RESOURCES
FOR THE FUTURE

Does Nature Limit Environmental Federalism?

V. Kerry Smith
Kurt A. Schwabe
Carol Mansfield

Discussion Paper 97-30

March 1997

Resources for the Future
1616 P Street, NW
Washington, DC 20036
Telephone 202-328-5000
Fax 202-939-3460

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Abstract

This research considers whether the principles developed to analyze the optimal jurisdiction for producing public goods can be applied in cases where regulations of private activities provide the primary means to deliver different amounts of public and quasi-public goods. The analysis evaluates how devolution affects the development of benefit cost analyses for regulations and the role of economic versus environmental factors in defining the extent of the regulatory market. Using a study of nutrient control for the Neuse River in North Carolina, the analysis develops area specific measures of the benefits and costs of regulations and illustrates how changes in the composition of the areas allowed to "count" for policy design can affect decisions about the levels of control judged to meet the net benefit test.

Key Words: environmental federalism, benefit-cost analysis, nutrient control

JEL Classification Nos.: H11, H23, Q28

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I. INTRODUCTION

Devolution left the sidelines of public policy and entered center stage with the 1994 election. Recent Republican congressional victories reinforced this call for changing the scope for federalism with a shift in responsibility for public services from the federal to the state and local levels. No economist has contributed more to the important theoretical and empirical issues of fiscal federalism than Wallace Oates, who this volume honors. As he observed in his collected essays on federalism (Oates [1991]), his Ph.D. thesis was motivated by Musgrave's [1959] initial treatment of the subject.[1] More than 30 years have passed since Wally's Ph.D. thesis started defining what most of us now understand about the preference, production, and taxation issues underlying the role of the various levels of government in the provision of different types of public and private goods. Moreover, few analysts would suggest that the conceptual dimensions of his work need to be revisited. Instead, like Gold [1996], they argue it is the set of empirical "realities" of these choices that need to be periodically updated with new, more specific (to current problems) information.

[1] Musgrave's three way categorization of the functions of government (i.e., allocation, distribution, and stabilization) argues that allocation issues are motivated largely through preference differences. This may be the reason why production advantages were not addressed in the same detail as preference heterogeneity in the early discussions of federalism. Oates [1991] cites Musgrave's key description of the fiscal federalism question as follows: "The heart of fiscal federalism thus lies in the proposition that the policies of the Allocation Branch should be permitted to differ between states, depending on the preferences of their citizens." (Musgrave [1959] pp. 181-182).

In a somewhat different context, comparable arguments are being made concerning the

organization of responsibilities for regulating of activities that affect environmental resources.

Schoenbrod [1996], for example, contends that EPA should be changed in dramatic terms that

would remove nearly all its regulatory authority.[2] Under such new rules it ". . . could retain its

leadership role only by convincing states to adopt its regulations by the quality and sensibility

of its [proposed] policies."[3] There is no formal analysis that underlies his conclusion and even

less empirical evidence. This absence of attention to the details has not diminished enthusiasm

for environmental devolution. The most ardent advocates of applying federalism concepts to

environmental regulation suggest that the trends for environmental improvement were

underway before the national legislation of the 1970's establishing a goal of uniform levels of

environmental quality was passed.[4]

In contrast to this perspective, there is some recent convincing evidence that the federal

air quality standards were effective in targeting private responses. That is, to the extent we

accept the statistic used to define the ambient standard as an adequate measure of the form of air

pollution that can have health effects, then the standard serves an important role in targeting

specific types of improvements (e.g. the severe episodes of pollution versus long term average

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[2] Schoenbrod's proposal to reform EPA is best described in his own summary: "The Environmental Protection Agency should be stripped of its power with four exceptions. First, it should gather and publicize information on pollution and its consequences, both on the national and local level. Second, it should propose to Congress rules of conduct to control types of interstate pollution that are not adequately addressed by the states or that require special protection, such as the Grand Canyon. Third, it should propose to Congress rules of conduct for goods, such as new cars, when state-by-state regulation would erect significant barriers to interstate commerce. Fourth, it should draft model state environmental laws and conduct policy studies that states could use when considering whether to enact such laws. States, however, should be free to amend or reflect federal proposals in favor of different approaches to pollution control." (p. 24).

[3] Schoenbrod [1996] p. 25, bracketed term added.

[4] Crandall [1985] suggested that substantial progress had been made prior to the 1970s in the case of air quality.

levels). Henderson's [1996] recent analysis of the distribution of ozone reading across monitoring stations from 1977 to 1987 provides a convincing example of how the form of the standard can definitely affect the nature of the response. Evaluated using the statistic that defines the standard (the second highest daily maximum), there is a clear shift down in the estimated mode and a tightening in the estimated spread of the distribution. No change in the approximate mode would have been detected using distributions across stations for the annual mean concentration over the same period. There was a tightening in these distributions, but this change came largely at the expense of reducing air quality at the cleaner areas (measured by averages). Thus, in this case we have evidence that national standards did have impact on the distribution of air quality around the U.S.

Limited attention has been given to applying the principles developed to assist in selecting the optimal jurisdiction to provide "produced" public goods for a different situation where government does not produce the public good. These cases arise where regulations of private activities are the primary means to "deliver" some types of public goods. This paper begins this process by considering factors that may limit the devolution of environmental regulations. We use the theoretical framework underlying benefit-cost analysis to describe devolution as an issue arising from defining "the extent of the regulatory market" for such analyses. A case study of nutrient control for the Neuse River in North Carolina illustrates how benefit cost analysis requires some resolution of the issue. That is in order to develop measures of the benefits and the costs, assumptions must be made about both consumer preferences and the production activities that influence the quality of the river.

Section II uses the Bradford [1970] aggregate bid function to describe how strategic separability assumptions underlie most arguments for decentralizing environmental

policymaking. In Section III we summarize the estimates of the benefits and the costs for a plan

for nutrient control along the Neuse River. Our primary focus is on the impact of the judgments

about the regulatory jurisdiction for components of the net benefits of different nutrient control

targets. The last section discusses the implications of this illustrative analysis. We argue that

nature "trumps" most of the conventional arguments for devolution. That is, the linkages

environmental resources create between activities taking place at different locations must

ultimately limit the extent of independence in decision making. Preference based considerations

can also lead to the need to impose more stringent control (and higher levels of quality) because

the impacted environmental resources are important to people outside a jurisdiction defined by

physical linkages alone. Both aspects of the task of delivering public goods efficiently must be

considered in making decisions about the levels of government given responsibility for the

design, implementation, and enforcement of environmental regulations.

II.   EFFICIENCY AND DEVOLUTION

A key premise of those arguing for decentralization of public sector responsibilities is

that most public goods are local, with production processes that do not exhibit appreciable

scale economies. As a result we expect, through a Tiebout [1956] argument, increased

prospects for both the variety (across jurisdictions) in the offerings of public goods available to

consumers and a form of competition (among jurisdictions for citizens) that limits a central

government's monopoly taxation policies (Brennan and Buchanan [1977]). In the case of

policies intended to maintain or enhance environmental resources, the ability to reproduce

environmental public goods is limited by the spatial distribution of natural assets that generate

these services as well as by the spatial interconnections in the consequences of economic

activities. Real world examples of these types of linkages are common. Current proposals for

amending the standards for ozone and particulate matter, two of the criteria air pollutants,

suggest that policy will increasingly focus on these links. Air quality along the East Coast, for

example, can be expected to be significantly impacted by the policies of coal fired, electric

generating plants in the midwest. The issues posed by such connections cannot be resolved

unambiguously at the conceptual level. Instead they become a part of the details of any

applied model addressing specific federalism questions.

Consider a simple specification for the i th individual's preferences with one private

good, x, and one public good, q, as in equation (1) to develop the issues in more formal terms.

$$u^i = u_i(x_i, q) \tag{1}$$

An individual's incremental willingness to pay for increases in q is defined by the change in x_i,

dx_i that would be paid for dq so that the individual is indifferent between the initial level of q

and q + dq. We assure this result by requiring $du^i = 0$ as in equation (2)

$$du^i = dx_i + \frac{u_{iq}}{u_{ix}} dq = 0$$

$$where\ u_{ij} = \frac{\partial u_i}{\partial j} \tag{2}$$

An efficient increase in the public good q would be set where the sum of these marginal

payments exactly equals the cost of providing q. In terms of what can be described as a bid

function (given in equation (3) below), this is consistent with the conventional public goods

condition illustrated in equation (4).

$$dx = \sum_i dx_i = -dq \sum_i MRS^i_{xq} \tag{3}$$

$$\sum_i MRS^i_{xq} = MRT_{xq} \tag{4}$$

The condition for an efficient allocation of resources between a private good and a public good

can be used to organize some of the issues that arise in discussions of fiscal federalism. Based

on that development, it is then possible to consider how these arguments should be amended to

consider what is likely to be the appropriate jurisdiction for environmental regulations.

Consider first the introduction of public financing for increments in q. A simple

approximation to the efficiency condition given in (4) involves multiplying the MRT (or the

private opportunity cost of increments to the public good) by what is often referred to as the

marginal cost of public funds(MCF).[5] This adjustment arises from a recognition of the welfare

losses due to the distortionary effects of most tax systems. If all public goods were financed

through lump sum taxes then MCF would equal one, otherwise, it is generally held to be greater

than one.[6] Thus, with this approximation, (4) becomes equation (5).

$$\sum_i MRS_{xq}^i = MRT_{xq} \cdot MCF \qquad (5)$$

Conventional discussions of federalism assume we can classify the cases where: (a) the

technology warrants a federal solution (i.e., based on properties of the MRT term); (b) the

practical financing issues imply a specific level of government based on ease or efficiency in

collecting required taxes;[7] or (c) the diversity in preferences warrant variety in public good

levels (the MRS terms). Implicit in this simplified classification is a set of separability

assumptions for both individual preferences and for whatever is assumed to be the process

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[5] Ballard and Fullerton [1992] provide an excellent summary of the optimal taxation literature in relation to estimates of the excess burden due to distortionary taxes and its role in evaluating the efficiency conditions for public goods. For more recent discussions of these issues in the context of measuring the costs of environmental regulations see Burtraw et. al. [1996] and Fullerton and Metcalf [1996].

[6] Some estimates imply values that are substantially larger, in the range of 1.30 to 1.50 (Repetto, et. al. [1992]).

[7] This is largely outside the simplified framework of equation (5), but which would ultimately impact the MCF effect.

associated with the production of q. If q is not separable from the activities taxed to finance

increases in the public good then the simple expression (and assumption of locally constant

values of MCF) collapses. When we consider evaluating the issues posed by federalism,

recognizing that changing q usually arises through some form of regulation on private

activities, we expect that there will be modifications in production activities for the private

goods linked in some way to q, and with these, changes in the MRT term.

There are several dimensions of these changes. In partial equilibrium terms we expect

marginal costs of q as well as other commodities held to be "responsible" for changes in q to

change. These effects will have general equilibrium consequences. The public good in these

situations is usually assumed to be associated with the services of natural assets that are

impacted by the production activities involved with other private goods. As a result the

interactions between the responses of q to these private goods depends on the environmental

system and production activities. With such linkages it is reasonable to expect that people will

be affected differentially by the measures used to change q. Returning to the air pollution

example, this point simply reflects the fact that efforts to control air pollution in the northeast

depend on the activities of firms and consumers in the region and the decisions of power plants

outside the region. Households in these other areas may well not experience beneficial effects

of the regulation (i.e., for them the dq need not be positive). Nonetheless, they will be affected

by the increased private costs.

These linkages do not simply affect how we add up who gets how much of the dq (the

left side of equation (5)) but, equally important, they impact the nature of the change in the

costs that give rise to the general equilibrium effects on MRT. Analyses that focus exclusively

on the market related general equilibrium effects and do not include the environmental effects in the models miss these impacts.

Linkages through markets can be important as well. The lessons from efforts to compute the social costs of environmental regulations suggest these are not simple adjustments (see Hazilla and Kopp, [1990] and Jorgenson and Wilcoxen [1990]). The numerical size of these general equilibrium effects can be at least the magnitude of the MCF adjustments. All of these effects are "buried" in the details of computing approximate estimates of the terms we would want to place in equation (5) for the MRS's, the MRT and MCF effects. They imply that the spatial dimensions of the environmental resources linking private activities to the public good matter. This point is, of course, not a new one. To our knowledge, however, it has not been integrated into discussions of federalism. Later in this section we will suggest why we think it is likely to grow in importance. Before turning to another difference in the way the level of government must be addressed for the case of environmental federalism it is useful to look at what has been said on these issues in the past literature.

The most significant early discussion can be found in the early work of Allen Kneese and colleagues at Resources for the Future in developing the Delaware Estuary model (see Kneese and Bower [1979]).[8] Environmental linkages were the central motivation for these models. Indeed the whole research program was organized with an explicit recognition that

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[8] To our knowledge, Haefele and Kneese [1973] provide the first integrated discussion in the economic and political economy dimensions of optimal jurisdiction. While their paper recognized the interactions between the physical or environmental limits on federalism, it seems to implicitly assume that environmental constraints define what they refer to as a "problemshed" and other factors must be considered within this pre-defined unit of analysis.

the regional locus of environmental quality management was a key decision.[9] Their realization

of the importance of the regional perspective lead to more than a decade of research

developing regional models for environmental quality management. These models attempted

to describe the economic, environmental, and political dimensions of alternative policy

decisions. They began from a spatial premise -- the definition of a regional unit of analysis

largely based on environmental criteria. Their most detailed case involved the lower Delaware

Valley. However, there was no analysis of different scales of regional analysis. The region

was treated as a maintained assumption for all the rest of their analysis.

Regulatory federalism makes this definition a part of the problem for analysis. If we

could assume the technical linkages were well known then they could be assumed to comprise

one component of the set of constraints that condition the economic decisions of private

citizens and local governments assigned responsibility for different environmental public goods.

Final decisions about the ideal jurisdiction could focus more on the preference side of

equation(s). Unfortunately, this set of circumstances is not fulfilled.[10] Examples of the

difficulties posed by uncertainty over the nature and costs of external effects are among the

important reasons for questioning the real world performance of incentive based policies.

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[9] One example of this role can be found in Kneese and Bower's description of how to start the environmental quality management problems. They note that it is necessary to start at the regional level, for their region embodied the key unit analysis because it incorporated environmental constraints. "It is necessary to use a word like regional rather than terms pertaining to political jurisdictions, such as nations, states, or cities because the extent of ambient environmental quality changes resulting from the discharge of materials and energy follow the meteorological, hydrological, and biological systems rather than the boundaries of political systems" (p16).

[10] Indeed, there are good reasons to question whether the information assumed to be available to private individuals and firms in models of individual adjustment to environmental circumstances, such as hedonic models, as implausible.

Moreover, these types of issues are not limited to environmental quality management. They are present in varying degrees with the services of other environmental resources. For example, the principles underlying the establishment of the national park system or the wilderness system were based on the premise that these different types of land areas could be set aside and managed to achieve their respective preservation and recreation objectives largely independent of what happened to the land around them. This view of the technical process of managing habitat would imply that one could assign responsibility for any particular park (or wilderness area) based exclusively on the left side of equation (5). There is now growing appreciation that there are zones of influence around these reserves that affect the environmental services that they provide.[11] The specifics differ depending both on the environmental resources involved and the external activities in each location, but the general issue is the same. There is an extended general equilibrium system that connects both sides of equation (5). The effects of the economic component of that general equilibrium system have been recognized for some time with the early writings on second-best and optimal taxation. They are largely "controlled" in analytical work through strategic separability assumptions imposed on preferences or production relationships.[12] These have been questioned by many authors before us and a common response is that without them we have no hope of simplified policy judgments.[13]

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[11] Botkin's [1990] arguments for a new ecology are examples of this difference in perspective. Christensen, et. al. [1996] have noted, based on these changing perspectives for ecosystems that management focusing on commodity outputs alone and failing to recognize the influence of surrounding areas is not sustainable.

[12] There are numerous examples of these in discussions in the double dividend literature. See Goulder et. al. [1996] and Fullerton and Metcalf [1996] as examples.

[13] Deaton [1987] is often attributed with highlighting the importance and plausibility in some circumstances of the separability restrictions required for the tractable versions of optimal taxation results. We are grateful to Jim Poterba for calling this work to our attention.

This may be a plausible argument for public goods that are produced by the government. It is not relevant to those associated with environmental public goods because there are linkages connecting activities outside the conventional boundaries used to define production and preference relationships. As a result, we can expect extended general equilibrium effects in addition to the preference and the production based contributions to the incremental opportunity costs measured in expressions like our equation (5).[14]

There is another aspect of the conditions for efficient allocation of resources that is sometimes overlooked. This issue relates to the number of people assumed to "care about" the level of q. It is also an important consideration for the calculations implicit in (5) (or in Bradford's counterpart to (5) that is used to rationalize benefit cost analysis). As a rule, discussions of this issue in the context of local public goods follow the logic Oates [1972, 1977] developed. That is, the welfare gains or losses due to centralization of the decisions about the amount of a public good to provide are generally held to depend on the heterogeneity in the levels of individual demand for a given "price" and the price elasticities of the individuals' demands. This approach assumes that the goods can be reproduced in different locations. For several dimensions of environmental quality (e.g. clean air, water, etc.) this characterization may be true. In those cases the linkage effects we discussed earlier require more complex analysis to account for the interactions leading to the marginal benefit and cost terms. However, national parks and other natural assets give rise to a different type of environmental public good. In

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[14] For a discussion of these issues in the context of a computable general equilibrium model with a nonseparable treatment of the effects of air pollution on people's preferences see Smith and Espinosa [1996].

these cases, decisions about who counts in the sum of the MRS_{xq}^{i} terms on the left side of

equation (5) are especially important to the amount of the public good that is provided.[15]

This issue is one of the most contentious questions in the current literature associated

with non-market valuation of environment resources. Often it is described in terms of the

"nonuse values" for environmental resources.[16] However, the issues extend beyond nonuse or

existence values. To the extent people outside the region assigned with responsibility for

decision about increments to q also have an economic stake in what is done, but are <u>not</u>

counted, then decentralization inevitably leads to welfare losses. The nature of their stake can

be infrequent patterns of use, expected future use, or motives attributed to nonuse or existence

values. This argument relies on the assumption that fairly close substitutes for the resources

are <u>not</u> available in locations where the individuals involved do have some "say" in the

allocation decisions. Thus, nonseparability arisi0ng from linkages in the environmental system

and extent of the economic market for q are two new dimensions added to the issues affecting

the extent of regulatory federalism for environmental resources.

These questions are not simply "grist" for an academic debate. They are made each

time a benefit-cost analysis is undertaken to evaluate the efficiency of a regulation whether at

the federal or more regional level. We need only recast equation (5) into the form Bradford

used to motivate these analyses. The same questions addressed in judging a decentralized

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[15] If we write out $\sum\limits_{i} MRS_{xq}^{i}$ as $\sum\limits_{i=1}^{n} MRS_{xq}^{i}$, then it is the "n".

[16] See Freeman [1993] for an overview of the various definitions for nonuse value. The original concept of existence value is due to Krutilla [1967].

delivery of public goods arise with decentralized regulation. In the past few years benefit-cost

mandates have started to become a part of rulemaking at the state level. As states have

recognized the need to consider the economic consequences of their rules, they have adopted

some form of benefit cost analysis. Over twenty states now have benefit cost requirements for

their own rules. As Whisnant and Cherry [1996] observed recently, there are few incentives

to confront external effects that extend across state boundaries whether they arise from

environmental linkages or consumer preferences for resources that are outside their state of

residence.[17] Moreover, lack of accurate data on the effects at increasing distances from

activities within the state, together with a presumption that those impacted are themselves

adjusting and mitigating the impacts, makes the analysis required to determine a prudent

assignment of responsibility exceed the limits of most states' analytical capacities.

Most economists, writing about the issues posed by regulatory federalism, and even

advocates of devolution appear to be willing to concede that environmental linkages set limits

to devolution.[18] Unfortunately this focuses exclusively on the supply-side of the problem. It

does not address how the devolved authority deals with those outside the immediate zone of

policy influence but who may have a "stake" in the outcome. In the next section we use the

benefit-cost analysis of nutrient control for the Neuse River basin in North Carolina to

illustrate the impact of how consideration of both cost and aggregate value can affect the

choices made in a decentralized regulatory system.

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[17] These authors observed, ". . . a state has little or now incentive to issue rules that costs its taxpayers -- more importantly, its voters -- for the benefit of the citizens of other states" (p. 736).

[18] Anderson and Hill [1996], suggest: ". . . the following principle should guide environmental federalism: To minimize the costs of monitoring regulatory agencies, authority should devolve to the lowest level of government that also allows for control of pollution other spillover effects" (p. 9).

III. NUTRIENTS IN THE NEUSE RIVER: A CASE STUDY

Most environmental management problems must be treated in a spatial context.[19]

There are two ways in which it is important. First, nature links activities undertaken in one

location with outcomes in another. Second, most environmental resources are best evaluated

as assets in specific "places." There are good reasons to believe people will care about the

state of the environmental assets in many locations in addition to those "close" to their

residence. To illustrate both considerations as limits to devolution, we use a water quality

management issue in North Carolina. It involves different locations within the state and the

divergence in uses and consequences for a natural resource--the Neuse River. The questions

raised by this case study are equally relevant to the federalism debate.[20]

The Neuse River Basin, with over 3,000 stream miles extends from nearly the north

western boundary of North Carolina continuous with Virginia, to the Pamlico Sound in New

Bern. Over the past two years, the river has been the subject of much local and national

attention due to fish kills attributed to excess nutrients. Considerable evidence has also been

accumulated indicating that toxic dinoflagellates may be involved. Indeed, a nutrient

management strategy for the Neuse River was the first rule subjected to a fiscal note (required

by the North Carolina's mandate for economic analysis of regulations). This note evaluates the

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[19] As we have suggested, RFF's Quality of the Environment Program of the 1970's was organized to integrate this insight into all the models used to evaluate policy instruments. It has also been an important part of Wally's work on environmental policies with his Ph.D. students. See Krupnick, Oates, and Van De Verg [1983], McGartland and Oates [1985] and Oates, Portney, and McGartland [1989].

[20] After the research for this paper was finished, the Raleigh *News and Observer* (January 31, 1997) reported that the EPA was taking steps (in response to a suit filed December 31, 1996 by the Neuse River Foundation) to enforce a provision in the Clean Water Act that requires states to set firm thresholds on the total waste a river can absorb daily from all sources. This would make our case study directly parallel to the conceptual issues underlying regulatory federalism, not due to the geographic boundaries but rather federal mandates for consistent measures for the waste handling capacities of river.

impacts of proposed policies to reduce nitrogen loadings throughout the Neuse River basin by at least 30 percent.

Analysis of this proposal requires addressing the same issues being posed under the mantel of regulatory federalism. Our case study illustrates the potential importance of any proposal to arbitrarily assign responsibility for environmental regulations to a specific level of government. It is organized in three parts. The first uses a large scale nutrient balance, process model for the Neuse River basin to illustrate how the activities identified as contributing nutrient loadings influence the cost estimates developed for different levels of control. This analysis demonstrates how devolution can influence the opportunity costs attributed to a regulation.

The second uses the model to evaluate a pure incentive based policy for meeting the 30 percent reduction envisioned by the plan. It focuses on the distribution of costs across the 12 counties included in Schwabe's [1996] model of the river basin. This distribution illustrates how environmental linkages, together with the spatial location of activities, influences the cost estimates for nutrient control measured based on the nitrogen loadings that reach the Pamlico Sound. The last combines the cost estimates by county with benefit estimates developed based on a telephone-mail-telephone survey of households in North Carolina conducted from November 1995 through January 1996. This survey was designed to evaluate whether households would support policies to reduce nitrogen loadings from swine operations that impact the same coastal areas. Net benefits are measured for each county as well as for the state as a whole to illustrate how the extent and composition of the regulatory market can influence the evaluation offered by the economic analysis.

**TABLE 1: Costs for 30% Nutrient Reduction in the Neuse River:
Extent of Regulatory Market (1994 $)**

	Baseline	Cropping Activities	Cropping and WWTP[b]	Cropping and Swine Operations	Complete Model
Total Costs[a]	$157,273	$162,449	$165,264	$163,665	$166,479
Control Costs[a]	—	$5,176	$7,991	$6,392	$9,206
Cost per Pound Removed	—	$4.76	$5.74	$5.37	$6.15
Unit Control Cost as % of Complete Model's Unit Cost Estimates	—	77	93	87	—

[a] These costs are measured in thousands of dollars. They are annual costs and do not include land costs.

[b] WWTP designated the eighteen major wastewater treatment plants included in the Schwabe model.

A.   Nutrient Control Costs

Table 1 summarizes the control cost estimates for a 30 percent reduction in nitrogen

loadings with four different versions of the Schwabe model. The first includes only cropping

activities. This entails treating each county as if it were a cost minimizing farm producing one

or more field crops -- corn, cotton or soybeans with different cropping systems and nitrogen

control practices (including conservation tillage, controlled drainage, and vegetative filter

strips). Land is distinguished by characteristics for nutrient runoff with three indexes --

erodibility, slope, and transmissivity. Crop land is distinguished into the Piedmont, Upper

Coastal and Lower Coastal Plains to account for yield differences.[21] The production activities

are adjusted based on the technical characteristics of the land in each area.

The second model adds to the cropping activities 18 wastewater treatment plants

located along the Neuse River, allowing for primary and secondary treatment of nitrogen

where the equipment available suggests these levels of treatment are feasible. The third model

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[21] See Figure 1 for the definitions of these areas.

includes nitrogen loadings from swine operations along with the cropping activities model, but does not allow for control options at these locations. This specification increases the base loading estimates and this requires greater effort on the part of the cropping activities to meet a 30 percent reduction. The last model combines all three components. All four cases consider command and control (CAC) regulations to meet the 30 percent reduction.

North Carolina's Division of Water Quality estimates that 8.7 million pounds of nitrogen enter the Pamlico Estuary from the Neuse River each year. About 2.1 million pounds of this total are attributed to point sources, the remaining 6.6 million to nonpoint sources. By varying the composition of the point and nonpoint sources included in the Schwabe model, we can see dramatic differences in the estimates of control costs. To some extent, the total control cost estimates may be misleading because what counts as a cost and the actual amount nitrogen removed from the effluent stream varies across these models. That is, the baseline loadings varies with the composition of the sources represented in each version of the model. To reflect this effect the third row reports the unit cost per pound removed from the waste stream (measured at the estuary). These average costs range from $4.76 to $6.15 depending on the composition of the model. This is nearly a 25 percent difference in unit cost estimates arising simply due to the activities allowed to count as contributing to the nutrient problem in the Neuse River. Thus, the issues posed in accounting for sources of nitrogen loadings parallel the questions that arise in defining a jurisdiction for environmental regulations. These cost differences illustrate the types of impacts such decisions have on the definition of nutrient standards by directly influencing the estimated costs associated with any environmental quality goal.

**TABLE 2: Spatial Distribution of Control Costs for a Command and Control Policy and
30% Reduction**

County	Annual Cost[a] Non-point Sources	Point Sources	Total Cost	Average Cost per lb removed
Orange	121.4	—	121.4	174.5
Durham	8.5	—	8.5	92.6
Wake	207.7	1125.4	1333.1	8.1
Johnston	728.4	202.3	930.7	6.7
Nash	240.0	—	240.0	7.4
Wilson	436.7	255.2	691.9	12.4
Wayne	936.1	15.6	951.7	4.1
Greene	724.4	—	724.4	5.1
Lenoir	936.2	1166.1	2102.3	7.4
Pitt	504.9	—	504.9	2.5
Jones	671.6	—	671.6	11.4
Craven	875.7	50.4	926.1	5.7

[a] These costs are measured in thousands of 1994 dollars. The estimates are developed from results reported in
Schwabe [1996].

B.   Spatial Disaggregation

Table 2 disaggregates the implied costs under a CAC policy with each county's cropping

activities and point sources required to reduce loadings by 30 percent (where it is technically

feasible). The first three columns detail the non-point, point, and total costs of realizing the 30

percent reduction. The last column reports the unit costs per pound of nitrogen removed

measured at the sound. Clearly there are wide differences in the average costs. As in the case of

re-evaluation of different mixes of source types included in determining the "incremental costs"

measured for the area as a whole, small changes in the spatial composition of the regulated area

will definitely change the costs of control. The measured differences in unit costs across counties

imply substantial scope for gains from trade (i.e., incentive based policies). Part of the reason for

these differences stems from the characteristics of the land in each county and its location in

relation to the Pamlico Sound. Because nitrogen loadings are measured in equivalent units at New

Bern, sources in the western portion of the state have the advantage of the river's absorptive

capacity. Nonetheless, the average cost estimates suggest that control measures in the western

counties would not be cost effective relative to those in the Upper and Middle Coastal Plain.

Limiting the trading areas to a few high or low cost counties treated in isolation such as

Wayne, Lenoir, Pitt, or Craven for the lower unit cost case would lead to an underestimate of

the potential gains from allowing permit trades. Failure to include counties as sources of

nitrogen also affects the estimated levels of nitrogen loadings; it also imposes greater costs on

the other counties that are identified. This is the spatial counterpart of our evaluation of

including different types of production sources responsible for nitrogen in the river, including

cropping activities, swine operations, and wastewater treatment plants.

We can develop some insight into the effects of re-allocating responsibilities for meeting

the 30 percent goal by comparing the average cost of a CAC versus an incentive based (IB)

approach. The former is about $6.24 per pound of nitrogen removed while the IB approach is

about $4.12 per pound. Table 3 reports the re-allocation in responsibilities for reducing nitrogen

loadings in the two solutions. The first 12 rows correspond to the cropping activities by county

and the 18 rows designated as point sources are the wastewater treatment plants along the river

that are included in the model. Clearly the two scenarios assign responsibility for the cleanup

quite differently. Moreover, this type of change likely understates what might be expected with

different assignments of responsibility for nutrient regulation.[22] As Whisnant and Cherry suggest,

there is no reason to expect that devolved systems will have incentives to develop the information

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[22] In these comparisons the size of the aggregate reduction in nitrogen loading was held constant.

necessary to promote assignment of responsibility based on costs, especially if those realizing the

largest cost savings would be outside that system's jurisdiction.

TABLE 3: A Comparison of the Nitrogen Loading Responsibilities Under CAC versus IB Policies[a,b]

Type of Discharge	Source	Baseline Solution (pounds)	Loadings Under 30% Reduction - CAC (pounds)	Loadings Under 30% Reduction - IB (pounds)	Change in Responsibility (pounds)
Nonpoint	*Orange*	2,318	1,623	2,318	-696
	Durham	307	215	307	-92
	Wake	36,848	25,794	36,848	-11,055
	Johnston	420,738	294,517	315,964	-21,447
	Nash	107,891	75,524	77,714	-2,190
	Wilson	125,123	87,586	94,993	-7,407
	Wayne	776,746	543,722	583,519	-39,796
	Greene	472,552	330,786	319,195	11,592
	Lenoir	711,951	498,366	472,437	25,928
	Pitt	676,993	473,895	524,966	-51,071
	Jones	195,863	137,104	195,863	-58,759
	Craven	438,073	306,651	330,268	-23,617
Point	*Zebulon*	2,087	1,441	2,087	-646
	Apex	7,504	5,197	7,504	-2,307
	Cary-North	53,010	35,679	53,010	-17,331
	Cary-South	50,863	34,386	50,863	-16,477
	Burlington	23,274	16,185	14,192	1,993
	Wilson	57,840	39,424	57,840	-18,416
	Wake	2,310	2,310	2,310	0
	Raleigh	330,450	220,374	48,269	172,105
	Benson	14,940	10,329	7,915	2,414
	Johnston	28,167	19,267	28,167	-8,900
	Goldsboro	166,568	112,746	69,451	43,295
	Farmville	10,215	10,215	10,215	0
	Kinston-Peachtree	64,226	44,381	64,226	-19,845
	Contentnea	46,305	31,446	13,297	18,150
	Kinston-North	34,560	34,560	29,107	5,453
	Dupont	8,110	8,110	8,110	0
	New Bern	101,127	69,769	50,648	19,121
	Havelock	17,568	17,568	17,568	0
Basinwide		4,984,527	3,489,170	3,489,169	0

[a] Solutions derived under county constrained module; Includes cropping activities, wastewater treatment plants, and swine waste; Cropping activities are responsible for swine waste under command and control; positive values indicate source assumes more responsibility for nitrogen loading reduction under IB compared to CAC.

[b] Source: Schwabe[1996]

C. Benefits and Devolution

The benefit side of environmental federalism questions is especially difficult. As we noted environmental assets are located in space and can have implications for more than the immediate neighbors. Moreover, there are not systematic means to keep track of how all these effects take place. Some of them arise from the linkages between production (or consumption) activities and these assets. In the case of the Neuse River, farming practices as well as the operations of the wastewater treatment plants influence water quality along North Carolina's coast around New Bern. Residents of the area experience the fish kills, algae blooms, odor, and other impacts.

During recreational seasons tourists will also be affected. Measuring the benefits that would arise from different regulatory regimes requires a specification of the composition of the "market" for all the services provided by the environmental asset(s). Often these decisions focus on the treatment of use and nonuse values, where the latter is associated with people who may experience enhanced well-being from improvements in a resource but do not display any behavioral response that can be attributed to these concerns. As a result some authors have considered them speculative and argued that they should not be included in a benefit-cost analysis associated with policies intended to manage most environmental assets.[23] As a practical matter, even within the category of

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[23] Diamond and Hausman [1993] appear to equate nonuse values with an expression of ethical beliefs and then conclude that monetary compensation for natural resource injury and benefit cost evaluations should be based on individual preferences not ethical judgments. Nonuse or existence values can also be argued to represent enhancements to individual preferences that parallel a pure public good (Plourde [1975]). Under this perspective one could agree to avoid ethical positions but continue to include nonuse values because of their relationship to public good services.

Diamond and Hausman[1994] would also have an objection to this position because such values would have to be measures with contingent valuation (i.e., nonuse values do not necessarily imply any behavioral response). They had noted that: ". . . behavioral contingent valuation is a deeply flawed methodology for measuring nonuse values, one that does not estimate what its proponents claim to be estimating. . . . There is a history of anomalous results in contingent valuation surveys that seem closely tied to the embedding problem. Although this problem

use values the composition of the "n" in equation (5) is rarely "clearcut". As in the case of those

contributing to estimates of the costs of regulations, the definition of whose benefits count is also

fundamental to what can be expected from a devolved system.

Figure 1 illustrates how this can happen. It takes the 12 counties in the Schwabe model

comprising the primary components of the Neuse watershed and computes the net benefits of the

proposed 30 percent reduction in nutrient loadings for each. These estimates are derived from a

fairly crude benefit transfer. That is, they do not come from a specific analysis of people's

willingness to pay for a 30 percent reduction in nitrogen loadings in the Neuse River.[24] To

illustrate the spatial differences we have placed the estimates on the map, reporting the aggregate

benefits (in thousands of dollars), net benefits assuming a CAC policy regime, and the number of

households in each county. Table 4 reports the estimates by county CAC and IB approaches to

realizing the 30 percent reduction in 1994 dollars. With the CAC policy, only two of the

counties, Greene and Jones, experience losses but this is enough to make our point. It is clear

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has been recognized in the literature for over a decade, it has not been solved. Thus, we conclude that current
contingent valuation methods should not be used for damage assessment or for benefit cost analysis." (pp. 62-63).

[24] In a separate analysis Smith and Schwabe used a random utility model (RUM) developed by Smith and Liu
along with a model linking nutrient loadings to sport fishing quality (Smith, Liu, and Palmquist [1993]) to
evaluate the impact of a 36 percent reduction in nitrogen loadings on the Neuse. The RUM was based on a 1988
(followup to the 1987) National Marine Fisheries Service survey that was conducted by Nancy Bockstael and
Kenneth McConnell of the University of Maryland. This followup involved fishing parties intercepted in North
Carolina.

The per trip Hicksian consumer surplus from the quality improvement (in 1988 dollars) was estimated at
$13.29. Using the estimated number of trips taken by only NC sport fishing anglers from 1991 National Survey
of Fishing, Hunting, and Wildlife Associated survey, together with the number of North Carolina sport fishing
anglers and the fraction of the fishing parties using locations around the Neuse River (adjusting the benefits for
the higher percent of reduction), our estimates suggested between $3.25 and $5.83 million dollar benefit.
These estimates assume either 12 or 22.7 percent of the trips originate from areas affected by the Neuse River.
They are limited to trips made by North Carolina anglers (estimated at 1.94 million per year).

The benefit transfer underlying the estimates in Table 4 and Figure 1 relate to all possible sources of benefits
from the water quality improvement to North Carolina residents in the area. When compared with these
benefits to sport fishing alone, the total benefits seem plausible.

Figure 1 is available from the authors.

from the estimates in Figure 1 (and Table 4) that decision about the composition of the region

given authority for nitrogen control will influence the extent of excess demand for water quality

improvement. Moreover, to make this argument in a fairly persuasive way we do not need to

extend the market area to include counties that are "outside" the set linked through the watershed

to water quality in the sound.

TABLE 4: Net Benefits of a 30 Percent Reduction in Nitrogen Loadings: CAC Versus IB Policies

| County[a] | Net Benefits[b] | |
	CAC	IB
Orange	$2,025	2,146
Durham	4,289	4,297
Wake	8,536	8,029
Johnston	946	1,440
Nash	1,486	1,545
Wilson	800	1,278
Wayne	1,256	1,657
Greene	-404	-513
Lenoir	-798	-37
Pitt	1,902	2,397
Jones	-464	208
Craven	830	1,068
Aggregate Net Benefit	20,388	23,515

[a] Counties are ordered from most distant to most proximate location to the Pamlico Sound.

[b] Estimates are in thousands of dollars and do not adjust for the fact that benefits are in 1995 dollars and cost in 1994.

Our benefit estimates are derived from a telephone-mail-telephone survey. In the first

stage, 1,002 households in North Carolina were contacted by telephone, collecting attitudinal,

demographic, and economic characteristics. In the process respondents were asked if they would

be willing to participate in a second telephone interview that required them to provide their

mailing address so they could send information about issues affecting the water quality of North

Carolina's rivers and coastal areas. 540 of the original 1,002 respondents completed the second interview.[25]

To estimate the benefits of controlling nitrogen loadings that impact the quality of coastal resources, two plans to regulate the operations of large hog farms were described in different booklets that were randomly assigned to each person who agreed to the second interview. The booklets included color photos of hog operations and described how regulations would reduce nutrients in surface and groundwater, as well as reduce the risk of future waste spills from large farms' waste handling systems into North Carolina rivers. These reductions were described in qualitative terms. The plans can be distinguished based on how much of the control costs to private operators would be shared by the state. The descriptions were closely aligned to the actual text of proposals discussed at the time in the state legislature.

The proposal we consider for our benefit estimate does not bundle private cost sharing with regulations and monitoring intended to realize nitrogen control. It also does not guarantee the 30 percent reduction envisioned in our cost analysis. Moreover it is described as a statewide initiative that relies on regulations imposed on large hog farms, and not one targeted to the Neuse River or one affecting other sources of nitrogen -- the cropping activities and wastewater treatment plants.[26]

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[25] Mansfield and Smith [1996] investigated the importance of selection effects with initial agreement to participate in the survey (using a model with county level aggregate data following Papke and Woolridge [1993]) and the selection effects associated with those respondents who answered the first phase survey completing the second interview. While age, education, and gender were important determinants of the likelihood of completing this survey, the results did not indicate that either selection effect was important to choice models derived for the contingent valuation question associated with the plan to regulate large hog farms.

[26] The text of the question associated with the plan to regulate large hog farms was distinguished according to whether it involved some cost sharing of initial capital costs (with farmers) or not and its order in the telephone interview. Our results relate to the plan without cost sharing when asked first. (Respondents were reminded of the plan which involved three changes in hog farms operations). We review the full sequence of questions as follows:

Our benefit estimates assume the respondents' answers to discrete, take it or leave it

contingent valuation (CV), questions provide adequate measures of household willingness-to-

pay for a benefit transfer analysis. The CV questions suggest that respondents will have to pay

for the regulations because state income taxes must increase from $10 to $750 each year to

pay for increased monitoring associated with the proposed new rules.[27]

This transfer may well seem a considerable "stretch" (given survey design) of the

available benefit measures. It is not clear, however, that we are overstating the willingness to

pay at the household level. Indeed, because the majority of the nutrient loadings on the Neuse

are due to cropping and wastewater loadings, not the operations of hog farms. This focus may

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The booklet described a plan with new regulations for reducing the potential contamination of coastal waters from releases of hog waste in the eastern counties of North Carolina.

   9. Do you remember the plan?
     01 yes
     02 no (go to 9b)
   9a. As you recall, the plan applies to large hog farms. (go to 9c)
   9b. The plan applies only to large hog farms.
   9c. It would require three changes in their operations. Their waste lagoons would be required to use mechanical techniques to increase the natural decay of the waste and reduce odor. Reinforced lagoons with plastic liners and annual inspections would be required. This would reduce the chances of accident spills in the leakage of nutrients into groundwater. And finally, spraying of waste would not be allowed within 1000 feet of a wetland or a river. This plan would be in addition to other actions the state is now undertaking.
   9d. Would you like me to repeat anything about the plan?
     01 yes
     02 no
   10. These requirements would raise the costs of operations at hog farms. Because they would be among the most stringent in the nation, it is anticipated that some farms would close and the major firms in the industry would move some operations outside the state. This would increase unemployment in eastern North Carolina.
   Here is how the plan for increased regulations and monitoring of the large hog farms would be paid for. Large hog farms would be required to pay for the mechanical processing the hog waste, the enhanced lagoons, and the controls on spraying. The state would pay for the increased inspections to assure the plan works.
   To pay for these annual inspections, there would have to be an increase in North Carolina residents' state income taxes. For your household it would be an additional (randomize and keep track: $10, $25, $50, $75, $100, $125, $375, $750) each year. This would be in addition to the amount you now pay in state income taxes. This payment would be required each year to maintain this program. Please keep in mind your current income and the things you now buy.
   If this plan to regulate large hog farms were on statewide referendum with your taxes increased by (repeat amount from above) and you could vote on the plan, would you vote for or against it?
     01 for the plan (go to 12a)
     02 against the plan (go to 12)
     03 don't know (don't offer, go to 11a)

[27] By using the per household estimates for our survey (with some adjustment explained below) we are assuming these differences would not markedly impact the WTP estimates for a plan targeted at the Neuse River with the households we include in our analysis.

imply our estimated WTP is a conservative measure of the value people would place on a plan perceived as addressing all aspects of the problem.

Equally important we applied a conservative method to develop the aggregate estimates from our household estimates of willingness to pay. Based on the estimated median WTP (derived from fitting a Weibull survival model to the CV responses) we adjusted the estimate assigned to households in each county by the response rate to our final survey (66 percent).[28] This procedure assumes nonrespondents had a zero value for the proposed plan to regulate hog farms. Finally, we assume only households in the 12 county area covered by the Schwabe model of the Neuse River watershed would be willing to pay. The estimated overall benefits from the plan (with the median estimate) would be 29.6 million (in 1994 dollars). This

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[28] Using a Weibull survival model to estimate the responses from the first question, the estimated median willingness to pay was $94.90 per year. The 95 percent confidence interval was $46.07 to $195.50. Because the survey was conducted between November 1995 and January 1996 we used the December 1995 Consumer Price Index to adjust the benefit to 1994 dollars for the aggregate estimates. Household income was reported for the last tax year, 1994, (1995 income taxes were not filled until after the survey was completed). The adjustment implies benefit measures in 1994 dollars that were about 95 percent of the 1995 levels.

The probit choice model from the CV data suggests that the proposed tax amount was a significant determinant of stated choices. One of the models reported in Mansfield and Smith [1996] is given as follows:

State vote for plan =	-2.44	-.0013 tax amount
	(-1.66)	(-2.70)
	+.055 Household income	+.655 College Grad.
	(1.35) (in ten thousand dollars)	(2.20) (=1)
	+.204 Likelihood of hog waste spills	+.125 Regulate Hog Farms
	(3.47)	(0.54) (=1)
	-.248 Live on Farm	+.877 IMR1
	(-0.68) (=1)	(0.41)
	+.475 IMR2	n=140
	(0.38)	pseudo R^2 = .159

This model was estimated for only the respondents receiving the booklet and question relating to the plan without cost sharing. IMR1 and IMR2 correspond to the inverse Mills ratios for initial agreement to participate (based on aggregate data) and participating in second phase sample. Missing values of household income were imputed for this model. The remaining qualitative variables are defined as follows:

Likelihood of Spills is a 1 (not likely at all) to 10 (very likely) Likert scale for individual's perception of possibility of future spills of hog waste comparable to events in North Carolina in summer of 1995.

Regulate Hog Farms is an attitudinal variable that =1 if respondent indicated regulating hog farms to reduce changes of waste spills was very important, zero otherwise.

Live on a Farm is equal to one if respondent lives on a farm and zero otherwise.

The Z statistics reported below the estimated parameters are based on robust estimates to account for potential heteroscedasticity due to selection effects.

compares with overall costs of the CAC program for a 30 percent reduction of 8.1 million

dollars to yield positive net benefits.

IV. IMPLICATIONS

Wally's research on federalism has emphasized the need to balance the simplicity of

conceptual models designed to highlight the information necessary to make jurisdictional

decisions with comparable attention to the specific details relevant to each application. We

believe these "details" are especially important in structuring the jurisdictional responsibilities

for the design and implementation of different aspects of environmental policy. Our

conclusions about the scope for devolution, in some respects, reiterate the important lessons

found in the design of Kneese's environmental management efforts in the seventies. Linkages

in environmental resources create spillover effects that cannot be ignored in evaluating the

costs of attaining any ambient quality level. Our example of the Neuse River suggested that

whether we identify jurisdiction by activity or location, the effects on the cost of reducing

nitrogen loadings can be substantial.

This is a different perspective than most discussions of fiscal federalism, where the

production component of the delivery of local public goods is considered in less detail than are

issues related to the available alternatives for financing public intervention or the consideration

given to the implications of preference heterogeneity for the amounts and types of public

goods provided by different jurisdictions. Here it is clear that regulations can impact costs in

different ways that are affected by the definition of the jurisdiction assigned responsibility. A

simple identification of the spillovers is not enough to assure these external effects will be

taken seriously without credible oversight. Few lessons are more clearly found in international environmental problems than this one.

The preference component of these decisions is also, we believe, more complex than with local public goods. The spatial dimension of environmental resources implies that in a number of cases "users" will extend beyond local residents. We expect (and for some approaches to non-market valuation we rely on the fact) that people will travel to some environmental resources to experience their services. This feature of the consumption of environmental services implies the user population is harder to define by residential location alone.

Nonuse values are also harder to dismiss as speculative for many environmental resources. It is harder to develop (without substantial effort and cost devoted to the estimates) values that will reliably distinguish those with very low or zero willingness to pay.

Both of these differences are central to how one must address the extent of devolution adopted for decisions involving the direct management or the regulation of activities impacting environmental resources. Our arguments concern differences for both the cost and the preference components of the federalism problem. They began from analyses that sought to understand the specifics of how each environmental resource is affected by and contributes to people's activities. Understanding the contribution of "nature" expressed in these terms is an essential component of the tasks to be addressed in environmental federalism.

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