to the importance of local political capacity in explaining patterns of swine waste intensification. Counties that began the period of restructuring with less political capacity experienced swine waste intensification. Moreover, counties whose political capacity declined between 1980 and 1992 also experienced an intensification of swine waste externalities during the period of industry expansion and consolidation examined here.

Discussion

Institutional Discrimination

The results of this analysis offer clear evidence of discriminatory impacts by race and class such that counties with larger minority populations, regardless of income, have larger concentrations of hog waste despite controlling for regional differences, urbanization, property values, and labor force attributes. Counties

with more nonwhite residents had larger hog populations at each of the four time points examined here (Model 1). However the effect of race is related to the effects of poverty, as race becomes nonsignificant in 1987 and 1992 when the regionally specific measure of poverty is included in the model. However, by 1997, following the period of greatest hog industry growth and concentration, counties with more nonwhite residents were absorbing greater swine waste externalities despite the regionally specific poverty effect. Moreover, results from the longitudinal analysis (Table 4) clearly indicate that between 1982 and 1997, minority communities experienced greater hog population growth than did other counties.

Combining this pattern of swine population intensification in minority areas with the results of prior research linking county-level hog industry growth to increased rates of farm loss and black poverty, offers further evidence that African American communities have shouldered a greater share of environmental and economic costs imposed by the restructuring of pork production (Edwards and Ladd 2000). Consistent anecdotal reports from African American farmers across the region indicate that there are very few, if any, blacks among the growing ranks of contract pork producers (Wing et al. 1996; Heath 1998; Land Loss Fund, n.d.), and suggests that not only are minority communities suffering greater environmental risks from corporate swine production, but that within those counties, minority households are also not sharing in the localized economic benefits.

While demonstrating racist intent in such outcomes is a crucial issue in models of "pure discrimination" and in civil litigation under current interpretations of civil rights law, the presence of environmental injustice, as we have argued, need not depend on the demonstration of intentional discrimination. Rather, the continuing effects of historic discrimination and the stratification of adverse impacts, regardless of intent, are core environmental justice issues, whether or not they lend themselves to litigation in the current political climate. In other words, the methodological individualism inherent in "judicial" approaches emphasizing racist intent deflects analytical attention away from structural socio-economic stratification processes. Following Downey (1998) and

Stretsky and Hogan (1998), we take an institutional view of discrimination. From that perspective, this analysis provides strong evidence of discriminatory outcomes by race, and shows that those impacts intensified during the period of most rapid industry growth and concentration between 1992 and 1997.

Poverty and Region

The interpretation of poverty is complicated by regionally specific patterns of uneven development. Over the period examined here, low-income counties outside of eastern North Carolina have seen their hog populations decrease, while the opposite is true in the East. The negative relationship between poverty and hog populations outside of eastern North Carolina is attributable to two broad phenomena. First, poverty rates in the mountains are higher than in the Piedmont, but the mountains have no history of significant commercial hog production and are geographically unsuitable because of topography and distance to slaughtering facilities and supply sources which are now all in eastern North Carolina. Secondly, in the Piedmont highly urbanized counties, which are less suitable for hog production, also have higher rates of poverty than rural or suburban areas. Generally, we found no effect of poverty statewide and failing to take account of regional variations would have missed an important dynamic in understanding patterns of environmental inequality in this case. Our results make clear that the relationship between poverty and swine waste concentration is regionally mediated.

At all four points in the cross-sectional analysis (Table 3) and increasingly over the 15-year period (Table 4), the poorest counties in the state's most economically distressed, underdeveloped and most politically marginalized region have shouldered larger concentrations of swine waste. Some recent commentators have argued that, if empirical environmental justice research included adequate controls for regional variations in economic development, urbanization, and other market factors thought to predict the spatial distribution of polluting industries, that the relationship between environmental justice variables and the intensification of environmental externalities would be mitigated if not eliminated altogether (Been 1994). Our findings here offer no support for that argu-

ment. In fact, our findings beg questions about how regionally specific paths of production became established in the first place. Better understandings of the causal mechanisms shaping the distribution of environmental hazards need to integrate qualitative historical analyses with the kinds of statistical analysis presented here. The structural origins of environmental injustice direct analytic attention toward the intersection of political-economy, historic and institutional discrimination, the uneven distribution of risks and rewards associated with contemporary patterns of economic development. Similarly, the conflicts surrounding persistent environmental injustices raise enduring questions about differential access to power by class, race and gender, as well as the often contradictory role of the state as different levels of government and agencies respond to different constituencies and work simultaneously to both facilitate environmental injustice and mitigate its consequences.

Mobilization Matters

Our findings also highlight the importance of political capacity in two ways and suggest that it be more consistently integrated into environmental justice research. First, a careful examination of the historical political economy of North Carolina would likely offer compelling evidence to explain the regionally specific patterns of environmental inequality presented here. Specifically such analyses could explain why eastern North Carolina came to be politically marginalized and how its powerlessness relative to the Piedmont region has led to contemporary patterns of underdevelopment and economic stress which erode its current political capacity.

Second, along with regional disparities, our results direct more analytic attention to localized mobilization capacity. Local political capacity is a strong negative predictor of hog population size across all four periods of our cross-sectional analysis, as well as a strong predictor of hog population decrease in the longitudinal analysis. The importance of local mobilization capacity on this issue is exemplified by the cases of Halifax and Edgecombe Counties. In the early 1990s, during a time when the state had made large hog operations exempt from local zoning authority, Halifax County made itself a path of more

resistance by passing county health ordinances to protect residents from industry externalities and effectively curtail hog population growth in the county. In 1995, a coalition of local officials, concerned citizens, and grassroots environmental organizations emerged in Edgecombe County to effectively block Iowa Beef Packers, Inc.'s plan to construct a large swine processing facility capable of slaughtering about 22,000 head per day. This facility would have increased the state's pork slaughtering capacity by more than half and led to a commensurate increase in the total hog population. It would also have led to an intensified hog concentration in that part of the coastal plain. Both of these local efforts were accomplished in large part by coalitions of local officials, strong grassroots advocacy organizations, and concerned citizens. Few other counties in the region had such political resources in place prior to the influx of CAFO-style hog operations.

Conclusion

The research presented here has examined the socio-economic and political attributes of communities within one of the world's leading pork production zones and their association with patterns of swine waste concentration over a 15-year period of pork industry expansion and restructuring. We find evidence that during this period of industry restructuring and consolidation, the adverse impacts of swine waste have followed a path of less political resistance with industry locating in minority and low-income communities of North Carolina's poorest and most politically marginalized region. Currently, one multi-national firm controls pork production and processing throughout North Carolina and is reaping enormous profits, which critics argue is possible in part because the industry has been able to shift the social and environmental costs of swine waste disposal onto the rural population. The research presented here provides strong evidence that politically marginalized, poor, and minority citizens are shouldering the bulk of these costs, even as industry profits are displaced to corporate shareholders or used to capitalize the acquisition of domestic and foreign competitors. For social scientists interested in the growing linkages between industrial restructuring, regional political

economy, and environmental injustice, the escalating conflicts surrounding "assembly-line swine" offer an instructive exemplar for further research.

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End Notes

¹ County-level environmental justice analyses have been criticized for aggregation problems inherent in the large areas covered by counties (especially in the West) and the statistical assumption that environmental risks are evenly distributed across the county. The major limitation of county-level analysis is aggregation bias or its inability to statistically account for varying levels of exposure within each county such as residential proximity to a CAFO, downwind/downstream location, or the extent to which residences along county borders may experience increased or decreased levels of exposure from neighboring counties. In the case of North Carolina, this is less a problem because on average North Carolina's 100 counties (487 sq. mi.) are less than half the size of those in the other 49 states (1,145 sq. mi.) (Statistical Abstract of the United States, 1998). Overcoming this limitation would require, at a minimum, data on the precise location and size of each CAFO over the entire period covered by this analysis, as well as geographical data on downstream dispersions related to wind patterns and to-

pography. Such data are not available. Data on the post-moratorium location of swine CAFOs have only recently been collected by state regulators. For a cross-sectional analysis of the demographic composition of census blocks that use GIS data on post-moratorium CAFO locations that come to largely compatible conclusions as the analysis presented here, see Wing et al. 2000.

² The total number of swine in the state during an entire year would, of course, be substantially higher because, roughly speaking it takes six months to raise a hog from “farrow” to “finish,” or more colloquially, from birth to bacon. We use the more common and conservative “daily average” herd size which estimates the number of hogs currently alive on any given day rather than the total number of hogs that pass through a county annually. An alternative measure would be the “steady state live weight” (SSLW) for each county. The state Department of Water Quality calculates this by considering the number of hogs at differing stages of development—farrow/birth to wean, wean to feeder, feeder to finish, boars and gilts, and breeding sows—in each county and the average weight of each type of hog. While SSLW might be a more appropriate measure of hog industry externalities in analyses of smaller spatial units, we chose the number of hogs because it is a more intuitive conceptualization that does not differ substantially from SSLW at the county level.

³ Two counties, Duplin and Sampson, are outliers in terms of hog population. Their proportions of nonwhite and poor residents also are approximately 1.5 times the state average.

⁴ This measure was calculated by subtracting the percent white from 100, thus it includes Native Americans who comprise the single largest proportion of residents in Robeson County, NC’s sixth largest swine producer in 1997. It also includes the North Carolina’s rapidly growing Latino/a population which was still quite small in 1990, much less 1980.

⁵ Our 1980 measure of local political capacity is the mean of each county’s Z score for percent registered to vote in 1980 and the percent with college degree in 1980. The 1990 measure uses percent regis-

tered to vote in 1992 and percent college educated in 1990.

⁶ Table 1 presented mean scores for unemployment and annual wages. The measures used in the regressions were derived from the mean of the Z scores for annual wages and employment rates so that a lower score corresponds with a more favorable business climate in terms of lower wages and higher unemployment.

⁷ For the results presented in Tables 2 and 3, the variables used to predict the 1982 and 1987 hog populations were measured in 1980, while 1990 measures were used to predict the hog population in 1992 and 1997. In analyses, not presented here, we used 1980 measures to predict the 1992 and 1997 hog populations and found a pattern of results comparable, substantively and statistically, to those in Tables 2 and 3

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