

Estimating Timber and Non-market Values
Of Maryland's State-Owned Forestland:
A summary of three research papers

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I. Introduction

State-owned forestland in Maryland delivers a range of goods and services whose values are not readily apparent. A central goal of the project that generated the research reported here was to develop better estimates of those values. Additionally, the project sought to extend a better understanding of the economic tools and methods used to estimate non-market values. The usefulness and limitations of these methods become more apparent in their description.

Because many of the goods and services generated by State-owned forestland are not traded in competitive markets, the project had to impute values by the best available methods. For recreational value, this meant enumerating a travel cost survey in order to quantify visitors' willingness to pay to visit forest sites. For passive use or "existence" value, we employed a group-format survey to ascertain how much respondents would have to be compensated to accept an increase in the area harvested on state-owned forestland. For the environmental services component, estimating value entailed adopting a biomass growth model that included the production of both carbon sequestration and timber on state-owned forestland.

The project generated three study reports that provide the basis for the research summary that follows. The interested reader is encouraged to read those background reports for a more complete description of what was done under each component and why. We summarize in the following how we estimated each different aspect of forest value. We also summarize the ways in which our research contributes to the scientific understanding of environmental values and we suggest ways in which it might be usefully extended, to advance our understanding and use of these values.

II. Findings

A. Timber and Carbon Sequestration Values

1. Introduction

Two objectives of the project – estimating State forests' timber value and estimating the value of environmental services they deliver – were combined into a single research component and reported in a two-part background paper¹. This combined estimation made sense on several bases. Most importantly, estimates of both timber value and

¹ Wieland, R and D. Strebel. (2007) Valuing Timber and Carbon Sequestration in Maryland Using MD-GORCAM.

carbon sequestration (the environmental service that it was feasible for us to assess, given data and available methods) are dependent on the change in forest biomass over time, (i.e., the growth of trees in the forest). A single model, using a unified framework, data, and assumptions, allowed us to make sure that estimates of timber and carbon sequestration were consistent. The project was able to make use of on-going research under the Maryland Power Plant Research Program (PPRP).

Prior applications of a carbon sequestration model (Maryland GORCAM) to Maryland forests² generated estimates of carbon stored in forest trees under fixed conditions. But in order to model what might be happening in a more dynamic setting, additional forest management information was required, and representative management scenarios had to be developed. The forest value project was able to access this information for State-owned forests and to develop realistic management scenarios which were then used to adapt the Maryland GORCAM model.

The potential usefulness of forests' ability to sequester carbon from atmospheric carbon dioxide, a greenhouse gas, has been widely studied³. Within this literature, there are somewhat divergent views concerning the long-term treatment of the forests which sequester this carbon. Some researchers, looking at shorter time horizons, suggest that market storage of forest biomass in timber and wood products is overwhelmed by short-term increases in the flow of forest carbon back to the atmosphere from harvest and production waste and by the lower sequestration rates of the young forests that follow a harvest⁴. Other researchers, looking at the global scope and economic incentives of timber growing find that harvesting temperate forests may reduce world-wide forest carbon sequestration through price effects⁵.

While these studies further our understanding of potential long term and wide-spread impacts of forest carbon accounting, they are based on expected market incentives and carbon sequestration production functions that have limited application with respect to Maryland's State-owned forests. These run the gamut from pine forests on the coastal plain to mixed hardwood and softwood forests in the piedmont. These different types of forests lead us to expect different rates of carbon sequestration by virtue of their different species composition and growing conditions. Moreover, Maryland's State-owned forests are managed for multiple uses and, even within the "general management zones" where timber is one management goal, profit maximization from timber production is not a governing objective.

With these considerations in mind, the project gathered information specific to Maryland's State-owned forestland, including: management practices, product utilization, harvest volumes and unit prices. We describe below how this information was used to adapt the MD-GORCAM carbon sequestration model to estimate biomass change in

² Strebel and others, 2002.

³ Intergovernmental Panel on Climate Change, 1996

⁴ See Gutrich and Howarth, 2006.

⁵ Sohngen and others, 2000.

those forests and the fate of carbon stored in that biomass under several relevant management scenarios.

2. Developing a forest biomass growth model

In order to simulate the accumulation of carbon on a forest plot, it is necessary to have some idea how forest biomass changes as the trees in the forest grow and die. Toward that goal, we used a logistic growth function as a reasonable approximation of trees' change in biomass over time. As our tree measurements were principally diameter at breast height (DBH), we used literature values to go from DBH to tree biomass for three different species that are common in Maryland forests: Red Maple, White Oak, and Loblolly Pine. The time that it takes Red Maple and White Oak to go from one DBH category to another was estimated using Maryland forest inventory data⁶ and plot data from the 1999-2000 Savage River Forest Inventory. Loblolly Pine estimates were based on modeled simulations of coastal plain pine forests.

The growth equation for individual trees is not sufficient to describe the net accumulation of biomass by a stand of trees in a forest because as neighboring trees grow larger, they compete for access to sunlight, water, and soil nutrients. Eventually the weaker trees die and the remaining trees expand into the released space. Most of the biomass of the dead trees will be lost as the branches, stems, and roots decay, and the carbon will be returned to the atmosphere. A portion of the carbon, however, will be incorporated into the permanent soil carbon reservoir. In order to simulate the change in the number of trees per acre in our model, a forcing equation links stems per acre to basal area and tree biomass at the starting period. This calculation predicts trees per acre for various DBH classes that matches empirical inventory data.

To estimate the fate of carbon in dead trees and forest litter, we consider three classes of litter with differing rates of decay and then allocate dead tree biomass among these three classes. Small trees that die are assumed to have a 50-50 mix of rapid decay litter and 10 year decay litter. Larger trees are assumed to have a smaller proportion of rapid decay litter (25%), but to have 25% of their biomass in large branches and stems that enter the 20-year decay pool when the tree dies. The decay and sequestration assumptions are summarized in **Table 1**⁷.

Table 1. Deadwood Decay

Tree Size at Death	Biomass to Atmosphere	Biomass to 10-year Litter Pool	Biomass to 20-year Litter Pool	Biomass to Permanent Soil Pool
	(instantaneous decay)	(0.1 of pool returned to atmosphere/year)	(0.05 of pool returned to atmosphere/year)	(0.01 of 20-year pool added/year)
Small (≤ 12 " dbh)	50%	50%	None	None
Large (> 12 " dbh)	25%	50%	25%	Indirect

⁶ Frieswyk and Giovanni (1990)

⁷ Source: Table 3, pg 6, Wieland and Strebel 2007.

3. Harvest effects

If trees die naturally in the forest, as discussed above, most of their carbon is released back to the atmosphere. The wood from trees that are harvested, on the other hand, may be preserved intact for very long periods. GORCAM, in its fullest implementation, is capable of tracking the fate of carbon in a variety of possible wood products if the rates of creation, conversion, and decay can be determined. We have adapted the GORCAM model so that wood from harvested trees may be left in the forest to decay, lost to sawdust or chips during processing, or end up as lumber that lasts for relatively long periods.

It is difficult to know the precise disposition of harvested wood biomass among wastage, residual and finished product. Birdsey (1996) estimated that over 70 percent of the carbon stored in standing timber is returned to the atmosphere soon after a harvest. Based on industry expectations reported by Maryland DNR utilization staff, we estimated that 1/2 of the tree biomass is left behind in the forest as unusable⁸. Of the half that is removed from the forest, only about 1/2 (1/4 of the total standing biomass) is actually turned into lumber. About 1/8 of the total is rendered into sawdust during processing, and the remaining 1/8 ends up as wood chips. The wood chips are typically collected and processed into composite products that are marketed for use as solid wood substitutes. This treatment is, we believe, generally representative of Maryland forest products utilization and it is not widely divergent from Birdsey's estimate.

Using these estimates of the rough distribution of harvested biomass, we can construct order-of-magnitude estimates of lumber yield and carbon sequestered. We assume that the material left in the forest adds directly to the existing litter pools and shares their fate. Sawdust is assumed to decay and release its carbon back to the atmosphere immediately. The chipwood products represent an intermediate term carbon storage pool (10-20 years), although we do not carry out further analysis of the size and decay of this pool⁹. Similarly, we assume that the lumber products themselves form a long-term carbon storage reservoir, without accounting for their functional longevity or ultimate disposition. The net result is an estimate of carbon sequestered in the lumber and chipwood at the time that it leaves the mill. The treatment of harvested products is summarized in **Table 2**.

Table 2. Distribution of harvested biomass.

Product:	Litter	Lumber	Chips	Sawdust
Biomass Fraction:	1/2	1/4	1/8	1/8
Disposition:	Decays in 10-20 years	Long term carbon storage	10-20 year carbon storage	Carbon released to atmosphere

⁸ There is increasing recognition that this material could be used for biofuels, e.g. Westbrook & Greene, "Adding a Chipper to a Treelength System for Biomass Collection", Forest Resources Association, Technical Release 07-R-3, February, 2007. In our estimates we do not include the carbon sequestration benefits that would accrue from the resulting reduction in fossil fuel use.

⁹ There is little certainty about the fate of chips in Maryland and the approach we adopted conservatively discounts the carbon sequestration implications of longer-term market storage in lumber substitutes.

With these assumptions in place, we can estimate, for any given harvest schedule, both wood product yields and carbon sequestration amounts. The simplest scenario is a fixed-length rotation in which trees grow without management between clearcut harvesting events. This is the fundamental scheme built into GORCAM. Forest management on Maryland's forestlands, however, sometimes employs one or two "thinning" harvests that alter the production and distribution of biomass. We adapted GORCAM to run in a piecewise fashion to account for these harvests and the growth of the forest plot between them. Different functions were developed for mixed hardwood and Loblolly Pine forests.

4. Model results

Using the growth predictions of the biomass model, and our specified expectations regarding natural and harvest mortality, the number of pounds of carbon sequestered per acre of forest can be estimated. This estimate takes account of carbon stored in the soil, returned to the atmosphere and sequestered for the long term as wood products. It can therefore be used to generate an average annual rate of carbon sequestration for forested acres, so that different management scenarios using different timber rotations can be compared with respect to this variable. **Table 3** reports the estimated average annual rates of carbon sequestration for several different rotation scenarios for White Oak and Loblolly Pine.

Table 3: Expected Pounds of Carbon Sequestration Under Various Timber Management Scenarios

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Units
White Oak					
Returned to atmosphere	156,177	167,357	243,315	382,178	lbs/acre
Sequestered	152,690	148,849	194,952	240,586	lbs/acre
Sequestration Rate	2,063	2,011	2,096	1,718	lbs/acre/yr
Loblolly Pine					
Returned to atmosphere	47,855	76,806	80,185	184,186	lbs/acre
Sequestered	76,825	80,578	117,857	117,356	lbs/acre
Sequestration Rate	1,787	1,874	1,964	1,381	lbs/acre/yr

White Oak Scenarios

- Scenario 1 Grow to 12", Thinning at 12" Final harvest @18" (74 yrs)
- Scenario 2 Grow to 18", Final harvest @ 18" (74 yrs)
- Scenario 3 Thinning at 12" Final harvest @25" (93 yrs)
- Scenario 4 No thinning, no harvest to natural mortality (140 yrs)

Loblolly Pine Scenarios

- Scenario 1 Thinnings @ 6"dbh and 8"dbh, and clearcut @ 12"dbh (43 yrs)
- Scenario 2 Grow trees to 12" and clearcut (43 yrs)
- Scenario 3 Thinnings @ 6"dbh and 8"dbh, and clearcut @ 18"dbh (60 yrs)
- Scenario 4 No thinning, no harvest, to natural death at 85 years

With the “per forested acre” estimates of biomass accumulation and our assumptions about what comes off in a harvest, we are able to compare the model’s predicted timber production per acre with historical output from the relevant State Forests. To do this, we convert our volume estimates, which are in pounds, to board feet. For hardwoods we use the ratio of 14 pounds of green biomass to one board foot of lumber and for Loblolly Pine we use the ratio 12.5 pounds of green biomass per board foot. A key comparison is white oak grown to 93 years with no thinning harvest. The model predicts that a stand of this age will generate 14,763 board feet of lumber per acre. However, when we look at the average harvests from the Savage River, Green Ridge and Potomac-Garrett State Forests, average board foot yields only rise to 6,793 bd. ft. per acre. These harvests are of stands estimated to be between 90 and 110 years old.

Several factors must be considered when comparing the average historical yields with our model results. First, the historical yields are calculated by dividing harvested area by tally (board feet) volume. This approach underestimates true yield per acre, to the extent that acres marked as harvested include non-harvested acreage (buffers – see below). Secondly, our model assumes a forest of a single species that grows in the manner of white oaks (growing in mixed hardwood stands). Given that most other species do not produce the volume after growing 93 years that white oaks do, we expect our estimate to be somewhat high. A third consideration is that our model was calibrated with growth data from Savage River State Forest where conditions for growth are somewhat better than either Green Ridge or Potomac-Garrett. When we look at annual board feet per acre measures for Savage River, 2003’s harvest was over 17,000 board feet per acre and the most recent two years were both greater than 10,000 board feet per acre. The average over nine years is brought down by several years of low-yielding harvests. And, fourth, the board foot harvest figures do not take into account cordwood, which amounts to 8 cords per acre across the sample of harvests.

Whereas the model’s predicted productivity for White Oak as a proxy for mixed hardwood appears high, predicted values for Loblolly Pine are lower than historical yields. If most of the stands harvested in Pocomoke State Forest are 70 years old, they generate an average yield of 17,821 board feet per acre. The model predicts that at 70 years, with no thinning harvests, the yield should be around 8,940 board feet per acre.

The model’s underestimate has two likely sources. First, we maintained the rate of removals to standing biomass (50 percent) that was assumed for hardwoods. Because so much of Pine’s biomass is in its trunk, it is possible that a larger percentage of the standing biomass is removed in harvests. Maryland straddles the border between southern forests where removals average 91 percent of softwood standing biomass and the northeastern forests where harvest removals average 53 percent of softwood standing biomass. Clearly, more accurate data specific to the State would help to refine this measure. Secondly, the model uses a basal area of 100 square feet per acre, and it is possible that the State Forests have a higher stocking rate than implied by that measure.

5. Carbon and timber values under different rotations

In our final application of the forest biomass growth model, we adjust our results to the actual \$/acre averages received in the forest(s) relevant to our Loblolly Pine and mixed hardwood estimates and use the biomass growth model to factor those returns for rotations of different lengths. In the case of Loblolly Pine, it is assumed that the per acre biomass at year 70 is to the historical price of harvested stands (reported to average 70 years old) as the per acre biomass at year sixty is to an imputed value for a 60 year old stand. The factor for the value at year sixty is the ratio of the two predicted biomass volumes times the 70 year value. Mixed hardwood forests are assumed to be 93 years old when they are harvested and a similar factor is applied to the value at year 93 versus values at different rotation lengths.

In the course of analyzing harvests over the past nine years at the three western forests, it became apparent that the harvest rates within the general management zones would, if continued, require up to 209 years to return to stands harvested now. The average length of rotation that foresters at those forests describe as applying, however, is 100 years. This mathematical disparity is likely a result of the fact that many of these forests were cut 75 to 100 years ago, before they entered the public lands. As these forests mature, it seems likely that there will be scope to increase harvest rates.

Regardless of how harvest rates may change, the current rate at each of the western forests is used as basis for estimating the average annual increment in the value of its timber. As a comparison value, the value of the average annual increment for a 93 year old forest is also calculated. In addition to these timber value estimates, we also factor the model estimates for carbon sequestration by hypothetical prices for carbon storage. Considering a range of prices comparable to those envisaged under the Regional Greenhouse Gas Initiative¹⁰, we can estimate the value of the average annual increment for carbon sequestered, given a specific rotation length. These results are reported in **Table 4**.

Table 4: Imputed Periodic Mixed Hardwood & Loblolly Pine Scenario Values

Scenario	Timber \$/acre/year	C@\$14.68 /ton \$/acre/year	C@\$25.69 /ton in \$/acre/year	C@\$37.60 /ton \$/acre/year
WO (209)	17.98	6.74	11.79	17.26
WO (153)	24.30	8.86	15.50	22.69
WO (120)	28.99	11.93	20.87	30.55
WO (93)	30.55	14.80	25.91	37.92
Pine (70)	77.89	11.02	19.28	28.22
Pine (60)	85.33	12.41	21.72	31.79

¹⁰ The carbon values used for this table are \$7.00 per ton carbon dioxide plus or minus \$3.00 and factored by 3.67 – the ratio of the molecular weight of carbon dioxide to our measure – carbon.

The values reported in **Table 4** do not take into account the time value of money (the interest rate) but only allocate a final harvest return evenly over the years that it took to generate that return. Discounting the final harvest price over those years would increase the timber value difference between the longer and shorter rotations.

While the value estimates generated by this deterministic model are reasonable, additional research to improve our estimates of growth in forest biomass and harvest removals would strengthen the usefulness of the model. The project sought to determine a single measure for all forests, although site-specific estimates would better inform managers about the timber value and carbon sequestration values of different management practices at each forest.

B. Recreational Values

The recreational value study enumerated a survey of visitors to three different sites from Maryland's State Parks and Forests. We completed 461 surveys on 34 days. The data were used to estimate recreational consumer surplus at those sites, using a method known as travel cost analysis. The survey and its analysis are reported in a research report by Wieland and Horowitz titled, *Estimating Recreational Values at Three Forested Sites in Maryland*. The following summary draws from that report.

1. Overview of the Travel Cost Model

The money and time that individuals spend to travel to a park or forest can be used to measure the value of their outdoor recreation experience. An extensive economic and statistical literature¹¹ has been developed to analyze these time-and-money costs, known as "travel costs." The underlying concept and the set of analytical tools used to advance it have been applied to fishermen, beachgoers, hikers, birdwatchers, wildlife-viewers, picnickers, mountain bikers, and many others. This research generates measures of the value of a fishing spot, beach access, a hiking opportunity, etc.

Travel cost analysis thus presents a useful framework in which to examine the recreational values of Maryland State-owned Forests. This approach estimates the value of recreation to the users, that is, the recreationists. It is important to recognize that the approach does not measure the value of the forest to the local economy, which is a separate concept.

The value derived from outdoor recreation is estimated based on the relationship between participants' costs of traveling to a site and the number of trips that they take. Individuals who live farther from a site incur greater time and money costs to visit the site and therefore typically make fewer trips over any given time period. In simple terms: if people are willing to spend \$X per trip to go to a site y times per year, they must get satisfaction worth at least $y \times \$X$ from doing so. This idea can be used, as described below, to estimate recreational value on a per-trip basis. Value in this context is what

¹¹ For an overview, see: Haab and McConnell, 2002.

economists label “consumer surplus,” a quantitative, dollar-denominated measure of individual satisfaction.

Travel cost analysis requires us to measure the time and money costs of visiting a site for each visitor. To gather the requisite information for this analysis, we conducted visitor surveys at Patapsco Valley State Park, Shad Landing State Park (Pocomoke), and Green Ridge State Forest from September 2005 to August 2006. A total of 461 surveys were conducted. Patapsco is a large State Park with multiple access points starting northwest of Baltimore City and extending almost to the Patapsco River’s mouth near Baltimore Harbor. Green Ridge is a State Forest about 140 miles west of Baltimore and Shad Landing is a State Park within the larger Pocomoke River State Forest on the Eastern Shore, about 140 miles south and east of Baltimore.

Visitors were asked their trip distance, trip time, number of trips per year, and personal characteristics, including income, age, and education. These data are the essence of travel cost analysis. Travel cost data are rough yet remarkably informative. Researchers, including this study, almost invariably find that a higher per-trip cost is associated with a lower number of trips, which is the basic relationship that motivates travel cost analysis. Travel cost analysis remains our best tool for valuing such recreational experiences.

Our analysis shows that visitors to the three study sites derive considerable utility from recreation there. Quantification of this utility, through the application of the model described in the technical report, provides estimates for per trip consumer surplus of \$96 for day users and \$400 for average overnights. This “per trip” value can be multiplied by the number of visitors (using DNR data) during the study period to yield a measure of annual consumer surplus generated by access to these parks and forests.

2. The model and its data

Our model for demand for trips uses a semi-log functional form which enjoys a number of advantages over its alternatives. Under this formulation, the consumer surplus per trip is easily calculated as the inverse of the cost coefficient.

The most important variables in the equation are those that are used to estimate travel costs. These include vehicle costs (as a function of distance) and the visitor’s opportunity cost of time (with respect to travel time, not time spent onsite). Several different specifications for time values were tested.

In examining the travel data across the three sampling sites, it was apparent that there were large differences between the travel costs of average overnight visitors and the average day use visitor. Moreover, in considering the nature and costs of a day visit versus an overnight visit, it is apparent that these are two different recreational experiences. Day users who decide to stay longer incur no additional cost except for the opportunity cost of time. Individuals who decide to stay overnight incur an extra cost. We therefore estimated separate models for day visitors and overnight visitors.

3. Findings

For day use visitors, we considered several different ways of calculating travel costs. Using four different specifications for these we obtained per trip consumer surplus estimates ranging from \$83 to \$118 per visitor. We adopted an intermediate value of \$96 as our preferred estimate. Using DNR visit data over the year that the field work was undertaken we generated estimates for the total visitor consumer surplus generated by the three sites. These are reported in **Table 5**.

Table 5: Annual Day-Use Consumer Surplus at the Three Forests		
Site	Annual Day Use Visitors	CS from Day Use @ \$96/visit (\$millions)
Patapsco	825,669	79.26
Green Ridge	16,294	1.56
Pocomoke	69,057	6.63

It needs to be noted that, of the three sites, Green Ridge has the greatest difficulty in counting the number of day visitors who use the site. The counts used here are of visitors who presented themselves at the Forest headquarters – an unknown fraction of total visitors.

Value estimates for overnight visitors are complicated by the absence of a theoretically consistent treatment for visits of different lengths and by the considerably fewer observations. We again used several different approaches (see report). Predicted consumer surplus per visit for Green Ridge and Pocomoke was \$369 and \$434, respectively. We were not able to estimate a value for Patapsco because there was not sufficient variation in the per-trip costs; see report for further explanation. We therefore chose an average of the Green Ridge and Pocomoke values (\$400) as a lower-bound estimate for Patapsco.

With these values and adjusted visit data we were able to estimate total consumer surplus for overnight visits at the three sites. These were estimated at \$1.96 million at Green Ridge, \$5.11 million at Patapsco, and \$5.89 million at Pocomoke.

It is important to recognize that our values, both per-day and total, are not measures of the value of the forest or park to the local economy. While local economic effects can be important to local economies, they “wash out” in the aggregate since any change in economic activity in one locale is typically offset by a change in economic activity elsewhere. This broad claim is based on services such as capital and labor being mobile and fully employed. This is the correct assumption for a state with a highly developed economy and a high-level of economic activity, such as Maryland.

C. Existence Value

1. The Meaning of “Existence Value”

Even Maryland citizens who do not visit Maryland’s State Forests or otherwise use the forest’s services may have opinions about or feelings for the status of these forests. In economic terms, these feelings form a category of environmental value known variously as passive use value, existence value, or non-use value.

This category represents the value placed on an environmental asset beyond the products or services it provides; beyond the wood products, outdoor recreational experiences, and ecological services such as watershed protection or carbon sequestration. It represents the value of “just knowing something is there.”

The role of existence value was established within neoclassical economics by Krutilla (1967). In the legal arena, U.S. courts have upheld the validity of existence value in the assessment of damages in natural resource cases, although this remains an evolving legal area¹². Existence value was a large component of the liability damages imposed in the Exxon Valdez oil spill. In that case, most people in the U.S. recognized that they would never visit the degraded area, Prince William Sound, or see the wildlife that lives there, but they were willing to pay something to keep the area pristine and ecologically functional; that is, they valued its existence.

The measurement of existence value is difficult, however. Because this value is, by definition, independent of the number of visits to a forest or the amount of “product” the forest produces, it can be estimated only through subjective surveys (Haab and McConnell 2002; Smith 2004).

It seems likely that existence value is substantial for Maryland forests, sufficient to warrant such a survey. This chapter reports a study of values expressed by Marylanders over forest management approaches for Maryland State Forests. More than 400 in-person surveys were conducted between February 2006 and March 2007 using two survey techniques (open-ended and closed-ended).

2. The survey

Even the best designed valuation surveys can be controversial. The subjective and hypothetical nature of the questions means that individuals are essentially unconstrained in their responses. Various survey practices can be used to minimize this problem. We followed state-of-the-art practices for valuation surveys (e.g., Arrow et al., 1996). We also included several new survey features designed to strengthen our results. An overview of the literature on valuation surveys is included in Horowitz (2008).

¹² See Arrow and others, 1996.

2.1 Protocol and population sampled

We used a *group format* to administer the surveys. Group format means that a group of individuals sits in a room, hears the survey described, and, if desired, asks questions aloud about the issues or the survey. At the end of the session each individual fills out his or her own survey. Group format surveys are like very large focus groups except that the tasks are more structured than the typical focus group. The groups recruited were non-profit organizations such as Parent-Teacher-Student Associations, citizens' associations, churches, or sports clubs. Twelve groups were surveyed for this research.

Group formats have most of the advantages of in-person surveys but at much lower cost. They also have many benefits over mail, telephone, and intercept surveys.

The group format approach has two possible disadvantages. First, the survey sample may not be representative of the general population in terms of observable geographic and demographic characteristics (income, race, education, location). We attempted to survey a wide range of socioeconomic groups. Since we found small socioeconomic effects across this sample, we did not attempt to expand further. Second, the survey sample may not be representative of the general population in terms of unobservable tastes and preferences. Group formats tend to attract more sociable individuals. This sociability *may* be an advantage for the group format, since it seems likely that individuals who attend group surveys are more likely to vote. The effects of this feature on survey outcomes are not known, however.

2.2 Forest valuation scenario

The heart of the survey was a question about management of Maryland State Forests. The economic concept of value requires a choice between two specific options. Think of these as “A vs. B” or “Before and After” or “With and Without.” It is not possible to value solely “Maryland forests”; a concrete alternative is needed. Just as with voting, if an issue is put to the voters, voters should know what will happen if the referendum passes or fails. We set up two options for Maryland forests: an “as is” scenario describing current management plans and an alternative with more area available for harvest.

Harvest area was chosen as a focus in our survey for two reasons. First, subjects could easily understand the options. It was also possible to demonstrate the options using photos, pie charts, and verbal description. Participants could understand the reason why the two options might be considered and why greater harvest area would yield additional revenue; that is, why a money-environment tradeoff exists and why choosing a point on this tradeoff was necessary. The second reason is that this is a dimension over which Maryland foresters have some leeway. Harvest area captures the balance between “working forest” and “natural forest.”

2.3 Survey design: Open-ended surveys

The first four surveys used an open-ended framework. In the open-ended framework, individuals report a dollar amount that represents their willingness-to-accept (WTA) the hypothesized change in harvest area (see Horowitz, McConnell, and Quiggin, 1999). A sample question is shown below. See technical report for the full survey and exercises.

Economists have recommended that this decision [described aloud and in survey handout] be based on voting by Marylanders to compare the increase in revenue against the changes to the forest.

I would like to know: What is the smallest amount of money that would lead you to vote in favor of accepting a yearly check from the State* and an increase in acreage available for harvesting by 33,000 acres?

What is the smallest amount of money that would lead you to vote in favor of accepting the offer and increasing the acreage available for logging?

Amount: _____ (yearly, per adult)

The procedure would be exactly the same as for the flashlights [see survey]:

If more than half of voters would have accepted the available payment, then the harvest area would increase and the State would make the payment to all eligible adult residents.

If more than half of voters would not have accepted the payment, then the harvest area would stay the same and no payments would be made.

*This situation is being used to help economists make recommendations that reflect people's household budgets and their values for the portion of the State Forests that are eligible for logging. This is a *hypothetical* situation, a *hypothetical* vote, and *hypothetical* payment.

2.4 Survey design: Closed-ended surveys

The remaining surveys used a closed-ended format: one requiring a yes or no answer. Closed-ended questions are also known as discrete choice or dichotomous choice. The harvest-area question looked like this:

Suppose the State payment [if the harvest area was expanded] were **\$37** per adult resident per year. If more than half of the people vote in favor, then the acreage available for harvesting would increase by 33,000 acres (330 additional acres harvested per year), and every adult would receive the payment.

State payment to you: \$37 (per adult, per year)

Your vote: _____ (YES)
 _____ (NO)

The dollar amount varied across surveys. For example, in the version of the survey administered in LaPlata, each participant received a survey listing one of the following amounts: \$18, \$38, \$78, \$178. These amounts were distributed randomly across subjects. See 3.2 below for discussion of how this approach can be used to provide estimates of median willingness-to-accept.

3. Results

3.1 Open-ended valuation

Table 6 shows mean and median values for the increase in harvest area for two samples: the entire sample and the sample restricted to “economically plausible” responses. In column 1 (Mean) we eliminated responses of “\$0” since most of these are likely to be protest responses. We also eliminated responses over \$5,000. See technical report for discussion of these cut-offs and the underlying rationale for imposing them.

Mean (# obs.)	Median (# obs.)	Trimmed mean (# obs.)	Trimmed median (# obs.)	Right-trimmed mean (# obs.)
\$173,500 (107)	\$1000 (107)	\$870 (60)	\$375 (60)	\$225 (68)

3.2 Closed-ended valuation

The offer that individuals voted on differed across surveys. In general, the higher the amount offered, the greater the proportion of people who would vote yes. That is, we might expect 20 percent of the participants who received an \$18 survey would say yes, whereas 60 percent of the participants who received a \$178 survey would say yes. We can use the pattern of responses to estimate the dollar value at which 50 percent of respondents would say yes. This is the estimated median WTA. The estimation procedure was developed by Hanemann (1984).

Estimation takes the form of a logistic regression where the dependent variable is 0 or 1 (no or yes) and the right-hand-side variables are a constant and the individual offer amount (e.g., \$37 in the above example).

Table 7 reports results from groups where WTA can be calculated. See report for discussion of this issue.

Table 7. Logit Results from Closed-Ended Surveys

	Baden	Bester-A	Bivalve	Potomac Hts.
Intercept	-2.47	-1.14	-3.06	-1.28
Offer	0.018	0.073	0.015	0.0065
Implied median WTA	\$137	\$15	\$204	\$197
<i>n</i>	46	53	29	13

Dependent variable is the 0-1 (no-yes) response.

3.3 Values for Maryland Forest Management Options

Tables 6 and 7 present our main results. The open-ended approach has the advantage that participants report individual WTA values. This has the disadvantage, however, of yielding many implausible responses. This problem also occurs for ordinary goods (Horowitz and McConnell, 2000). It remains a perplexing problem for research on willingness-to-accept.

In closed-ended surveys, only the group's median value can be observed. Closed-ended surveys are considered superior to open-ended surveys because of their close connection to the democratic process, a connection we elaborate on in the technical report. Closed-ended surveys do not provide any opportunity for individuals to report implausible responses, however, and therefore the results may be sensitive to the highest offer price that is used in that sample.

Our open-ended surveys yield median WTA estimates of around \$375 per adult per year for an increase in potential harvest area of 30,000 acres. Our closed-ended surveys yield median WTA estimates of around \$200.

These numbers are predictions of the price (for example, a rebate to all Marylanders similar to what has been provided by the state of Alaska to residents as payment for natural resources revenue) at which a referendum on increased harvest in Maryland would pass. They are, however, much higher than any revenue that would possibly be gained from increasing harvest. They suggest that any increase in harvest area of Maryland State Forests would almost surely fail a benefit-cost test.

An alternative policy question is whether harvest area should be decreased. In this case, the appropriate measure of value is *willingness-to-pay*. For environmental goods and

services, willingness-to-accept has consistently been found to be 10 times higher than willingness-to-pay (Horowitz and McConnell, 2002, Table IIIA).

Our study predicts willingness-to-pay, per adult per year, for a decrease in potential harvest area of 30,000 acres, of between \$20 and \$45. This reflects primarily non-use value but may include some recreation values. This number can be compared to estimates of lost harvest revenues for a benefit-cost test of a possible decrease in potential harvest area of Maryland State Forests.

4. Alternatives to measures of existence values

4.1 Environmental Services *versus* Existence Value

It is not always clear why individuals want to protect the environment. Some individuals justify their desire to preserve the environment on moral or cultural grounds – protecting the environment is the “right” thing to do. This is an existence value. Other individuals justify environmental preservation by the services that the environment provides – it sustains life, through water, air, climate, and biological resources (biodiversity). These are environmental services. Environmental services are the ways in which the environment adds to our material well-being, including amenities such as comfort.

Existence values and environmental services have very different implications for the role of economists, scientists, and the public, and for environmental valuation approaches. If individuals want to preserve the environment based on moral and cultural grounds, then individuals are the “experts” to whom we should appeal in making environmental decisions. Individuals are the ones who should say what the right level of existence value is. This is the principle underlying valuation surveys.

On the other hand, if individuals want to preserve the environment because of the environmental services it provides, then scientists and economists are the experts to whom we should appeal in making environmental decisions. Scientists and economists will have the most reliable information on such services. Valuation surveys, which elicit the public’s opinions and values, would be a poor stab at an estimate of the value of environmental services.

Both sources of values may have been reflected in the responses to our survey. Therefore, our research included an effort to distinguish between these two sources of values.

4.2 Scientists *versus* Public Opinion for Environmental Decisions

Our surveys also asked participants about their willingness to cede environmental decisions to resource managers. A sample question is shown below. This question was included in all surveys before the harvest-areas valuation question.

A. When society is choosing wild areas to protect, should priority be given to:

_____ Those areas that scientists say are most important to maintaining the Balance of Nature, *or*
 _____ Those areas most enjoyed by people?

If citizens are concerned about protecting the balance of nature and the integrity of the natural environment then we would expect them to rely on scientists, not public opinion, to make decisions about environmental protection. On the other hand, if they wanted environmental protection to reflect individual values that would not be available any way other than by canvassing citizens (such as through the surveys in Part 3) then we would expect them to select the latter option.

We used two other versions of this question, labeled B and C. There were two parts to version C. Results are shown in **Table 8**.

Table 8. Responses to Questions A, B, and C

	Rely on scientists	Rely on public	n
A	82%	28%	258
B	70%	30%	67
C-a	80%	20%	20
C-b	70%	30%	20

These show a remarkably widespread willingness to rely on scientific expertise for environmental decisions.

Table 8's results must be viewed with caution. A generic willingness to accept scientific expertise is not the same as willingness to accept scientific judgment in any specific instance. Note that this line of research is relatively new. In particular, question wording has not been subject to the long academic process that environmental valuation questions have. Other cautions are described in the accompanying report.

III. Discussion and recommendations

The estimation of timber, carbon sequestration, recreational and existence values described in this summary provides quantitative measures of those values grounded in an economic framework. Along with generating these estimates, we have attempted to explain the analytical models on which they are based. By seeing how these values are derived, the reader can more readily understand the uses to which they can be put, as well as their limitations. These limitations range from uncertain technical production functions to conceptual gaps in the definition of environmental values.

Our estimates provide quantitative measures of four important services provided by forests. As a first approximation of the forests' timber value, we can multiply the estimated per acre average annual yield for the mixed hardwood forests times the effective general management zone acreage (e.g., decreased by 30 percent for buffers) for an annual timber increment value. This works out to \$532,236 at Green Ridge, \$650,226 at Savage River, and \$223,870 at Potomac-Garrett. A corresponding annual value estimate for the Loblolly Pine forest at Pocomoke State Forest is \$477,680. These estimates are based on a single average value from Maryland-wide growth data, State forest harvest data, and expectations for biomass change under the most favorable rotation scenarios (with respect to average annual accrual) for White Oak and Loblolly Pine.

Similar estimates can be derived for carbon sequestration from these same data, taking carbon values as exogenously determined. Moreover, the average annual increment for carbon, like that for timber, is sensitive to changes in the length of rotation. A contract to grow trees for sequestering carbon should therefore take account of rotation length in determining the carbon sequestration value of any given project. If the timber is being grown under a profit maximization objective where interest is accounted, adding the value of carbon sequestration will lengthen the optimal rotation. Under the volume-maximizing objectives apparent on Maryland's forestland, carbon sequestration values will also be maximized. However, under very long rotations that exceed the maximum volume yield, accounting the value of carbon sequestration would argue for shorter rotations.

Our study of recreational value on State-owned forestland generated estimates of total consumer surplus from day use and overnight recreation on the order of \$3.52 million at Green Ridge, \$12.52 million at Pocomoke, and \$84.37 million at Patapsco River State Park. These estimates quantify the recreational benefits derived from public access to these forests. Unlike timber value, which entails income paid to the state from the sale of stumpage and carbon value that might someday be priced in a market, these recreational consumer surplus estimates do not represent money income to state-owned forests. Some income is derived from nominal charges for camping and visit access, of course, but our value estimate captures a broader measure of the recreational benefit generated by public access.

The sensitivity of these recreational values to forest attributes (e.g., size or age of the forest, quality of built amenities, management practices, and others) was not directly investigated and remains an important area for further study. Our calculations of value are premised on the per-unit value remaining roughly constant, so that any changes in the overall value due to changes in management would be due to increases in the number of visitors. We have argued that (potential) change in recreational values owing to a change in management is an empirical question and we have indicated the scale of the value at risk. Clearly, forests close to urban populations have great recreational value.

The relationship between recreation and timber extraction is one example of a management question that might be addressed by further study of recreational values. A prior expectation might be that timbering reduces recreational value by creating unsightly stands of slash and stumps. This would imply that timber and recreational uses are competitive products and that producing more of one implies less of the other. Alternatively, if (as at Green Ridge) camping facilities are placed at landings that were originally cleared for timber extraction and reached on roads originally improved for logging trucks, or, if young transition forests generate wildlife benefits that are in turn enjoyed by recreational users, it might be that timber extraction is complimentary to recreational value. Because both recreational and timbering activities take place at some of the same forests, these hypotheses could be empirically tested.

The existence value survey directly examined the question of increasing harvests on State-owned forestland and found that, among our samples, people would need to be compensated by more than the revenues that would be generated by the additional harvesting; by a large margin. This research also provided an estimate of citizen's willingness-to-pay for a decrease in harvesting. We predict that a majority of Maryland voting age residents¹³ would be willing to pay \$20 for a 30 percent decrease in timber harvests, which works out to roughly \$84 million per year. This far exceeds the value lost from reduced timber harvest.

On the other hand, a sizable fraction of our sample thought it best to leave resource use decisions to professional scientists and economists. This latter way of framing the public policy issue has not received much attention from environmental economists, and surely warrants further research.

Using economic considerations about both market and non-market values can help policymakers decide between well-specified management actions on forests. Additionally, considering these values can be important with respect to other forestland in the State which public moneys secure. In particular, a large share of Maryland's protected lands is made up of private property on which the State has bought an easement, limiting the owners' ability to change current land use. If those lands are forested, they provide potential timber and environmental services and likely generate existence value. But they do not provide recreational services, to the extent that access to them is restricted to the owners and those to whom the owners have given permission to visit. As we have shown that recreational values can be quite significant, this limitation

¹³ This figure is based on US Census figures for Maryland's population over 18 years of age and not voters.

might be a factor in the State's considerations for allocating resources between either buying easements or increasing public landholdings.

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