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The Benefits of the Falls Lake Nutrient Management Strategy

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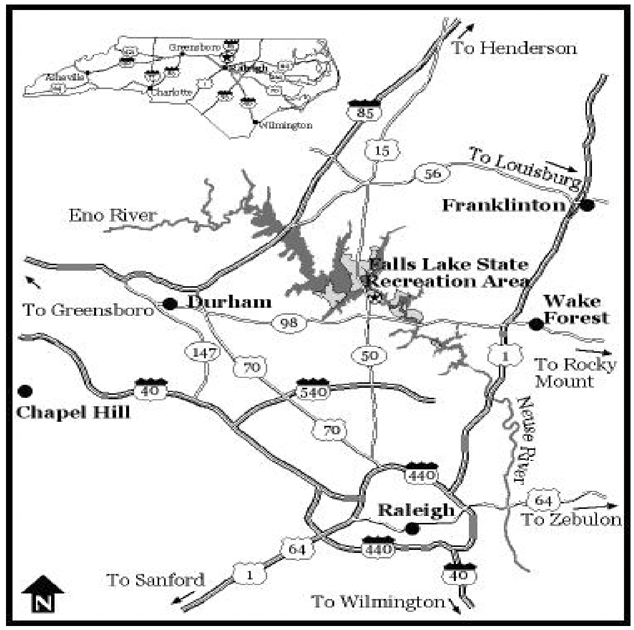
Falls Lake is a 12,000 acre Army Corps of Engineers reservoir in Durham, Wake, and Granville counties (see map). It was constructed in the late 1970s to mitigate flood damage and store water supplies for surrounding communities, but over time has evolved into a popular outdoor recreation destination for nearby residents.



Source: www.ncparks.gov

North Carolina's Division of Water Quality (DWQ) first designated Falls Lake as nutrient-impaired in 2008, with the primary causes identified as stormwater, wastewater, and agricultural runoff. The North Carolina legislature passed and then Governor Perdue signed Senate Bill 1020 in 2009, which delegated to DWQ the responsibility of developing strategies to improve water quality in the Falls Lake watershed.

In March 2010, the DWQ proposed the Falls Lake Nutrient Management Strategy (FLNMS), a comprehensive set of regulations designed to reverse the long-run trend of water quality degradation in the watershed. After a period of study and public debate, North Carolina's Environmental Management Commission approved the FLNMS in December 2010.

When DWQ issued these regulations, North Carolina law required that they also quantify in dollar terms the economic benefits and costs of the regulations to the maximum extent possible. DWQ's widely publicized estimate of $1.5 billion in discounted costs over a 25-year time horizon raised many eyebrows among businessmen, politicians and local residents. The regulations' likely benefits, however, have received far less fanfare. Interestingly, these benefits are similar in magnitude to the costs and may justify the FLNMS' substantial costs. This issue of the *NC State Economist* summarizes the research design and key findings of the work – conducted jointly between economists and ecologists at Research Triangle International and North Carolina State University – that developed those benefits estimates.

Study Design

Improving water quality at freshwater reservoirs like Falls Lake is likely to generate two broad categories of social benefits: 1) diversionary benefits arising from water extraction for residential or industrial purposes; and 2) *in situ* benefits arising from keeping the water in its natural environment. *In situ* benefits include enhanced recreational experiences, higher property values, and improved ecosystem services. Previous economic studies of the benefits of major environmental regulations (such as the federal Clean Water Act) suggest that these *in situ* benefits represent roughly two-thirds of total benefits from improved water quality. The largest single component – roughly three-quarters – of *in situ* benefits arise from more enjoyable water-based recreational experiences such as boating, fishing and swimming. This empirical finding served as motivation for focusing on the recreational benefits associated with the FLNMS.

It was assumed that individuals trade off travel costs (both money and time) against water quality when deciding whether, how often, and where to recreate. A cleaner Falls Lake will be visited more often and will enhance the enjoyment derived from each recreational visit. In both of these ways, improved water quality generates greater benefits to individual recreators visiting the site. Aggregating these incremental benefits from the improved water quality across all recreators represents the total recreational benefits of the FLNMS.

To operationalize this logic, an economic model of recreational behavior was developed. The model assumed that for every year between 2011 and 2040, every adult North Carolinian decides whether and how often to engage in water-based outdoor recreation at 14 North Carolina state parks. Two of the 14 state parks – Falls Lake and Eno River – are located in the Falls Lake watershed and are predicted to experience significant water quality improvements from the FLNMS.

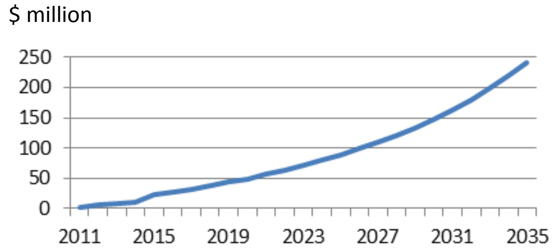
Calibration of the recreation demand model relied on several data sources. 2000 Census data for all North Carolina zip codes was used to characterize the spatial distribution and wages of potential recreators. The distance and travel time from all zip code origins to each of the 14 state parks were calculated with the software package PC*Miler. Time costs (valued at one-third the wage rate, as is typical in recreation demand analysis) were added to money costs (gasoline plus maintenance and repair) to arrive at a round-trip travel cost for each origin-site combination. 2006 water quality data for Chlorophyll-A and five other water quality parameters were obtained for Falls Lake and Eno River from DWQ. These parameters were transformed into summary measures of water quality in consultation with water quality experts. Aggregate visitation data from NC's Department of Parks and Recreation for each site from 2006-2009 were used to calibrate the model's trip predictions at all 14 sites. Falls Lake staff also provided estimates of the number of multi-day trips to the park as well as the number of trips that were not water-based (e.g., mountain biking trips). This information formed the basis for a statistical analysis of North Carolinians' willingness to pay for water quality improvements – that is, the benefits associated with improved water quality.

These willingness to pay estimates were combined with predictions for how water quality will likely change over a 25-year time horizon – with and without the FLNMS – that were developed in collaboration with DWQ staff. The dynamics of other key variables – e.g., park visitation rates, population (especially in Wake and Durham counties), incomes, wages, gas prices, automotive fuel efficiency, and maintenance and repair costs – were specified based on historical trends and expert judgment.

Findings

Figure 1 depicts the predicted undiscounted annual recreational benefits of the FLNMS predicted by the model. The figure suggests the benefits are small initially when the policy has minimal effects on ambient water quality. Over time, the FLNMS generates larger

Fig 1. Undiscounted Benefits from the FLNMS, 2011-2035 (millions 2010 dollars)



benefits as the cumulative effects of the regulations generate more substantial water quality improvements. In total the present discounted value of the policy's recreational benefits are $686 million using a 7% discount rate. This baseline estimate is slightly less than one-half the widely reported $1.5 billion DWQ cost estimate over the same time period.

In order to gauge how sensitive these baseline benefit estimates were to key assumptions made in developing the model, a sensitivity analysis was conducted. This involved comparing the baseline results with results generated using different assumptions about key variables. The results of the sensitivity analysis are presented in Table 1.

The economic model predicts that the FLNMS will generate nearly double the quantity of recreation trips at Falls Lake and Eno River over the 25 year period. This finding is driven by the dramatic improvement in water quality DWQ expects the policy to generate. However, such a large increase in visitation may result in increased congestion that would partially offset the attractiveness of water-based recreation in these parks. To evaluate this possibility, Alternative Specification #1 considered the case where improvement in water quality would generate no increase in visitation rates – that is, benefits would only come via the enhanced experience of the existing visitor population. This exercise suggests that were this the case the undiscounted benefits of the policy would be 31 percent lower – roughly $470 million (or one-third of estimated costs).

Table 1. Estimated Recreational Benefits, 2011-2035 (millions of 2010 dollars)

	Estimated Benefits
Benefits to NC residents (baseline assumptions)	$686
Sensitivity analysis (economic assumptions)	
1) No increase in trips with policy intervention at Falls Lake and Eno River State Parks	$469
2) Marginal willingness to pay for improved water quality rises at 1 percent per year (baseline = no growth)	$884
Sensitivity analysis (H_2O quality assumptions)	
3) Slower degradation in mean Chlorophyll-A readings without policy intervention (1% vs 1.5% annual degradation)	$507
4) Faster degradation in mean Chlorophyll-A readings without policy intervention (2% vs 1.5% annual degradation)	$903
5) Smaller improvement in mean Chlorophyll-A readings with policy intervention (15% and 30% vs 25% and 40% below 2006 levels at Falls Lake and Eno River State Parks, respectively)	$546
6) Larger improvement in mean Chlorophyll-A readings with policy intervention (35% and 50% vs 25% and 40% below 2006 levels at Falls Lake and Eno River State Parks, respectively)	$842
Overall range	**$469 - $903**

Alternative Specification #2 allows for the possibility that individual's willingness to pay may rise as incomes grow over time. Economists have accumulated considerable evidence that our willingness to pay for environmental protection rises as we become wealthier. To reflect this possibility, willingness to pay for water quality improvements was assumed to rise at 1 percent per year. Results from this specification imply 29 percent larger aggregate benefits compared to the baseline predictions.

Alternative Specifications #3-6 assess how sensitive benefit estimates are to alternative assumptions about water quality with and without the FLNMS. The FLNMS' goal was defined in terms of reducing Chlorophyll-A levels. In the baseline model, mean Chlorophyll-A readings were assumed to increase at a rate of 1.5 percent per year at Falls Lake and Eno River without the policy intervention. This is consistent with historical trends. With the policy intervention, mean readings are predicted to fall to 25 percent below 2006 levels at Falls Lake by 2040, and 40 percent below 2006 levels at Eno River by 2040. Considerable uncertainty should be attached to these estimates, however, given the complex biophysical and economic processes at play. For this reason, alternative assumptions about water quality dynamics were considered.

For Alternative Specification #3, it was assumed that in the absence of the FLNMS a slower Chlorophyll-A degradation rate of one percent (rather than 1.5 percent) would take place. This assumption implies a smaller improvement in water quality from the FLNMS, and thus a 26 percent reduction in undiscounted benefits. Conversely, Alternative Specification #4 assumes a faster degradation rate (two percent) in the absence of policy, and thus a larger water quality improvement with the policy. Results suggest a 32 percent increase in undiscounted benefits in this case.

Alternative specification #5 considers a scenario in which water quality improvements at Falls Lake and Eno River are about 60 percent less than what DWQ predicts. For this scenario, benefit estimates fall by 20 percent. Finally, Alternative Specification #6 assumes that Chlorophyll-A levels would fall by more than anticipated – i.e., that water quality would improve more than DWQ predictions. Assuming a 35 and 50 percent reduction in mean levels relative to 2006 conditions, the recreation demand model predicts net benefits will be 23 percent higher than the baseline.

In sum, results from the sensitivity analysis suggest that discounted recreational benefits from the FLNMS lie between $469 and $903 billion. When comparing these benefit estimates to DWQ's widely publicized $1.5 billion cost estimate, a number of considerations should be kept in mind. First, the benefit estimates presented here pertain only to recreation inside Falls Lake and Eno River State Parks, even though the policy intervention will improve water quality throughout the Falls Lake watershed. To the degree that water-based outdoor recreation opportunities improve outside these state parks but within the watershed, aggregate recreational benefits will be larger.

Second, and most importantly, the benefit estimates ignore non-recreational benefits that the FLNMS will likely generate such as higher property values, lower water treatment costs, and more substantial ecosystem services. As noted previously, past assessments of major environmental regulations suggest that one-half of total benefits relate to recreation. Thus it may be reasonable to double recreational benefits to arrive at a crude estimate of total benefits. Doing so raises the estimate range of total benefits of FLNMS to between $938 million and $1.8 billion.

Third, DWQ's $1.5 billion cost estimate is conservative in that it assumes: 1) no technological change that would lower compliance costs over time, and 2) minimal water conservation efforts that would reduce that amount of water extracted and therefore needed to be treated before it is returned to Falls Lake. Thus, the true cost of implementing the FLNMS is likely to be less.

Finally, both the benefits and costs of the policy are discounted at a 7 percent discount rate – the rate suggested by state guidelines. Most economists would argue that this is a relatively high discount rate for evaluating government programs. If a lower discount rate were used, the present value of both estimated costs and benefits would increase. However, the benefits would likely rise more than the costs because many of the costs occur in the early years of the FLNMS (and thus are discounted less) whereas the largest benefits arise in the later years (and thus are discounted more).

Lessons

Given the above considerations, it is uncertain whether the FLNMS will generate benefits greater than costs over the next 25 years. This finding may support the adaptive management approach that DWQ and stakeholders have adopted. If better information about the key parameters affecting the benefits and costs of the FLNMS are obtained in the future, the uncertainties about the net benefits of the policy might diminish such that a clearer judgment about the FLNMS' benefit-cost ratio can be made. This information could then inform ongoing discussions about whether and how to modify the policy going forward.

Quantifying net benefits is a complex task requiring analysts to make a number of assumptions. Those assumptions can give rise to a range of conclusions, as evidenced by the sensitivity analysis described above. Benefit-cost analysis typically ignores distributional considerations, which are often the crux of political discussions. Moreover, a benefit-cost ratio greater than 1 does not imply that a particular policy or investment is the best among feasible actions. Thus, benefit-cost analysis should best be thought of as a policy tool and not a decision rule. Nonetheless, as a framework for policy evaluation, it can sharpen public thinking about how to manage scarce resources.