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Watershed development restrictions and land prices: Empirical evidence from southern Appalachia☆

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ABSTRACT

The State of North Carolina's Water Supply Watershed Protection Act of 1989 required local governments to adopt land use measures in watersheds to protect the water supply emanating from the watersheds. We examine vacant land prices in the Ivy River watershed of Buncombe County, NC, at the time such regulation took effect. Our results suggest that costs of watershed development restrictions are borne primarily by those vacant land owners in the watershed for whom the development restrictions make land subdivision infeasible. We find benefits accruing to land owners on the public water supply or who are adjacent to creeks.

1. Introduction

The goal of watershed regulation is to protect and preserve freshwater ecosystems. While freshwater rivers and lakes are only 0.01% of the earth's available water, they are a key component to human, plant, and animal survival (McAllister et al., 1997). Recent studies have found declines in freshwater biodiversity and overall freshwater ecosystem health (Loh, 2000; Hascic and Wu, 2006). A prominent socioeconomic cause of this degradation is land-use change (Dale et al., 2000). Land use practices that influence watershed health include agriculture, forestry, mining, industrialization, recreation, and urbanization.

While agriculture has historically been viewed as the land use practice most likely to impact water quality (Harding et al., 1998; Palmquist et al., 1997), recent trends suggest that in some parts of the southeastern United States urban development is now the greatest threat to freshwater ecosystems (Gragson and Bolstad 2006). In southern Appalachia there was dramatic agricultural intensification during the first half of the twentieth century, as well as expansion of coal mining and textile manufacturing. However, by the end of World War II the economic transformations brought on by industrial expansion made it difficult to achieve economic self-sufficiency through household farming. The result was a large scale migration out of area (Markusen, 1997; Gragson and Bolstad, 2006:180-181). This emigration began the transformation of southern Appalachia's economy during which agriculture has consistently declined in importance and the service sector, especially tourism and residential development, has become more important (Gragson and Bolstad, 2006:180).

In North Carolina pressures accompanying development have been substantial; total cultivated land area in the state declined by 32% between 1945 and 2002 (Lubowski et al., 2006). Further, the population is expected to increase by 50% over the next quarter century, affecting up to 8 million acres of natural land (Holman et al., 2007).

While the specific effects of urban development in southern Appalachia are not fully understood (Jones et al., 1999:1463), its general effects are well documented. Urbanization affects water quality and watershed health in three primary areas: alteration of the hydrologic cycle, manipulation of the physical habitat, and contamination of the water chemistry (Silk and Ciruna, 2005). For example, urbanization influences the hydrological cycle by increasing impervious surface coverage such as roads, driveways and rooftops. These impervious surfaces reduce water infiltration into the soil, increase surface flow, and alter flood patterns, causing potential damage to private property and endangering the local population. Urbanization can alter water chemistry by increasing the prevalence of freshwater contaminants from landscaping, construction activity, and roads. A number of studies document

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the effects of urbanization on various facets of freshwater ecosystem health (Alloway, 1995; Czech et al., 2000; Ehrlich and Ehrlich, 1981; Ferguson, 1982; Frissell, 1993; Harding et al., 1998; Hascic and Wu, 2006; McKinney, 2002; Malmqvist and Rundle, 2002; Richter et al., 1997; Rivard et al., 2000; Rottenborn 1999, Schindler 1977; Schnoor, 1996).

The regulation of land use in a watershed may be warranted because of the potential negative externalities that arise from private development decisions, and because the costs of private contracting between interested parties are considerable. If development in a watershed increases density sufficiently, the health of the water supply can be adversely affected, which imposes a negative externality on those outside the watershed who rely on the watershed for drinking water and other uses, such as recreation, waste removal, electricity, and flood control. In the absence of regulation, development in the watershed is predicted to exceed the optimal level because the full social cost of each development project is not borne by the private developer or land owner.

Are the costs and benefits of watershed regulation capitalized into property values? If residents benefit from clean water, and if the costs of adopting protection measures are less than the benefits, we would expect watershed regulations to correlate with higher land prices overall. On the other hand, land prices may be adversely affected by a restriction on the density of development, and hence the ability to subdivide. If the ability to subdivide vacant land is curtailed, then owners of vacant land in protected watersheds would bear the direct cost of the regulation, while those downstream of the protected area would receive benefits without paying direct costs.[1] Because any indirect costs incurred to develop, administer, and enforce development restrictions in the watershed are borne by all land owners, we expect the net effect of watershed regulation to vary according to where land is located. We also might expect, as has been found in the literature, a supply effect and/or open space amenity accruing to properties in the watershed.

While there are many studies that focus on the effects of local land use regulations, such as the impact of zoning on property values (see Zhou et al., 2008; McMillen and McDonald, 1993; Netusil, 2005), there are substantially fewer studies that focus on state and national land use initiatives that restrict development density or use to bring about environmental protection. Frech and Lafferty (1984) use a linear hedonic price equation to examine the effect of the California Coastal Commission on housing prices in four coastal cities in California. The Commission, created with the passage of the 1972 Coastal Initiative, holds veto power over all development within 1,000 yards of the coastline. They find increased housing prices both within and beyond 1000 yards from the coastline.

Parsons (1992) examines coastal land use restrictions while examining the impact of the State of Maryland's Critical Area Commission on housing prices in Chesapeake Bay County. Development in "Critical Areas," defined by the Commission as land within 1000 ft of the Bay, is restricted in terms of density and use, with restrictions varying in severity depending on the particular designation. Parsons finds housing prices increase both within and outside of the Critical Area after the imposition of the regulations, with designated parcels experiencing the greatest percentage increase.

Beaton (1991) examines the effect of land use controls resulting from New Jersey's 1979 Pineland's Protection Act on property values in the New Jersey Pinelands. Within the Pinelands a comprehensive growth management plan established districts with various degrees of use and density restrictions. Both leading up to and following the enforcement of the restrictions, developed residential property values in the restricted areas increased by more than those in an outlying control group.

Holway and Burby (1990) examine the effect of the National Flood Insurance Program (NFIP) floodplain designation. They find that both elevation requirements and prohibitions on development reduced the value of floodplain land in NFIP participating communities.[2]. Dehring (2006) also looks at the effect of participation in the NFIP, as well the establishment of a Coastal Building Zone, and the reestablishment of a Coastal Construction Control Line on vacant land prices on Florida's barrier islands. She finds that land values decrease in response to all three regulatory changes, suggesting that benefits of safety from increased building standards are outweighed by the additional costs of compliance brought about by the code changes.

Finally, Spalatro and Provencher (2001) examine the effect of minimum frontage zoning on vacant lakefront property values in Northern Wisconsin. Statewide zoning restricts the minimum frontage of lakefront lots to 100 ft, while more strict measures have been adopted by several towns. The authors test whether minimum frontage zoning has an impact on land prices, and find the restriction on lot subdivision had no adverse effect on land values. On the other hand, they do find a positive amenity effect associated with the future assembly of other parcels (less overall development).

This is the first paper to empirically measure the effect of developmental density restrictions associated with water supply protection on land prices. We examine the effect of the State of North Carolina's Water Supply Watershed Protection Act (WSWPA) regulation on vacant land prices in Buncombe County, NC. Development restrictions mandating minimum lot sizes of two acres in the Ivy River watershed were imposed in 1998, after an unsuccessful challenge to the constitutionality of the Act, and a short-lived effort to exempt Buncombe County's Ivy River watershed from the Act.

The model developed here tests whether the restrictions on land subdivision decrease vacant land prices within the watershed on those properties for which the option to subdivide is taken away. We also test whether benefits of improved water quality accrue to landowners on public water supply systems that are fed by surface water or to those landowners living adjacent to creeks. Following Irwin (2002), McConnell and Walls (2005) and Walsh (2007), we test whether properties in the watershed experience an open space amenity effect from the subdivision restriction. Also, following Fischel (2001) and Glaeser and Gyorko (2002) we test for the aggregate effect of supply restrictions. Different models are estimated, including a matching model that uses only sales from within or directly near the watershed. The results of the empirical analysis suggest that the costs of watershed development restrictions are borne primarily by owners of undeveloped land in the watershed most impacted by the development restrictions. The results also suggest there are benefits from improved water quality that accrue to those landowners bordering creeks and utilizing surface water-fed public water supplies.

2. Watershed protection in North Carolina: background

In the 1970s, watershed regulation in the State of North Carolina was under the authority of the Environmental Management Commission (EMC), which operates through the Division of Natural Resources and Community Development (DEM).[3] The EMC was created with the passage of the Clean Water Management Act of 1972 by the United States Congress. Formally, the EMC had responsibility to "promulgate rules to be followed in the protection, preservation, and enhancement of the water and air recourses of the State."

[1] A watershed is defined as "the land area that drains water to a particular stream, river, or lake." It can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge. Watersheds are referred to as "drainage basins." Watersheds are also nested at multiple spatial scales. "Large watersheds, like the Mississippi River basin, contain thousands of smaller watersheds" (USGS, 2007). In Buncombe County, the watershed drained by Ivy River was protected so to provide clean water for the larger number of people within the larger French Broad River drainage basin, of which the Ivy River watershed is only one part.

[2] We note that Shilling et al. (1991) find no effect of environmental protection-related land use controls (coastal zones, wetlands management, and designation of critical areas and wilderness) in housing prices.

[3] The DEM is within the Department of Environment, Health, and Natural Resources.

The classification of public water supplies was one of the EMC's responsibilities. Prior to 1985, a dual classification system classified drinking water sources in the State of North Carolina as either isolated pristine and not requiring filtration, or not. In 1984, the EMC set out to develop a new system which would distinguish between headwater supplies and "run of the river" supplies, the latter of which is generally more susceptible to pollution. In 1985, the EMC proposed a three-category system, which the DEM incorporated into a voluntary water supply protection program in 1986.

In 1987, the North Carolina General Assembly introduced legislation to impose minimum watershed protection measures throughout the state. This was not supported by most local governments. A panel was commissioned to determine whether the state's involvement in imposing minimum standards was required to achieve adequate water protection or whether the protection of water supplies could be left to local governments. In 1989, after concluding that state-imposed minimum standards were, in fact, needed, the Legislative Study Committee on Watershed Protection drafted a watershed protection bill.

The Water Supply Watershed Protection Act of 1989 required local governments to adopt protection measures in watersheds at least as restrictive as the state's minimum standards.[4] Implementation and enforcement of the WSWPA was given to the EMC. Further, new revised water supply classifications, standards, and management requirements were to be adopted by the EMC by January 1, 1991. Public hearings were held in August 1990 regarding the EMC's proposed regulations, and protective regulations were adopted in December of that year. However, in the face of widespread complaints that the new rules were too restrictive, the EMC resubmitted the regulations to the public comment process, and revised regulations were adopted in February 1992. In May of 1992 the EMC reclassified all watersheds in the State of North Carolina. Local governments with land use planning jurisdiction were required to adopt and enforce local water supply water protection plans and ordinances by January 1, 1994 for potential water supplies, regardless of when they may be used.

The new watershed regulations feature a five-tier water supply classification system, where a higher classification carries stricter development rules in general. The highest classification, WS-I, applies to waters within essentially natural and undeveloped watersheds. These watersheds are on publicly owned land and have no permitted point source (wastewater) discharges. The WS-II classification is used where a WS-I classification is not feasible, and applies to predominantly undeveloped watersheds. The WS-III classification applies to low to moderately developed watersheds, while the WS-IV classification applies to land in moderately to highly developed watersheds. The WS-II, WS-III, and WS-IV classifications vary by whether the land is located within a critical area, defined as within one half mile of the water source, and hence subject to greater risk of pollution. Finally, the WS-V classification has no categorical restrictions on watershed development, and local governments are not required to adopt watershed protection ordinances.

Local governments can use either a free-standing watershed ordinance to enforce the regulations, or can do so through the adoption of a zoning ordinance. Residential, commercial and industrial uses can be regulated through density limits, limits on built-upon area, stream buffers, development clustering, and structural storm water control devices.[5] Table 1 reports the density and built-upon area limit for the WS-I, WS-II, and WS-III classifications.

[4] The WSWPA was the last of three measures passed by North Carolina in the 1970s and 1980s aimed at protecting its natural resources through land use regulation. The first, the Coastal Area Management Act (1974) regulated land use in the State's coastal area. The Mountain Ridge Protection Act of 1983 created land use regulations designed to protect the aesthetic provided by the State's mountains vistas.

[5] The "built-upon" area measures the amount of impervious surface area on a site.

2.1. Challenges to the Water Supply Watershed Protection Act

In the mid-1990s, the reach of the WSWPA, as it applied to the Ivy River watershed, was challenged directly and indirectly. First, the Ivy River watershed was specifically exempted from the WSWPA. North Carolina State Senator Herbert Hyde, from the 28th district (which includes Buncombe County, of which Asheville, North Carolina, is the county seat), proposed an amendment to House Bill 686. Known as the Hyde Bill, the amendment laid out numerous criteria which, if all met, would exempt a water supply watershed from the WSWPA:

> Notwithstanding any other law, the provisions of G.S. 143-214.5 shall not apply to any water supply watershed area classified as WS II by the Environmental Management Commission prior to July 1, 1993 and formerly classified as Class C, comprising 70,000 acres or more but less than 75,000 acres in watershed and protected area lying in two or more counties, one of which has land use jurisdiction therein, and part of which lies in the land use regulation jurisdiction of a city or town, having a point of elevation of at least 1,650 feet above sea level and was not being used as a water supply for any municipality on July 1, 1993, said area also lying adjacent to a third county which lies within the same two-member State Senate district as do all or parts of the other two counties.

Bordeaux (1994) notes that only Buncombe County's Ivy River watershed met the Hyde Bill's criteria for WSWPA exemption. The Hyde Bill, which was enacted in July 1993, safeguarded any such exemption until the EMC reclassified the area and removed any designated critical area, and until the General Assembly enacted certain legislation.

A second way in which the reach of the WSWPA was challenged was through the courts. In the fall of 1996, in Town of Spruce Pine v. Avery County, N.C, the North Carolina Court of Appeals ruled that the WSWPA was an unconstitutional delegation of legislative power to the Environmental Management Commission (EMC) without adequate guiding standards. The case went to the North Carolina Supreme Court, which overturned the decision in July 1997, thus upholding the constitutionality of the Water Supply Watershed Protection Act. The court also ruled that the Hyde Bill's statutory exemption of the Ivy River watershed, which may have been unconstitutional, could be severed from the act, and the rest of the act remained constitutional.

On October 24, 1997, Buncombe County received a letter from the DEHNR which read, in part, "In light of the recent NC Supreme Court decision...the division of water quality is notifying all local governments with land use jurisdiction in the Ivy River WS-II watershed of the requirement to adopt and implement water supply watershed protection ordinances in accordance with the statewide rules governing drinking water supply watersheds." Buncombe County drafted a new ordinance, consistent with the state-wide legislation, and this ordinance became effective on July 7, 1998.[6,7]

[6] According to Susan Massengale at the North Carolina Division of Water Quality, there is nothing in the DWQ records that indicates any discussion or correspondence between the July 1997 court decision and the October 1997 receipt of the letter (Massengale, 2008). Thus, we have no reason to believe that Buncombe county officials or individual property owners were privy to the decision before it was effective.

[7] Buncombe County has planning jurisdiction over several water supply sources, including five undeveloped watersheds that became Class I water supply watersheds: the Lower French Broad River, in the south part of the county, and the Ivy River watershed in the Northwest part of the county. In the early 1990s, landowners would have any of these water sources to be included with others under the rules of the WSWPA, and affected land owners would have had notification at the time of the reclassification. On November 16, 1993, after legislators agreed to exempt part of the Ivy River watershed from the regulations, Buncombe County adopted watershed regulations relating to the French Broad WS-IV area. On February 8, 1996, the EMC approved the declassification of the French Broad watershed from WS-IV to a non-water supply classification. The reclassification became effective on April 1, 1996.

Table 1
Selected North Carolina water supply classifications

Classification	Restrictions
Water Supply I (WS-I)	Allowed uses –Agriculture –Silviculture –Water withdrawal, treatment and distribution facilities –Restricted road access –Power transmission lines
Water Supply II (WS-II)	Critical Area (WS-II-CA) SFR land use intensity maximum of one dwelling unit per two acres All other residential and non-residential development shall be allowed at a maximum six percent (6%) built-upon area Balance of Watershed (WS-II-BW) SFR land use intensity maximum of one dwelling unit per acre (1 du/ac) All other residential and non residential development shall be allowed a maximum of twelve percent built-upon area New development may occupy ten percent (10%) of the watershed area which is outside the critical area, with seventy percent (70%) built-upon area when approved as a special intensity allocation (SIA)
Water Supply III (WS-III)	Critical Area (WS-III-CA) SFR land use intensity maximum of one (1) dwelling unit per acre (1 du/ac) All other residential and non-residential development shall be allowed at a maximum of twelve percent (12%) built-upon area Balance of Watershed (WS-III-BW) SFR land use intensity maximum of two (2) dwelling units per acre (2 du/ac) All other residential and non-residential development shall be allowed at a maximum of twenty-four percent (24%) built-upon area New development and expansions to existing development may occupy ten percent (10%) of the balance of the watershed area with up to seventy percent (70%) built-upon area when approved as a special intensity allocation (SIA)

NC Division of Water Quality.

Properties in Buncombe County receive their water supplies from one of three types of sources. The majority of properties receive their water from the City of Asheville's public water system, which is in turn fed by a variety of surface water sources, including government owned Class I water supply watersheds, public reservoirs, and the French Broad River. A smaller number of properties are supplied by individually held subsurface wells and privately owned and maintained surface reservoirs. The smallest group consists of properties supplied by the public water system maintained by the town of Weaverville. Much of the water for this system comes from the Ivy River Class II water supply watershed that was created by the 1998 regulation. In both Asheville and Weaverville, a substantial number of properties are fed by public water systems even while the properties lie outside the zoning regulation jurisdiction of their associated municipalities. Because of variability in zoning regulations, we focus our analysis on unincorporated areas of Buncombe County, North Carolina.

3. Empirical analysis

The development and amenity effects of watershed development restrictions are modeled similar to Spalatro and Provencher (2001). To test for differences in vacant land prices between the pre-watershed ordinance and post-watershed ordinance periods, a hedonic model is developed which allows for the effect of development restrictions to vary by lot size, by whether the property is in the watershed, and by whether the watershed ordinance has been enacted. The entire Ivy River watershed is designated a WS-II Critical Area, and hence subject to a minimum two-acre lot size requirement. The empirical specification accommodates a potentially positive water quality effect, open space effect, and supply effect caused by the protection of the watershed, and also a potentially negative development-restriction effect for affected properties within the watershed. Following Colwell and Sirmans (1978), we expect the land value-parcel size function to be increasing and concave, so that land values increase at a decreasing rate in parcel size. If the development effect is negative, this would indicate a reduction in the marginal willingness to pay for land that cannot be subdivided after the development restrictions, or, in the case of properties over four acres, are constrained to the extent they can be subdivided. As the loss in value imposed by the restrictions on subdivision is most severe for properties less than four acres in size, the model accommodates a discontinuity in the land value-parcel size function at four acres for properties in the watershed.[8]

The estimated hedonic price function for the complete model is:

$$\begin{aligned}\ln\mathrm{PRICE} = {} & \beta_0 + \beta_1 \ln\mathrm{ACRES} + \beta_2\mathrm{DISTASHE} + \beta_3\mathrm{ADJBRPKWY} + \beta_4\mathrm{ADJUSFS} \\ & + \beta_5\mathrm{MOBILEHOME} + \beta_6\mathrm{TIME} \\ & + (\delta_1 + \delta_2\mathrm{INSHED} + \delta_3\mathrm{INSHEDPOST})\mathrm{LESSFOUR} \\ & + (\phi_1 + \phi_2\mathrm{POST})\mathrm{INSHED} + \gamma_1\mathrm{POST} + (\gamma_2 + \gamma_3\mathrm{POST})\mathrm{ADJCREEK} \\ & + (\gamma_4 + \gamma_5\mathrm{POST})\mathrm{ASHEWATER} + (\gamma_6 + \gamma_7\mathrm{POST})\mathrm{IVYWATER} + v_i, \end{aligned} \quad (1)$$

where the β's, δ's, ϕ's, and γ's are parameters to be estimated and v_i is a zero-mean stochastic error term.

The dependent variable, PRICE, is the sale price of a vacant land parcel measured in 2000 dollars.[9] The variable ACRES is the size of the lot in acres; we expect the area elasticity of price, β_1, to be between 0 and 1, indicating that land values increase at a decreasing rate with lot size. If β_1 takes the value of one, land prices increase proportionally with parcel size; if β_1 is greater than one, the relationship between parcel size and land prices is convex. A number of studies have shown land values are concave in parcel size (see Colwell and Munneke (1997) for example). The variable DISTASHE is the Euclidean distance from the center of the property to the boundary of the City of Asheville in meters; we expect β_2 to be negative, such that land values fall at a decreasing rate with increased distance from Asheville.

The model controls for various features thought to contribute to land values in the Asheville area. The variables ADJBRPKWY and ADJUSFS indicate whether the parcel is adjacent to the Blue Ridge Parkway or US Forest Service land, respectively.[10] If access to the Blue

[8] The restriction of a two-acre minimum lot size implies that a parcel less than four acres can not be subdivided. Thus, the impact of the restrictions is presumed to be greater on these parcels than for those greater than four acres. We note that existing properties less than two acres in size could still be developed.

[9] Nominal sale prices are adjusted by the GDP Deflator reported by the Bureau of Economic Analysis.

[10] The Blue Ridge Parkway is a scenic motorway which runs along wider ridge tops in the Blue Ridge Mountains and is maintained by the Natural Park Service (NPS). The parkway is 469.9 miles long and connects the Great Smoky Mountains National Park, in Tennessee and North Carolina, with the Shenandoah National Park, near Washington D.C. (NPS, 1997). On either side of the parkway, the NPS maintains scenic lands, historic properties, and recreational areas in buffers that vary in width from about one-tenth of a mile to well over two miles.

Ridge Parkway is beneficial, then we expect β_3 to be positive. Following Thornses (2002), we expect higher prices associated with adjacency to US Forest Service land due to an open space amenity. The variable MOBILEHOME indicates the lot has been classified by the County Assessor's office as accommodating mobile home use. Following Munneke and Slawson (1999), we expect β_5 to be negative, i.e., property values are lower when associated with potential mobile home use. We also include a daily time index (TIME) which captures overall land appreciation over the sample period; we therefore expect β_6 to be positive.

The δ coefficients in the price function test the development effect. The variable LESSFOUR is an indicator variable which takes a value of one for any lot that is less than four acres in size. If parcels under four acres sell for less than larger parcels with otherwise similar characteristics, we expect $\delta_1 < 0$. To control for whether smaller properties in the watershed have a different price than similar properties in other areas of Buncombe County, this variable is interacted with INSHED, which takes the value of one if the parcel is located within the Ivy River Watershed. The coefficient δ_2 therefore reveals any additional percentage change in price for properties that are less than four acres and in the watershed. If there was anticipation of the regulation before the county received the DEHNR letter, we might expect $\delta_2 > 0$; although if the announcement was unexpected, δ_2 is expected to be insignificant. To test the development effect of the watershed ordinance, we create an indicator variable POST. The County Ordinance which adopted watershed regulations in the Ivy River Watershed was passed July 7, 1998. Accordingly, POST is assigned the value 1 for any sale on or after July 7, 1998. The coefficient δ_3 thus reveals any additional percentage change in the price of vacant land less than four acres in size and in the Ivy River watershed caused by the watershed ordinance. We expect $\delta_3 < 0$, reflecting the economic loss associated with the more stringent development regulations.

The ϕ coefficients in the price function reveal a supply or amenity effect due to the regulation for properties greater than four acres and in the watershed. The coefficient ϕ_1 is the additional percentage change in price for properties greater than four acres and in the watershed, while ϕ_2 reveals any additional percentage change in price for these properties after the regulation. If the regulation in the Ivy River Watershed was anticipated, or if parcels larger than four acres and in the watershed sell for a premium regardless of watershed regulations, we might expect ϕ_1 to be positive. If, after the regulations, lower density increases value in the watershed, or if a substitution effect causes open space to decline in areas outside the watershed, we would expect $\phi_2 > 0$.

The γ coefficients in the price function test for amenity effects of improved water quality. We again include the dummy variable POST to control for any county-wide benefits that accrue to property holders in any portion of unincorporated Buncombe County after the watershed regulations were enacted. If there are county-wide public benefits to all property holders, we expect γ_7 to be positive. As discussed above, we expect amenity benefits to accrue to those living adjacent to creeks, those who rely on the Asheville water supply for their drinking water, and those who receive their water supply directly from the Ivy River. The three variables used to capture these amenity effects are ADJCREEK, ASHEWATER, and IVYWATER. The variable ADJCREEK indicates whether a property is adjacent to a creek and we expect $\gamma_2 > 0$ if creek access is a positive amenity. However, creek access could indicate greater flood risk. By interacting ADJCREEK with POST, γ_3 reveals any additional effect to properties adjacent to creeks following the establishment of the ordinance. We expect $\gamma_3 > 0$ if creek properties receive reduced flood risk or improved recreational benefits from preservation of water clarity or quality. The variable ASHEWATER indicates whether a property is on the City of Asheville's public water supply system. The coefficient γ_4 reveals whether parcels with a public water source are valued differently than parcels with private surface and subsurface water supplies (wells or private reservoirs). The coefficient γ_5 reveals the percentage change in price for those parcels on the public water supply following the watershed ordinance. A positive amenity effect from preservation of the drinking water supply would be indicated by $\gamma_5 > 0$. The variable IVYWATER indicates those properties on the part of public water supply system

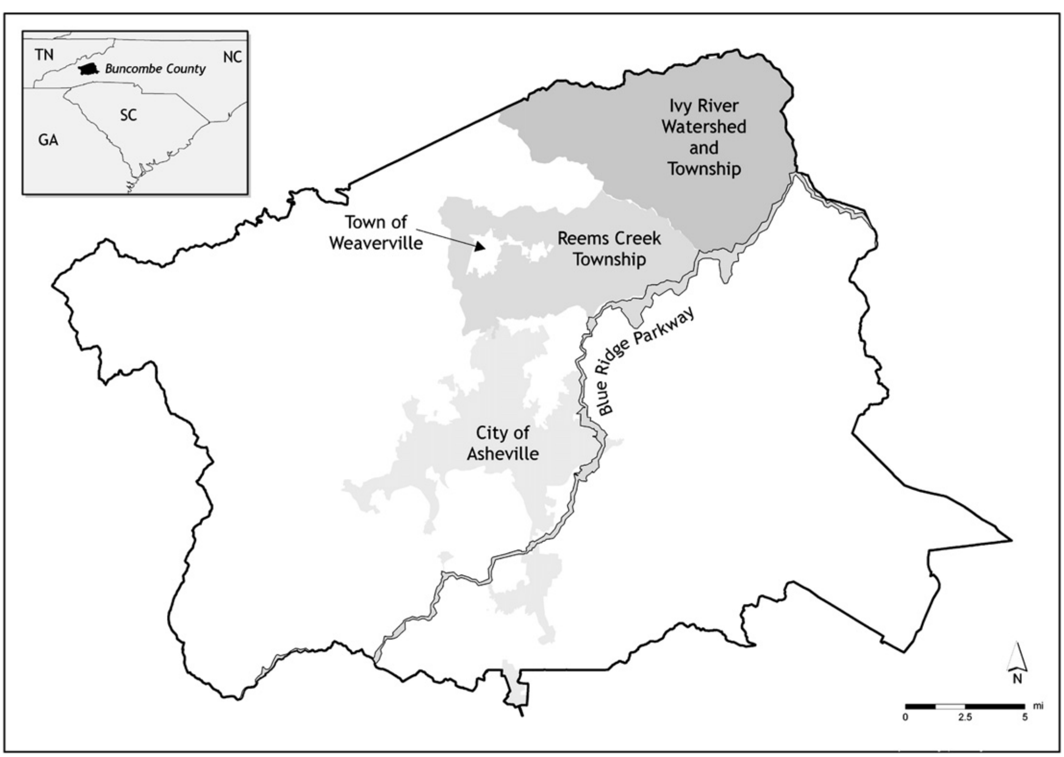

Fig. 1. Ivy River watershed, Buncombe County, NC.

which is directly fed by the Ivy River. The coefficient γ_6 indicates any additional percentage change in price for these properties prior to the regulation, and the coefficient γ_7 indicates any additional percentage change in price for these properties following the regulation.

3.1. Data

In addition to its location within southern Appalachia and the legislative history of its Ivy River watershed, Buncombe County is the focus of this study because of the availability of vacant residential land sales data both pre-and post-ordinance. Parcel information and sales information are from the Buncombe County property appraiser. This information is matched with data generated from (or with) a geographic information system (GIS). The GIS was used to calculate the Euclidean distance from Asheville, whether the parcel is adjacent to a creek, to the Blue Ridge Parkway, or to US Forest Service property, to determine whether the parcel lies within the Ivy River watershed, and to determine whether the parcel obtains water from the Asheville water system or whether the property receives any surface water originating from the Ivy River water basins. A map showing the location of the Ivy River watershed within Buncombe County is presented in Fig. 1. In order to minimize unanticipated price effects related to public service provision parcels lying within any Buncombe County municipal area with zoning enforcement are excluded. The working sample includes 11,304 qualified vacant land sales which occurred between January 1, 1996 and December 31, 2007.

Descriptive statistics for the full sample and for sales from the Ivy River watershed are presented in Table 2, with nominal dollar values adjusted to year 2000 dollars. The average sale price for the full sample is $83,672, and average lot size is 1.84 acres. The average parcel in the sample was 14.29 km, or approximately nine miles, from the Asheville city limits. Sixty properties adjacent to the Blue Ridge Parkway sold during the sample period, and there were 1887 sales of parcels adjacent to a creek. Parcels adjacent to U.S. Forest Service land comprise approximately 1% of the sample, and approximately 12% of sales were of parcels associated with potential mobile home sites. Most sales, around 81%, occurred after the watershed regulations were enacted.

Watershed properties sold for less, on average, than in the full sample. The average sale price in the watershed is $41,260, average lot size in the watershed is 4.29 acres, and average Euclidean distance from Asheville for properties that sold in the watershed is 12.7 miles. As we would expect, a higher percentage of properties in the watershed (23%) are adjacent to a creek. Because the Blue Ridge Parkway does not pass through the watershed, there are no properties in the watershed that are adjacent to this road. Sixteen percent of watershed properties are potential mobile home sites, which is slightly higher than in the broader sample. In total, there are 331 sales of parcels within the watershed during the sample period.

According to the three-part water source classification described at the end of Section 2, 123 sales involved parcels that received surface water benefits from the watershed protection and 5403 parcels are supplied by The City of Asheville's public water system. The remaining 6353 parcels are supplied by private subsurface wells and private reservoirs.

3.2. Empirical results

The regression results for various OLS models are presented in Table 3. Each model reports adjusted standard errors to accommodate unspecified heteroscedasticity (White, 1980). While Eq. (1) presents the complete model, in the empirical analysis, we take a specific-to-general approach by starting with a base model and extending the model by adding different groups of variables. Model (1) includes only the most basic property characteristics and does not control for watershed-specific issues; Model (2) controls for the watershed ordinance but does not differentiate whether the prices of the most impacted properties respond differently; Model (3) and Model (4) include all watershed-relevant variables; Model (5) includes variables that test for whether the watershed policy provided third party benefits; Model (6) presents estimation results using a geographically matched subsample, described in more detail in the next section.

The estimated parameters for property size and distance to Asheville are significant and take the expected signs. The area elasticity of parcel price is consistently in the area of 0.30 in the various specifications, suggesting that prices increase with lot size but at a decreasing rate. Somewhat counter-intuitively, land values increase with distance from Asheville proper whereas properties adjacent to the Blue Ridge Parkway sold for considerably more than properties that did not enjoy such proximity. The results suggest that properties adjacent to U.S. Forestry Service land sold for approximately 22% more than other similar properties, and properties associated with potential mobile homes consistently sold for approximately 18% less. Those properties adjacent to a creek sold for about 5% more, *ceteris paribus.* This premium suggests that the amenity effect of proximity to a creek outweighs the costs of any

Table 2
Descriptive statistics

Variable	Description	Full sample Mean	Full sample St. Dev.	Watershed Mean	Watershed St. Dev.
PRICE	Sale price in 2000 dollars	83,672	148,792	41,260	39,168
ACRES	Lot size in acres	1.84	5.45	4.29	9.01
DISTASHE	Euclidian distance in meters to Asheville City limits	14.29	5.12	20.32	2.09
ADJBRPKWY	Parcel is adjacent to the Blue Ridge Parkway	0.01	0.07	0.00	0.00
ADJCREEK	Parcel is adjacent to a creek				
ADJUSFS	Parcel is adjacent to US Forest Service land	0.01	0.10	0.02	0.12
MOBILEHOME	Parcel is a potential mobile home site	0.12	0.33	0.16	0.36
INSHED	Parcel is within the Ivy River watershed	0.03	0.17	1.00	0.00
POST	Parcel sold after the watershed restrictions enacted	0.81	0.39	0.81	0.40
INSHEDPOST	Parcel is within the Ivy River watershed and sold after the watershed restrictions enacted	0.02	0.15	0.81	0.40
LESSFOUR	Parcel is less than four acres in size	0.91	0.28	0.76	0.43
LESSFOURSHED	Parcel is less than four acres and in Ivy river watershed	0.02	0.15	0.76	0.43
LESSFOURSHEDPOST	Parcel is less than four acres, in watershed, and sold after watershed regulations enacted	0.18	0.13	0.63	0.48
IVYWATER	Parcel receives surface water from the Ivy River watershed	0.01	0.10	0.01	0.11
ASHEWATER	Parcel receives water supply from Asheville water system	0.48	0.49	0.00	0.00
ADJCREEKPOST	Parcel is adjacent to a creek and sold after watershed regulations enacted	0.14	0.34	0.18	0.38
ASHEWATERPOST	Parcel receives water supply from Asheville water system and sold after watershed regulations enacted	0.39	0.48	0.00	0.00
IVYWATERPOST	Parcel receives surface water from the Ivy River watershed and sold after watershed regulations enacted	0.01	0.09	0.01	0.11
		$N=11{,}304$		$N=331$	

Notes: data describe 11,304 unique transactions of vacant land parcels in Buncombe County, North Carolina from January 1996 through December 2007.

Table 3
The impact of watershed development restrictions on residential property values

Variable (coefficient)	(1)	(2)	(3)	(4)	(5)	(6)
ln ACRES (β_1)	0.296***	0.307***	0.304***	0.303***	0.303***	0.343***
	(0.011)	(0.011)	(0.015)	(0.011)	(0.011)	(0.039)
DISTASHE (β_2)	0.003*	0.005***	0.005***	0.005***	0.005***	0.014
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.012)
ADJBRPKWY (β_3)	0.661***	0.612***	0.613***	0.613***	0.610***	
	(0.134)	(0.135)	(0.135)	(0.135)	(0.132)	
ADJUSFS (β_4)	0.204**	0.222**	0.218**	0.219**	0.209**	−0.199
	(0.089)	(0.088)	(0.088)	(0.088)	(0.088)	(0.413)
MOBILEHOME (β_5)	−0.229***	−0.202***	−0.202***	−0.202***	−0.202***	−0.061
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.087)
ADJCREEK (γ_2)	0.049**	0.037*	0.037*	0.037*	−0.045	−0.343**
	(0.022)	(0.021)	(0.021)	(0.021)	(0.051)	(0.170)
ASHEWATER (γ_3)	0.651***	0.648***	0.646***	0.646***	0.530***	1.723***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.043)	(0.163)
IVYWATER (γ_4)	0.483***	0.485***	0.483***	0.482***	0.254	0.153***
	(0.089)	(0.088)	(0.087)	(0.087)	(0.281)	(0.197)
INSHED (ϕ_1)		−0.130	−0.213	−0.126	−0.178	−0.610***
		(0.141)	(0.282)	(0.141)	(0.143)	(0.212)
INSHEDPOST (ϕ_2)		−0.235	0.202	0.113	0.173	−0.321
		(0.146)	(0.291)	(0.160)	(0.161)	(0.0.200)
LESSFOUR (δ_1)			0.006			
			(0.036)			
LESSFOURINSHED (δ_2)			0.137			
			(0.317)			
LESSFOURINSHEDPOST (δ_3)			−0.586*	−0.446***	−0.443***	−0.375***
			(0.328)	(0.089)	(0.089)	(0.108)
POST (γ_1)		−0.284***	−0.286***	−0.286***	−0.370***	−0.398***
		(0.028)	(0.028)	(0.028)	(0.037)	(0.136)
ADJCREEKPOST (γ_3)					0.099*	0.226
					(0.055)	(0.182)
ASHEWATERPOST (γ5)					0.142***	
					(0.046)	
IVYWATERPOST (γ_6)					0.275	0.153
					(0.294)	(0.197)
Constant (β_0)	5.849***	5.018***	5.005***	5.012***	5.093***	6.172***
	(0.118)	(0.127)	(0.135)	(0.128)	(0.129)	(0.369)
R^2	0.30	0.31	0.31	0.31	0.31	0.39

Notes: data describe 11,304 unique transactions of vacant land parcels in Buncombe County, North Carolina from 1996 through 2007. The dependent variable in each specification is the log of real price in 2000 dollars. Explanatory variables are described in Table 1. All models use a Huber–White-Sandwich estimator to accommodate unspecified heteroscedasticity. Model (6) uses a geographically proximate subsample of 1236 properties located in the watershed or in the Reems Township of Buncombe County NC. All specifications include a continuous time trend measuring days. Robust standard errors in parentheses. ***$p<0.01$, **$p<0.05$, *$p<0.1$.

restrictions associated with the use of land immediately adjacent to water and the possible flood hazard of being located next to running water and the accompanying insurance. Properties supplied by the Asheville public water supply or that receive surface water from the Ivy River watershed sold for a considerable premium over other parcels; the former result suggests that there is considerable value placed on access to a municipal water system, even if the municipal water system entails greater taxes.

The values of the parameter estimates for the basic characteristics of the properties are rather stable in Models (1) through Models (4). This suggests that the addition of variables testing for the impact of the watershed policy explains considerable variation in parcel prices not explained by the basic hedonics of the properties.

In Model (2) we add two additional variables: INSHED and POST. The parameter estimate on INSHED is not statistically significant, suggesting that land parcels in the Ivy River watershed were not priced at a discount relative to comparable land before the watershed ordinance came into effect. This also suggests there was no development effect capitalized in the prices of land parcels within the watershed before the regulations went into effect. The coefficient on POST is negative and significant, suggesting a lack of a net positive environmental amenity effect for properties in Buncombe County after the watershed ordinance is established. However, Model (2) may be underspecified because it does not control for the impact of the policy on those properties that were most affected.

Model (3) includes the three additional variables that control specifically for the impact of the policy on those properties less than four acres and in the watershed. We include the LESSFOUR, LESSFOURINSHED, LESSFOURINSHEDPOST to test the impact of the watershed policy on parcels less than four acres. The interpretation of these three variables is relatively straightforward: the parameter on LESSTHANFOURINSHEDPOST reflects the change in parcel prices for parcels less than four acres within the watershed that sold after the policy was enacted. The results show that LESSFOUR and LESSFOUR-INSHED are both insignificant but that LESSFOURINSHEDPOST is negative and statistically significant. Thus, the prices for parcels less than four acres in the watershed and which sold after the policy went into effect were approximately 44% lower than otherwise similar parcels. This effect is depicted in Fig. 2. The analysis reveals a substantial negative impact of the development restrictions embodied in the watershed protection on those watershed properties for which subdivision was made infeasible.

In Model (3) LESSFOUR and LESSFOURINSHED are jointly insignificant (F=0.11, p=0.89); therefore in Model (4) these two variables are dropped. Furthermore, we estimate the model using an iterative weighted least squares approach that mitigates the influence of outliers. The remaining parameter estimates do not change in their values or significance except for that on LESSFOURINSHEDPOST. In that case, the parameter estimate is slightly smaller in absolute value but is considerably more precise. The parameter estimate of −0.466 implies a reduction in price for impacted parcels within the watershed of approximately 35%, which compares favorably with the discount implied in Model (3); however, the standard error of the parameter estimate in Model (4) is approximately 72% smaller than its

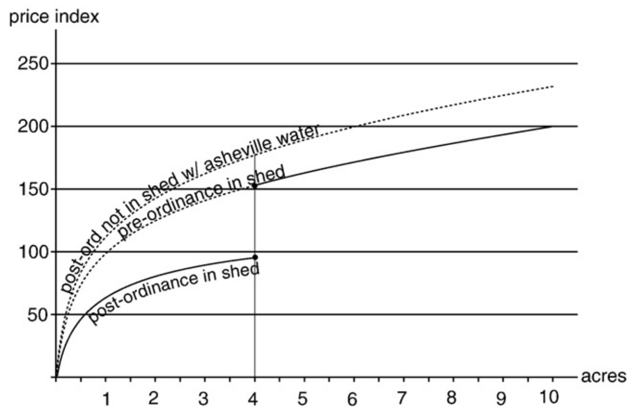

Fig. 2. The effect of minimum 2-acre lot restrictions on land prices in the watershed.

counterpart in Model (3). Therefore, the exclusion of the theoretically justified yet statistically insignificant variables LESSFOUR and LESSFOURINSHEDPOST appears reasonable.

Model (5) adds the three additional variables testing for third party costs or benefits of the watershed protection. The watershed policy was not necessarily intended to impact only those property owners within the boundaries of the watershed as additional third-party benefits might exist downstream from the impacted watershed. The variables ADJCREEKPOST, ASHEWATERPOST, and IVYWATERPOST control for three distinct potential third-party benefits from the watershed policy. ADJCREEKPOST tests whether properties adjacent to a creek and which sold after the watershed policy was enacted sold for a premium. If so, it would imply some amenity effect was capitalized into the land coincident with the watershed policy. ASHEWATERPOST tests for any increase in property value after the watershed policy was enacted for those parcels serviced by the Asheville municipal water system. To the extent that the quality of the water from the Ivy River watershed that enters the Asheville water system is actually or is perceived to improve after the watershed policy was enacted, there might be a capitalization of this benefit in land values. Finally, we test whether properties that receive surface water directly from the Ivy River watershed are impacted by the watershed policy by interacting POST and IVYWATER.

The results in Model (5) suggest that there were at least two distinct groups of property owners who gained from the watershed policy even while some landowners in the watershed experienced losses because of the watershed policy. Those properties adjacent to a creek experienced a 10% increase in price, on average, after the watershed policy was put into effect. Furthermore, properties serviced by the Asheville water system experienced an average increase in price of approximately 15%. Owners of properties that receive surface water from the Ivy River watershed did not experience a statistically significant impact on property values after the policy was enacted, although the parameter estimate is positive. Thus, there were property owners who stood to gain from the watershed policy and, in theory, these property owners could have been directly or indirectly taxed in order to compensate property owners harmed by the watershed policy.

3.3. Robustness checks

The results from the entire sample of vacant property sales suggest that the policy did have a deleterious impact on the value of those properties most directly impacted by the limitations on land use. However, there are several compelling reasons to investigate the general finding more closely through various robustness checks. We undertake a series of such checks to determine whether the results in Table 3 are a fabrication of the data, are based on miscalculated standard errors which might cause incorrect inference, or are a fabrication of the estimation technique.

First, we investigated whether the results in Table 3 were generated by our choice of announcement date. The period between July 7, 1997, and July 7, 1998 was one of uncertainty as the watershed policy was litigated. If property owners in the watershed area were privy to hidden information or were otherwise motivated to sell (or not sell) their land based on their expected resolution of the case, then choosing the announcement date of July 7, 1998 would be incorrect and lead to a specification bias. We first defined the watershed policy announcement date to be July 7, 1997 rather than July 7, 1998 and re-estimated the specifications in Table 3. In general, the property characteristics had the same parameter estimates. While POST was still negative and statistically significant, all of the interaction terms between the policy and property characteristics (LESSFOUR and LESSFOURINSHED) and those variables intended to test for third party benefits were statistically insignificant. We interpret this as suggesting that July 7, 1997 is not the appropriate announcement date.

We further defined the period between July 7, 1997 and July 7, 1998 as a period of uncertainty during which property owners had incomplete information. We interacted this uncertainty period with property characteristics and with those variables focusing on the effect of the watershed policy to test whether there were statistically different responses to property values during this period of time. These additional interaction terms were also insignificant, suggesting that during the period of uncertainty there was no meaningful change in property values simply because of the uncertainty. We interpret these results as suggesting that the July 7, 1998 announcement date is appropriate.[11]

Yet another potential problem is that the prices of properties geographically distant from the watershed are determined in a systematically different way. If this were the case, then using the entire sample of properties might introduce bias in the results reported in Table 3. We address this concern by restricting the full sample of properties to only those that are within the watershed area and the most proximate group of properties in the sample, those located within the Reems Township of Buncombe County, North Carolina. The results of using this sub-sample of properties are reported in Model (6) in Table 3. Many variables are necessarily dropped because of collinearity, e.g., there are no properties in this subsample that are adjacent to the Blue Ridge Parkway. The results are encouraging, in that not many parameters change dramatically and inference is only altered on a few, most notably the parameter on INSHED, which is consistently insignificant in the full sample but is in this subsample negative and significant, suggesting that in this subsample properties within the watershed are of considerably lower value, all else equal. However, the parameter estimate on LESSFOURINSHEDPOST does not change much in magnitude and remains significant. We interpret this as suggesting that the results in Models (1) through Models (5) in Table 3 are not artificially generated by our sample.

Another possibility is that our statistically significant results are caused by spatially-related error terms which the Huber–White–Sandwich approach does not accommodate (see e.g. Basu and Thibodeau, 1998; Pace and Barry, 1998). In the case of spatially autocorrelated errors, the error terms of economic units in close proximity are related, in which case the standard errors of the OLS (or robust OLS) parameters are incorrect, and could cause incorrect inference (Anselin, 1988; Anselin and Hudak, 1992).

The Global Moran's I coefficient for our sample's dependent variable is 0.14 using a five mile inverse distance weight matrix and 0.37 using a one mile inverse distance weight matrix, both of which are well above the 95% critical value of 0.0346.[12] Thus, there appears to

[11] We are indebted to an anonymous referee for suggesting this robustness check.

[12] Using the PSMATCH2 module (Leuven and Sianesi, 2003) in Stata 9. The propensity score was estimated including the natural logarithm of ACRES, MOBILEHOME, DISTASHE, ADJCREEK, ADJUSFS, IVYWATER, and DATE as explanatory variables.

be some spatial autocorrelation in our data. We re-estimated the models using one, two, three, four, and five mile bands using the technique developed by Conley (1999) and find that, in general, while the standard errors change slightly they do not change enough to alter inference. The only exceptions are the INSHED, LESSFOURSHED, and LESSFOURSHEDPOST variables; in these cases, the standard errors increase dramatically but the variables were already determined to be insignificant. We interpret these results as suggesting that the results in Table 3 are not a fabrication of miscalculated standard errors and mistaken inference.

Yet another concern is that the standard OLS model is not the correct estimator to address the problem studied herein. To determine if this is the case, we estimate a propensity score matching model in which the outcome variable is the log of real price and the propensity score is based on the property being less than four acres, in the watershed, and sold after the policy was in place. We find that the difference in the log of real price between the treated and control parcels is approximately −0.57, significant at the 5% significance level, and not dramatically different from the parameter estimates on LESSFOURINSHEDPOST in Table 3. The full results of this estimation are available upon request. We interpret this as suggesting that the results in Table 3 are not a fabrication of the OLS model itself.

4. Conclusions

In this study we examine the effect of the State of North Carolina's Water Supply Watershed Protection Act (WSWPA) on vacant land in the Ivy River watershed catchment area. There was no measurable general impact (good or bad) on the transaction prices of vacant parcels that were located outside of the watershed after the restrictions were put in effect. However, for parcels which are adjacent to a creek and for parcels serviced by Asheville municipal water, there were significant and substantial benefits from the watershed policy. This suggests that for certain parcels outside the area impacted by the regulations, there were net positive environmental amenity effects arising from the development restrictions. However, the impact of the regulations was negative and statistically significant for those properties within the watershed that were most directly impacted by the regulation.

To put the effect of the watershed restrictions in context, of the 331 transacted watershed parcels in the sample, 250 were less than four acres in size, and of these 208 transacted after the watershed restrictions were implemented. Combining the estimated parameter on INSHEDPOST4 (−0.443), which implies a 36% decline in property value, and the actual transaction prices of those properties that were affected by the regulations, we find that property values fell on average by $10,368 with a 95% confidence interval of [−$11,193, −$9544], where all dollars have been converted to 2000 values. Amongst these particular properties, the smallest estimated real dollar impact was −$752 and the largest was −$35,670. The total estimated impact of the watershed restrictions, reflected in 1,294 parcels of less than four acres existing in the watershed in 2001, is $13,416,192. In 2001, there were 48,568 residential parcels on the City of Asheville surface-water-fed public water system. Therefore, a per-capita tax of approximately $276.24 would be sufficient to compensate those property owners harmed by the watershed policy. This is less than the average real price effects of $18,492 to those on public water supply.

Admittedly, we are missing various additional private and public pecuniary and non-pecuniary benefits and costs of watershed management policy. For example, the Ivy River Watershed also lies in Madison County, North Carolina, which was not included in our analysis because of insufficient data. On the other hand, our estimate understates the benefits to the extent that it ignores a positive non-excludable environmental amenity effect of the watershed restrictions. Finally, as noted by Defries et al. (2004), people most directly involved in decision-making regarding land use change are often unaware of the full ecological consequences of their actions. In such cases, benefits from natural systems are undervalued (Finlayson et al., 2005).

Economic theory suggests that efficient public policy generates enough pecuniary and non-pecuniary benefits for proponents to compensate any who suffer economic damages from the policy. To the extent that the effects of watershed protection are capitalized into vacant land prices, our analysis reveals measurable costs to affected landowners in the catchment area from the WSWPA for whom flexibility in land development is compromised. While we lack estimates of the economic costs and benefits to the broader society served by the watershed, the current results suggest that some form of compensation from the population that benefits from the watershed management policies to those property owners adversely affected by the policies might be justified.

Continued deterioration of freshwater ecosystems can have profound effects on the freshwater species they directly support and to those who depend on freshwater for survival. This is particularly true in mountain forest landscapes like those in southern Appalachia. The Millennium Ecosystem Assessment of current trends on the environment and human well-being (Scholes et al., 2005:207) determined that one of the most important functions of forested mountain watersheds is the provision of clean water, noting that, in humid climates, mountain watersheds account for 20–50% of all freshwater discharge. Population growth and land use changes will likely increase the pressures on water supply and water quality. This, in turn, warrants continued examination of watershed management and protection practices.

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