Valuing New Jersey's Natural Capital:

An Assessment of the Economic Value of the State's Natural Resources

April 2007

State of New Jersey
New Jersey Department of Environmental Protection
Jon S. Corzine, Governor
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PART III:

NATURAL GOODS

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Executive Summary

I. Overview and Scope

Part III of this three-part report on New Jersey's natural capital deals with the natural goods provided by New Jersey's natural assets, i.e., its living and non-living environment. The concepts of natural capital and natural assets emphasize the fact that the natural environment, like any other capital asset, provides a stream of economic benefits over an extended period of time; given maintenance of that capital and sustainable harvest levels, those benefits can in principle be generated in perpetuity. The natural goods dealt with are divided into seven categories for analytic purposes: water, minerals, farm products, non-farm animals, non-farm plants, fish, and wood. This report is careful not to double-count ecosystem services covered in Part II.

II. Determination of Economic Value

Total Economic Value (or Total Willingness to Pay) has two main components: Market Value and Consumer Surplus. Consumer Surplus is the amount that consumers would be willing to pay for a natural good but do not actually have to pay. Market Value can be obtained from official and quasi-official data for all of the natural goods discussed in this report; Consumer Surplus, however, must be estimated. Economists have developed various ways of generating such estimates, but many of those methods require data that is not readily available or involve mathematical techniques that result in implausibly high estimates of Consumer Surplus. This report uses a more conservative approach based on the assumption of a linear demand function and a point estimate of elasticity of demand; this approach allows Consumer Surplus to be estimated based solely on Market Value and elasticity.

III. Water Resources

Based on information in the 1996 Statewide Water Supply Plan**,** New Jersey's natural environment provides between 494 and 579 billion gallons of raw (unprocessed) water annually.[1] That resource has an estimated *in situ* market value of $0.394 per 1,000 gallons. In order to measure only the value of the water itself, that figure excludes the costs of treating the water and delivering it on demand to end users. Based on the methodology described in Section II and Appendix A the Total Economic Value of that water in 2004 dollars is estimated to fall between $262 and $696 million/year (central estimate = $385 million/year), including the estimated Consumer Surplus. The present value of that benefit stream is between $9 and $23 billion (central estimate = $13 billion), based on conventional discounting at 3%/year in perpetuity. These values are subject to change based on changes in land use, climate, and other factors.

IV. Mineral Resources

According to 2004 data from the United States and New Jersey Geological Surveys, New Jersey's mines and quarries provide an average of $321 million in Market Value annually in construction and industrial sand and gravel and crushed stone. (That figure excludes a significant amount of sand dredged offshore by the U.S. Army Corps of Engineers for use in beach

[1] To avoid double-counting, these figures are net of water used for agriculture (including irrigation).

replenishment.) In order to measure only the value of the minerals themselves, the $320.9M figure excludes the costs of delivering them to end users. The Total Economic Value of that annual output in 2004 dollars is estimated at between $481 million/year and $1.1 billion/year (central estimate = $587 million/year), including the related Consumer Surplus. The present value of that benefit stream is between $16 and $37 billion (central estimate = $20 billion. These values are subject to change based on changes in extraction rates, which in turn depend on the demand for these materials.

V. Agricultural Products

Based on information from the U.S. Department of Agriculture, New Jersey's farms provided plant and animal products with a total Market Value of $787 million in 2004 dollars or $108 million net of farm production costs. The Total Economic Value of that annual output in 2004 dollars is estimated to be about $6.5 billion/year ($885 million net of production costs), including the related Consumer Surplus. The present value of that benefit flow is estimated at about $216 billion ($30 billion net of production costs). These values are highly dependent on land use, climate, and other factors and may decline as farmland is converted to other uses.

VI. Non-Farm Animals

Game animals and birds and fur-bearing animals harvested in New Jersey have an annual market value of about $3 million, based on volume data from NJDEP's Division of Fish and Wildlife and prices for related meat products in the Northeastern U.S. (The retail prices provided by the U.S. Bureau of Labor Statistics were adjusted to approximate wholesale prices.) The Total Economic Value of that annual output in 2004 dollars is estimated to be about $21 million/year, including the related Consumer Surplus, and the present value of that flow of benefits is estimated at about $703 million. The maintenance of these values depends on the stability of land use patterns, hunting policies and practices, and other factors.

VII. Fish and Shellfish

New Jersey's commercial fishing vessels harvest finfish and shellfish with a total average Market Value of about $123 million/year, according to data from the National Marine Fisheries Service. Of that amount, shellfish represent about 62% by weight and 85% by value. This harvest has an estimated Total Economic Value in 2004 dollars of about $750 million/year, including the estimated Consumer Surplus. The present value of that benefit stream is estimated at about $25 billion. These values are subject to change based on changes in fish stocks, consumer demand, and other factors.

New Jersey's recreational anglers harvest saltwater and freshwater fish with a total average Market Value estimated at about $34 million/year, according to data from various sources. This harvest has an estimated Total Economic Value in 2004 dollars of about $207 million/year, including the related Consumer Surplus; the present value of that benefit stream is estimated at about $7 billion. As with commercial fisheries, these values are subject to change based on changes in fish stocks, fishing regulations, and other factors.

VIII. Non-Farm Plants

New Jersey's landscapes provide an unknown amount of useful non-farm plants, including flowers, medicinal plants, and others. The data on these products are meager, and it is not currently feasible to estimate their economic value. Methods are being developed to estimate such values (where volume data are available), but those methods are still in the developmental stage.

IX. Timber and Fuelwood

In 2003, New Jersey used about 1.6 million cords of wood and wood wastes as an energy source, primarily for electric power generation and residential heating. The share of that fuelwood originating in New Jersey cannot be determined, and this analysis assumes that 100% of it comes from in-state sources. Based on a value of $23.48/cord in 2004 dollars, 2003 consumption had a Market Value of about $39 million/year and a Total Economic Value of about $95 million/year (including Consumer Surplus), for a present value of about $3 billion.

Between 1987 and 1999, New Jersey's marketable timber resources increased by an average of 204 million board-feet/year, of which hardwoods (i.e., deciduous trees) represented about 89%. Based on wholesale prices for the various tree species, that annual growth had a Market Value of $49 million/year in 2004 dollars. Including Consumer Surplus, this represents a Total Economic Value of between $96 and $293 million/year (central estimate = $147 million/year) and a present value of between $3 and $10 billion (central estimate = $5 billion). Whether the growth rate of the 1987-1999 period continued after 1999 is not known. The maintenance of that growth rate and therefore the above value estimates depends on a variety of factors, including land use change, climate change, harvest policies, species mix, tree disease patterns, and others.

X. Summary and Limitations

The values presented above total $1.2 billion/year in terms of Market Value (range $820 million to $1.6 billion/year) and $5.9 billion/year in Total Economic Value (range $2.8-9.7 billion/year); the difference between Market Value and Total Value represents Consumer Surplus. Based on these flows of value, New Jersey's natural capital has an estimated worth of $196 billion in present value terms (range $93-322 billion). Farm products and fish command the largest shares, followed by minerals and raw water; wood (including both sawtimber and fuelwood) and non-farm animals have the lowest shares, while the value of non-farm plants was not estimated.

The value provided varies by ecosystem, depending on the types of natural goods provided, the total acreage of the ecosystem, and the average value per acre. The value provided varies by ecosystem, depending on the types of natural goods provided, the total acreage of the ecosystem, and the average value per acre. Farmland and marine ecosystems generate the highest values in terms of total value, followed by barren land (which includes mines and quarries), forests, and freshwater wetlands. In terms of value per acre, non-ecosystem land (mines and quarries) ranks first, followed by farmland, marine ecosystems, and open fresh waters.

The results of this study should be treated as first estimates and not as final definitive valuations. For various reasons, the results do not include secondary economic benefits supported by direct expenditures on natural goods, including such secondary benefits as the economic activity supported by spending by employees in agriculture, retail food distribution, commercial fishing, mining, timber and timber-using industries, etc. These omissions lead to an *understatement* of total economic value. On the other hand, the results of the study *do* include producer costs, resulting in an overstatement of *net* economic value.

Future research should focus on the following:

- All ecosystems: more current land use/land cover data.
- All ecosystems: relationships between production of services and goods.
- Water: more current data on supplies and leakage rates.
- Minerals: tonnage and market value of sand dredged offshore.
- Farm products: more recent data on the amount of farmland by type.
- Fish: prices for recreational freshwater species; role of wetlands.
- Non-farm plants: data and methods for preparing rough valuations.
- Fuelwood: share of wood harvested in-state; estimated sustainable yield.
- Timber: more current annual growth data; estimates of sustainable yield.
- All natural goods: further research on relative per-acre ecosystem productivity.
- All natural goods: further research on elasticity of demand.

A valuation study such as this one can never be regarded as a closed book, any more than a valuation analysis in business or any other sphere: as conditions change, so do values, and the process of change is continuous. Nonetheless, it is clear that New Jersey's natural capital, both living and non-living, makes a substantial contribution every year to New Jersey's economy and quality of life by providing natural goods worth several billion dollars both annually and in present value terms.

Section I: Overview and Scope

Part II of this three-part report described in detail the valuation methods applied to the services provided by New Jersey's ecosystems and presented the results of those valuations; Part III does the same for ecosystem and abiotic *goods* (together termed "natural goods"). As Table 1 (next page) shows, New Jersey's ecosystems and the state's non-living natural capital provide a variety of economically important natural goods; for purposes of analysis and presentation, these have been grouped into the seven categories shown. While each of these categories include many specific goods, the categories themselves will frequently be referred to as "natural goods".

As Table 1 indicates, all of the natural goods considered in this report are provided by more than one ecosystem, and in some cases, it is difficult to allocate the total value of natural goods among the relevant ecosystems, as these examples show:

- "Groundwater recharge areas" are not identifiable as such from aerial photographs; rather, they exhibit one of the standard land cover types, e.g., forest or meadow. However, it cannot be assumed a priori that *all* forested lands function as recharge areas. In addition, surface waters and underground aquifers are usually hydrologically connected, so that some part of "groundwater" recharge is attributable to surface waters and vice versa.

- While forests produce more fuelwood than forested wetlands, the latter probably produce *some* fuelwood; and some farms also have woodlots. There is no clear way to determine the relative contributions of each to total fuelwood production.

Because of these and other factors, this study of natural goods does not develop detailed maps of the sort presented in Part II of this report. Additional research would be needed to address such issues and plot the results. However, Part III does allocate the value of New Jersey's natural goods on a pro rata basis among the ecosystems relevant to a particular class of goods.

The next section of this report describes the approach that will be used in estimating the economic value of the various ecosystem and abiotic goods and the value of the natural capital that produces them. After that, the seven categories of natural goods will be discussed in turn; a concluding section will assemble the results for the individual types of goods into an overall statewide summary. Each section ends with a discussion of the applicable limitations.

It should be noted that this study was unable to estimate monetary values for some natural goods (e.g., non-farm plants) due to the unavailability of certain kinds of data and/or the lack of accepted valuation methods. We omitted urban greenspace from this analysis based on the assumption that the natural goods theoretically obtainable in such ecosystems (e.g., wood) would not actually be available for harvesting; and we omitted other urban areas on the assumption that such areas do not produce any economically significant and legally available natural goods.

(text continues following Table 1)

TABLE 1: ECOSYSTEM AND ABIOTIC GOODS PROVIDED BY NEW JERSEY'S NATURAL CAPITAL[2]								
New Jersey Ecosystem	**Area (Acres)**	**Water Resources**	**Mineral Resources**	**Farm Products**	**Non-Farm Animals**	**Fish and Shellfish**	**Non-Farm Plants**	**Timber & Fuelwood**
Coastal / Marine:								
Coastal shelf	299,835		x			x	x	
Beach/dune	7,837						x	
Estuary/tidal bay	455,700					x	x	
Saltwater wetland	190,520				x	x	x	
Terrestrial:								
Forest*	1,465,668	x			x		x	x
Pastureland	127,203	x		x	x		x	
Cropland	546,261	x		x	x		x	
Freshwater wetland**	814,479	x			x	x	x	x**
Open fresh water	86,232	x			x	x	x	
Riparian buffer	15,146	x			x		x	
Urban / Other:								
Urban (impervious)	1,313,946							
Urban green space	169,550	x					x	
Barren land	51,796		x					
TOTAL	5,544,173							
***Freshwater wetland:*								
-Forested	633,380	x			x	x	x	x
-Other	181,099	x			x	x	x	--
Total	814,479							

**includes wooded farmland*

[2] In Table 1, NJDEP 1995/1997 land use/land cover data have been used to allocate Freshwater Wetlands between Forested and Other and to separate out Barren land.

Several further introductory comments are warranted. First, this part of the natural capital report deals solely with natural *goods*; Part II focuses on ecosystem *services*. In comparison, the United Nations Millennium Ecosystem Assessment treats the ecosystem goods dealt with in Part III as resulting from ecosystem "provisioning" *services*, putting the subject matter of Parts II and II in a common "service" framework. The division between goods and services in the present study is based partly on the availability of market value data for the products of "provisioning services" and not on any fundamental disagreement with the MEA's theoretical framework.

The other main reason for maintaining the distinction between goods and services (or between provisioning and other services) is to avoid double-counting benefits. For example, Part II of this study excluded the value of food from its discussion of farmland because Part III addresses it. If we include provisioning services in Part II and in Part III, we would be double-counting a major part of the value provided to New Jersey by its farmland.

Next, it should be understood that the approach to valuation used in this study uses standard economic concepts and techniques as those currently exist in "mainstream" or "conventional" *environmental* economics. Some of the basic assumptions, including the focus on human-oriented, instrumental exchange value and the use of discounting (see Section II), are contested by *ecological* economists, and there are strong arguments in favor of some of those challenges. However, the development of easily-used and widely-accepted alternative valuation techniques is still in its early stages, and the current study therefore relies on approaches which can be characterized as based on "standard" environmental economics.

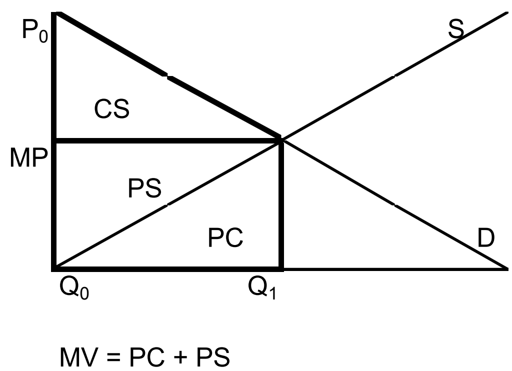
Finally, the natural capital values presented later in this report are estimates—they do not represent "the" value of any of the natural goods discussed. Estimates of the value of our natural capital will in all likelihood never be "final" because of the inherent complexity of the subject and because economic theory, empirical economic research, and "the facts on the ground" do not stand still at a given point in time. These analyses are subject to unavoidable uncertainties; and in recognition of this fact, this report presents high-end, central, and low-end estimates of the value of each natural good where the available data support this approach.

Despite these cautions, the estimated values presented in this report are supported by both data and economic theory and offer a reasonable basis both for further research and analysis and for use in policy and planning applications where it is important to have plausible estimates of the value of the many goods that nature—both living and non-living—provides to New Jersey. Together with the analyses of ecosystem services presented in Part II of this report, they give analysts, decision-makers, and the general public information that is essential for informed discussion of the values involved in environmental protection and economic development.

Section II: Economic Value of Natural Goods

This section presents a simplified summary of the approach used in this study to estimate economic value. In standard economics, the value of a good or service is the amount that consumers are willing to pay for it. Total Economic Value (TEV)[3] has two components: the amount consumers actually pay for the item, i.e., its Market Value (MV), and the additional amount they would be willing to pay for it if they had to but which they do not actually have to pay under the prevailing market conditions. The latter amount is termed Consumer Surplus (CS).[4] These components of economic value are usually illustrated as follows:

Fig. 1: Components of Economic Value



In Fig. 1, the horizontal axis represents the quantity Q of the natural good sold by producers and bought by consumers, and the vertical axis represents the price P for that good. The upward sloping curve S represents the supply of the natural good, and the downward sloping line D represents the demand for that good. Q_1 represents 100% of the annual output of the good, and MP represents the average market price for that output. Market Value MV equals MP * Q_1.

The Market Value of the natural good in question is represented by the area inside the square box and the Consumer Surplus by the triangle lying above that box. MV in turn has two components: Producers' Cost (PC) and Producers' Surplus or profit (PS). Economic Value EV therefore equals MV + CS = (PC + PS) + CS. All of the terms defined above represent *annual* amounts.

The task of this study is to estimate the value of MV and CS for each natural good analyzed. As described in the subsequent sections of this report, estimates of MV are available from various official sources or can be calculated readily from price and quantity data provided by such sources. The challenge therefore is to estimate CS. Since we know MV, the value of CS

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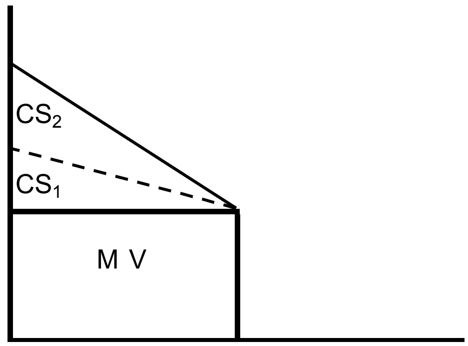
[3] Total Economic Value is also referred to as Willingness to Pay (WTP) or Total Willingness to Pay (TWP).

[4] Consumer surplus is a simplified measure of the amount by which Total Economic Value exceeds Market Value; in a more refined analysis, measures known as "compensating variation" and "equivalent variation" might be used instead.

depends entirely on the shape[5], relative steepness or slope of the demand curve, and the value of the curve close to or at the vertical axis, as Fig. 2 shows:

Fig. 2: Alternative Values for Consumer Surplus



Although we have no direct information on the shape (straight or curved), slope (steep or flat), or vertical intercept for the demand curves for the natural goods we are studying, we do have indirect information in the form of estimates for a parameter known as the "elasticity of demand" for each of these goods. Combined with certain assumptions, that information allows us to estimate the shape and slope of the demand curve for each natural good, which then allows us to estimate CS.

The mathematics involved in making these estimates is rather involved and is presented in Appendix A. The results are presented below, expressed in two ways: 1) as the ratio of Total Economic Value to Market Value, and 2) as the ratio of Consumer Surplus to Market Value, expressed as a percentage add-on. The difference between the two figures represents the Market Value itself. As can be seen, multiple estimates were developed for some goods.

Table 2: Consumer Surplus Add-Ons for Natural Goods

Class of Goods*	Ratio of Total Economic Value to Market Value	Consumer Surplus Add-On to Market Value
Fur	1.72	72%
Water	1.83 - 2.25 - 3.50	83% - 125% - 250%
Fuelwood	2.47	147%
Timber	1.96 - 3.00 - 6.00	96% - 200% - 500%
Minerals	1.50 – 1.83 - 3.50	50% - 83% - 250%
Fish	6.10	510%
Game animals	6.62	562%
Farm products	6.43 - 8.46	543% - 746%

**Comparable data are not available for non-farm plants.*

As noted above, the assumptions and formulas used to derive these figures are presented in full in Appendix A.

[5] While demand "curves" are most commonly shown as straight lines, they can also have "non-linear" shapes, as discussed below.

Stock and Flow Values

Thus far we have been focusing on the value of an annual stream or flow of economic benefits. In standard economics, the value of an asset is the present value of the future benefits that it generates; this general principle applies to all types of capital assets, including natural capital. This report will present estimates of both the value of the natural goods produced by New Jersey's natural capital and the value of the natural capital itself, calculated as the present value of the recurring annual flows of natural goods.[6]

To convert future annual values to present values, it is necessary to select a discounting technique, a time horizon, and a discount rate.[7] Conventional discounting uses a single constant discount rate and assumes a finite time horizon. Under these assumptions the total present value of a benefit flow of X dollars/year for N years discounted at an annual rate of r percent equals:

$$PV = X / (1+r)^1 + X / (1+r)^2 + \ldots + X / (1+r)^N \quad (1)$$
$$= \Sigma^N_{i=1} [X / (1+r)^i]$$

When this formula is used, the higher the discount rate, the smaller the present value of benefits received in the "distant" future. However, even at "low" discount rates, the present value of future benefits ends up being heavily discounted. For example, with a 3% discount rate, the present value of a dollar received in 50 years from now is \$1 / (1.03^50) = \$0.228.

The entire area of discounting is the subject of active research and debate in economics, and new discounting techniques have been developed in recent years that use multiple discount rates (with lower rates used for the more distant future) and/or completely different mathematical formulas for weighting benefits received at different times.[8] Rather than add this complexity to the report, we limit our analysis to conventional discounting of the type reflected in Equation (1). In keeping with a common practice in valuing benefits to society, we use a "social" discount rate of 3% rather than the much higher rates used in valuing private projects. See, e.g., OMB (2003).

The appropriate time horizon for valuing natural capital is also open to discussion. In principle, renewable natural capital such as a forest has a potentially infinite life if sustainably managed and if external forces do not intervene; the same is not true of non-renewable natural capital such as mineral deposits, which will eventually be exhausted regardless of the extraction

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[6] Absent better information, common practice is to assume that the annual harvest and the market value of that harvest will be constant over time. Obtaining better information would require a detailed model for projecting future harvest levels and market values for each type of natural good, an effort that is beyond the scope of the current study. Moreover, even if such models could be developed, their projections of future harvests and market values would be subject to considerable uncertainty.

[7] The opposite process of converting present values to annual future ones is called amortization, and if a single rate is used, as in loan amortization, it is called the amortization rate.

[8] See, e.g., Weitzmann (2001), Newell and Pizer (2001), Newell and Pizer (2003), and Part II of this report. Some ecological economists and environmentalists argue on economic and ethical grounds against discounting future benefits, e.g., Daly and Cobb (1999); this report follows the more general practice of discounting such benefits.

rate.[9] For natural capital with a potentially infinite life, it can be shown mathematically that Equation (1) above reduces to the following over a sufficiently long time horizon:

(2) $$PV = X / r$$

In this report, present values will be converted to annual values using Equation (2), except where a relatively short time horizon is mandated by the facts applicable to a particular type of natural capital, in which case Equation (1) will be used instead. If necessary, we can also work in reverse, calculating an unknown X by amortizing the present value PV at rate r in equal annual "installments" or benefit flows:

(3) $$X = PV * r$$

This can be useful if we have an a priori estimate of PV (e.g., a price per acre for farmland) and want to estimate X (e.g., the annual rent from that land at a given amortization rate).

Inflation and Uncertainty

In looking at flows over value over time, the treatment of inflation is relevant. There are two consistent approaches in this area: 1) use real (i.e., constant dollar) values and a real discount rate, or 2) use values in current or nominal (i.e., inflated) dollars and an inflation-adjusted discount rate. For example, if the real discount rate is 3% and we assume inflation at 2%, we would inflate values by 2% each year and then discount the resulting values by a rate of about 5%.[10] However, this gives the same present value as simply ignoring inflation and discounting using the real rate of 3%, and that is the approach used in this study.

The estimates presented in this study are all subject to uncertainties of various kinds. For some natural goods, there is sufficient information to present a range of estimates; for others, there is not. In no case, however, does this study present a formal analysis of uncertainty; given the many factors whose future values are difficult or impossible to quantify, any such analysis would need to use either complex statistical techniques such as the Monte Carlo method or analysis of multiple scenarios whose individual probabilities would itself be highly uncertain. The estimates presented in this report should therefore be regarded as first-order approximations subject to change as our knowledge improves.

In Situ vs. Delivered Values

As described in detail in the following section, there is an important difference between the value of natural goods and natural capital at their source (the *in situ* value) and their value at the point of final consumption (the *delivered* value). Using the terminology developed above, the former includes the cost of extracting or harvesting the natural goods; in addition, the latter also reflects processing, distribution, transportation, and marketing costs. *All* producer costs reflect value added to the raw natural goods by physical, human, and social capital; the goal of this

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[9] In each case, renewability is judged on the basis of time frames relevant to society; thus, a mineral deposit that is potentially renewable given thousands of years of geological activity is classified as non-renewable in this and most other analyses.

[10] It can easily be demonstrated that the correct discount rate in this case is not 3% + 2% = 5% but rather (1.03 x 1.02) – 1 = 5.06%.

study is to estimate the value of New Jersey's *natural* capital by getting as close as possible to the *in situ* value. Table 3 summarizes the type of valuation data used for each of the natural goods discussed in this report.

TABLE 3: VALUATION DATA FOR NATURAL GOODS			
Natural Good	**Description of Price**	**Source of Price Data**	**Producer Costs Included in Price**
Water	Contract price for raw water sold to purveyors	NJ Water Supply Authority	budgeted supplier cost and estimated return on capital
Minerals	"Free on board" price at quarry or mine site	US Geological Survey	extraction cost and profit for commercial operators
Farm products	Market value of agri-cultural products sold	US Department of Agriculture	all farm expenses (including non-cash items) and profit
Game animals	Estimated price based on selected meat prices*	US Bureau of Labor Statistics	hunter's cost and "profit"
Fur animals	Official estimate of market value	NJ Dept. of Env'l Protection	trapper's cost and "profit"
Fish	Commercial ex-vessel (dockside) price	National Marine Fisheries Svce.	harvest cost and profit for commercial fishing vessels
Fuelwood	Estimated expenditures by end-user sectors	US Energy Inform. Admin.	harvest cost and profit for commercial woodcutters
Sawtimber	Commercial sawlog price (stumpage)	Various state websites	harvest cost and profit for commercial loggers

*adjusted by deducting estimated retail margins and marketing costs.

In general, these data include the initial harvest or extraction cost and profit but not the cost of subsequent distribution, shipping, processing, etc.[11] In other words, for the most part they represent only the payments to the enterprises or individuals who first sever the natural goods from the land or water and are therefore comparable to each other and an appropriate basis for the natural capital valuations presented in this report.

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[11] Some prices do reflect the cost of delivery from the harvest site to the next link in the value-added chain, e.g., delivery to dockside of commercial fish harvests.

Section III: Water Resources

Essential to life itself and to all economic activity, water is the most important of the natural goods provided by New Jersey's ecosystems and abiotic environment. Water is used as a commodity in every sector of the economy, it is widely used as a sink for pollution, and, as described in Part II, it provides a wide variety of economically and ecologically important ecosystem services.

The natural capital involved in the "production" of water resources is considered here to include all terrestrial ecosystems other than urban and barren land:

Table 4
Natural Capital for Water Resources

Ecosystem Type	Area (acres)
Forest	1,465,668
Freshwater wetland	814,479
Cropland	546,261
Urban green space	169,550
Pastureland	127,203
Open fresh water	86,232
Riparian buffer	15,146
Total	**3,224,539**

This broad definition reflects the lack of information on the specific types of land cover above New Jersey's underground aquifers, as well as the fact that wetlands also play an important role in the hydrological system. On the other hand, it is assumed here that neither impervious surfaces nor bodies of saltwater contribute to the usable water supply. These land cover assumptions can be revisited if and when more detailed information on the makeup of the hydrological system's land cover becomes available.

Valuation of New Jersey's water resources requires estimates of the quantity of water being valued and the value per unit, e.g., per thousand gallons (a common unit in water economics). In estimating the quantity of water, two general approaches are available:

- estimate the total resource "stock" contained in surface waters and aquifers and use amortization techniques to convert that stock into annual flows.

- estimate the annual "flows" of water and use discounting techniques to convert those flows into a present value i.e., a "stock value".

The stock method is very difficult to apply with any precision because we simply do not know the amount of water contained in the state's underground aquifers, and developing an estimate of that quantity would involve a major undertaking by geologists and hydrologists. The author is not aware of any water valuation studies that use this approach for a region as large and as geologically and hydrologically complex as New Jersey.[12]

This leaves us with the flow approach as a valuation method. In estimating the annual flows to be valued, we again have two major types of estimates:

- *demand* for water, i.e., the amount of water *actually withdrawn* for use.
- *supply* of water, i.e., the amount of water *potentially available* for withdrawal.

Each approach raises conceptual and data issues, as discussed below.

A. Water Demand[13]

The 1996 Statewide Water Supply Plan (Table 4.2) presented an estimate of statewide usage for 1990 of 1,499 MGD or about 547,000 MG based on average reported withdrawals for 1986-1988 for users of more than 100,000 gallons/day plus an estimate for self-supplied residential users. These figures exclude water withdrawn for power generation and storage because those uses do not involve consumptive or depletive use of the water in question.

More recent estimates of the demand for water in New Jersey were prepared by the New Jersey Geological Survey (NJGS); estimates are currently available for the period from 1990 through 1999 and are summarized below (MG = millions of gallons; per capita use in gallons). To facilitate comparison with other estimates of water demand and supply presented in this report, the table below omits water withdrawn for power generation or storage.

Table 5: Statewide Withdrawals of Fresh Water for Selected Uses (MG)
(ranked by 1999 volume; per capita figures = gallons)

Selected Use Group	**1990**	**1999**	**Avg. pct. change/yr**	**1990-1999 Average**
Potable supply	414,253	431,068	+0.4%	420,206
Agricultural/irrigation	46,775	66,240	+3.9%	58,120
Industrial/commercial	87,873	46,539	-6.8%	79,732
Mining	26,351	32,376	+2.3%	34,023
Total of selected uses	**575,272**	**576,222**	**+0.02%**	**592,082**
Total in MGD	1,576	1,579	+0.02%	1,622
NJ Population*	**7,747,750**	**8,143,412**	**+0.6%**	
Potable supply per capita	53,468	52,935	-0.1%	
Other uses per capita	20,780	17,825	-1.7%	
Total use per capita	74,248	70,759	-0.5%	

*1990 = 4/1/90 Census; 1999 = 7/1/99 estimate by US Census Bureau.

[12] According to NJGS, the next revision of the Statewide Water Supply Plan will use stream gauge records to help estimate the amount of water available for consumption.

[13] In this discussion, "demand", "use", and "withdrawals" are used as rough synonyms; despite the important distinctions among the three concepts, this usage is sufficiently precise for present purposes.

As the above table shows, use groups differ substantially in terms of their withdrawal trends. In addition, withdrawals for some uses fluctuated widely from year to year, e.g., irrigation.[14] However, considering that the 1996 Plan estimate for 1990 was based on 1986-1988 data, the agreement with the NJGS figure for actual 1990 withdrawals is quite good (547,000 MG vs. 575,000 MG).

While the figures in Table 5 represent the most recent data available on statewide water flow, using estimated withdrawals (i.e., demand) in valuing New Jersey's hydrological resources can create a serious "accounting" problem. If withdrawals exceed the level that can be sustained over time, then by definition the withdrawals must come partly from current supply and partly from depletion of (natural) capital.

Given this, discounting projected future withdrawals as though they could be maintained indefinitely would *overstate* the amount and value of our hydrological capital. Similarly, if future withdrawals were projected to fall short of what is sustainable, we could in effect be adding to our natural capital (by increasing groundwater reserves, stream and reservoir levels, etc.), in which case discounting the future withdrawals would *understate* the amount and annual value of that capital. For these reasons, estimates of water supply are arguably preferable to estimates of water demand, and the most recent supply estimates are discussed next.

B. Water Supply

The most recent estimates of the amount of water available in New Jersey are those contained in the 1996 Plan (Table 3.1) and presented below. Amounts are shown both as millions of gallons per day (MGD) and as millions of gallons per year (MGY); the latter is often referred to simply as millions of gallons (MG), the time period of a year being assumed. All figures are rounded to the nearest one thousand MGD or MG(Y).

TABLE 6: NEW JERSEY'S AVAILABLE WATER SUPPLY ACCORDING TO THE 1996 STATEWIDE WATER SUPPLY PLAN

Water Source	MGD	MG(Y)
Available surface water	853	311,000
Available ground water	903	330,000
Total available freshwater	1,756	641,000

Before we discuss these figures in detail, several caveats need to be mentioned:

[14] In evaluating these figures, it should be noted that according to NJGS staff, the most important measure of water use is not withdrawals but rather the total of consumptive (evaporative) and depletive uses, including net inter-basin transfers. On a statewide basis, about 15% of all potable supply is lost consumptively in an average year, while the other 85% is returned to the hydrological system. In some basins, such as the Passaic, such non-depletive and non-consumptive "returns" can be reused, and the reused water may represent a large part of the area's total withdrawals. The 1996 Plan discussed the significance of these factors in detail but did not include estimates of water returns in its final analysis of water availability; the updated version of the Plan will take such factors into account. Since the present study relies on the 1996 Plan for basic data, these factors are not reflected in the analysis here.

1. While the Plan is dated August 1996, the data are actually based on conditions in 1986-1988 and prior years and are therefore considerably out of date. The SWSP is currently being updated, and the new version will include more recent estimates of the state's available water supply; however, that update is not complete at this time.

2. Water for hydro and thermal power generation is not included. Leaving aside issues such as thermal pollution, water that flows through power generating equipment such as turbines is in principle available for other uses once it is discharged from the power generating facility. Therefore, the Plan omitted water used for this purpose to avoid potential double-counting.

3. Similarly, water that is diverted to storage facilities (such as reservoirs) for use in subsequent years is technically not considered to be "used" in the year in which it is diverted. Therefore, the Plan omitted stored water to avoid potential double-counting.

The sustainability or dependability of the water supply over the long-term is a key issue in this valuation analysis. In technical terms, the question is sometimes described as how to estimate the so-called "safe yield" for both surface and ground water. This question will be discussed separately for surface water and groundwater supply.

1. Surface Water Supply

The Plan defines available surface water in terms of "safe yield", i.e., the amount of surface water continuously available even during a recurrence of the worst drought on record (SWSP 1996). Surface water yield excludes water sources not backed by reservoir capacity adequate to maintain yield during a drought of that severity. Safe yield essentially represents an educated guess as to how much water it is "safe" to withdraw, based on assumptions about such variables as future precipitation, reservoir evaporation rates, stream flow needs, and other factors.

Since the severity of the worst drought of record changes whenever the record is surpassed, this factor can change over time. However, despite the severe drought of 2001, the 1963-1966 drought (often referred to as the 1960s drought) remains New Jersey's worst drought since 1895, the earliest year for which annual precipitation estimates are available.[15] Therefore, apart from changes in reservoir capacity, the SWSP estimate for surface water yield could be considered acceptable for valuation purposes. In fact, according to NJGS data, the available surface water yield given in the Plan exceeded actual withdrawals of potable surface water during the 1990s,

2. Groundwater Supply

Groundwater *recharge* is the amount of rainfall that percolates (flows) into underground aquifers (SWSP 1996). Rainfall that percolates into unconfined aquifers becomes groundwater *discharge*, i.e., water that flows out of such aquifers to streams, lakes, wetlands, and natural sub-ocean reservoirs. For groundwater, "safe yield" implies that the withdrawal rate must equal the

[15] More precisely, the 1960s drought is the worst that New Jersey has experienced as far as potable supply and reservoir levels are concerned; however, drought impacts on agriculture and other sectors have been worse in other years.

recharge rate. That is, as consumption increases, withdrawals by public and private wells must be offset by an increase in recharge, a decrease in discharge, or both, since otherwise there will be a reduction in the amount of water stored in the aquifer.[16]

The adequacy of safe yield as a measure of sustainable supply has been questioned by some experts because it fails to take "induced recharge" into account. Induced recharge is the process whereby, at certain well pumping rates, declines in groundwater can induce water to flow out of an adjacent surface water body into the aquifer, which can in turn lead to stream flow depletion; for this reason, groundwater withdrawals are sometimes limited to help maintain streamflows and stream ecosystems. In other words, while water pumped from the aquifer initially comes from stored groundwater, its ultimate source may be induced recharge from surface water.

For this reason, unconfined aquifers and surface water together can be considered as a single resource; the concept of sustainable yield takes account of the need to look at hydrological resources as an integrated system in estimating the available water supply. As applied in the 1996 Plan, the result was that only about 15% of the total groundwater recharge was considered to be available for human use.

TABLE 7: GROUNDWATER AVAILABILITY ACCORDING TO THE 1996 STATEWIDE WATER SUPPLY PLAN		
Water Source	**MGD**	**MG**
Total groundwater recharge	5,995	2,188,000
Average % available	15%	15%
Available groundwater	903	330,000

The 15% is actually a weighted average of 15% for aquifers near the Lower Delaware River, 16% for aquifers in Monmouth County, 10% for other aquifers near the coast, and 20% for aquifers in North Jersey (SWSP 1996). Each of these figures reflects expert judgment as to how much groundwater can be physically extracted in a given region without subjecting the hydrological system to "significant and unacceptable stresses", including inadequate streamflows, intrusion of saltwater into coastal aquifers, etc.

3. Projections of Water Supply

Given how out-of-date the Plan's estimates are, the question in terms of valuing New Jersey's water resources is whether the available supply is likely to have changed significantly since 1986-1988, and if so, whether there is a simple way of approximating the magnitude of the change. The most important determinant of water supply is the amount of precipitation; another possible factor is the increase in impervious surface in the state due to continued urbanization. These two factors are discussed below.

a. Precipitation Trends

Depending on the time period considered and the statistical techniques and scale used, different analysts have come to different conclusions regarding the presence or absence of a

[16] This assumes constant groundwater storage; under some circumstances, such storage can decrease.

statewide trend in precipitation in New Jersey. However, in terms of actual availability to meet human and ecological needs, the statewide precipitation totals are less important than the totals for different parts of the state, because actual water availability and the demand for water vary significantly from region to region. A given total for statewide precipitation may combine surpluses in some drainage basins and shortfalls in others; and in some cases the areas with excess available water may not be located near the areas in greatest need of that water.

Based on a detailed analysis of regional precipitation trends, Watson et al. (2005) concluded that over the last 30 years, there has been a statistically significant increase in precipitation in northern New Jersey: for the period 1895-1970, annual precipitation in that area averaged 44.6 inches, while for 1971-2001 the average was 49.8 inches, an increase of 5.2 inches or about 11.7%. For southern New Jersey, the same study found a slight but statistically insignificant increase in annual precipitation. However, the uncertainties associated with climate change make predictions based on these results subject to substantial uncertainty.

Although regional and inter-basin differences in available supply and demand are important, an analysis of economic value at the regional or basin level is beyond the scope of this study. Therefore, this analysis uses the entire state as the basic unit. A similar analysis performed at a smaller scale, e.g., HUC-11, HUC-14, WMA, or water purveyor service area could yield different results, and the differences could be material.[17] For example, while inter-basin transfers in New Jersey are significant in some areas, they impose infrastructure and other costs on society, which could affect the analysis.

b. Changes in Recharge Rates

Another factor that could affect the available water supply is the extent to which potential groundwater recharge areas have been covered with impervious surfaces such as roadways, parking lots, buildings, etc. Most water falling on impervious surfaces runs into the nearest stream or stormwater collection system and flows downstream to the ocean without recharging aquifers along the way. As development in New Jersey continues, the amount of impervious surface in the state has been increasing. Between 1986 and 1995/1997, the amount of urbanized land[18] increased by 16,545 acres annually or about 1.0%/year or much more than the 0.2%/year increase in precipitation. Even if the pace of urbanization between 1995-1997 and 2002 turns out to have slowed considerably, it seems likely to remain substantial.

Since runoff from impervious surfaces helps sustain stream flows between precipitation events, Watson et al. (2005) analyzed trends in low stream flows as a surrogate measure of changes in groundwater recharge. They found decreases in low flows at some stream gauging stations and increases in others; overall, there appeared to be no statistically significant

[17] WMAs are watershed management areas; HUC-11s and HUC-14s are smaller hydrological areas (HUC stands for hydrological unit code).

[18] In this context, the amount of urbanized land is used as a proxy for impervious surface. Most urban areas contain some green space, and many generally undeveloped areas contain some amount of paved surface, so the correspondence between land use and land cover is not exact; however, the proxy is believed to be sufficiently accurate for present purposes.

correlation between increases in impervious cover and changes in base stream flow for the period covered by the study.

Notwithstanding these results, the impact of increases in the extent of impervious surface is receiving renewed attention in the wake of the recent repeated flooding of certain reaches of the Delaware River, and the issue cannot be regarded as settled. While such flood waters inflict considerable economic damage, they move downstream too quickly to contribute significantly to New Jersey's available water supply. However, pending further research on these effects, this study make no attempt to adjust the 1996 Plan's estimates of available water supply to reflect the impacts of continued development.

C. Conclusions on Water Flow

Given the various uncertainties, there is clearly no ideal method of quantifying the amount of water that can be considered as part of New Jersey's natural capital.

- The 1996 Plan presented an estimate of statewide usage for 1990 of 1,499 MGD or about 547,000 MG based on average reported withdrawals for 1986-1988 for users of more than 100,000 gallons/day (including an estimate for self-supplied residential users but excluding water withdrawn for power generation and storage).

- Annual water withdrawals averaged 592,000 million gallons during the 1990s, again excluding power generation and stored water. This estimate represents the average for the decade; withdrawals in 1990 (the most recent year for which data are currently available) were about 3.7% *below* the average, while demand in more recent years may have increased as a result of New Jersey's continued strong population growth.

- The 1996 Plan estimates total available water supply at 641,000 million gallons/year excluding power generation and stored water. This estimate reflects allowances for maintenance of streamflow and avoidance of saltwater intrusion into coastal aquifers and is therefore arguably the best estimate of sustainable yield *based on the levels of precipitation, urbanization, etc. in 1986-1988*.

Some economists would argue that the demand figures are the most relevant ones for a valuation analysis, since water that is available but not used creates no apparent benefits for society. However, this argument ignores the fact that water not withdrawn from surface waters or aquifers can improve streamflows, increase the amount of stored (and therefore potentially available) groundwater, and provide other benefits. Therefore, the valuation analysis presented later in this section uses both the demand and supply figures to provide a range of estimated valuations.[19]

[19] It should be noted that under natural conditions, the hydrological system is in a state of approximate dynamic equilibrium. That is, over a sufficiently long period, wet years (in which recharge/supply exceeds discharge/demand) offset dry years (when the reverse is true). Within the hydrological cycle, the amount of water entering the system will always equal the amount leaving it in the long-term. Changing precipitation patterns and human activities can alter the distribution and timing of this circular flow of water, but artificial changes to the hydrologic cycle become part of that cycle.

In the context of the current study, one adjustment is needed before the above figures can be used for valuation purposes. As shown in Table 5, an average of 58 MGY or about 9.8% of the average total withdrawals of 592 MGY for the period 1990-1999 went for agriculture, including irrigation. (Comparable figures for water flow estimates derived from the 1996 Plan are not readily available.) Water is obviously an essential input for food production, but as such it is reflected in the value of the food produced in New Jersey (see Section V). Therefore, including the value of that water in this section as well would amount to double-counting. To adjust for this factor, 9.8% of the assumed annual flow is deducted in the valuation analysis below, leaving 90.2%.

In closing this discussion of the quantity of water to be valued, we note that climate projections for the mid-Atlantic states indicate that in New Jersey, global climate change could lead to increased precipitation and flooding, increased drought, or some combination of the two (e.g., flooding at certain times of the year and drought at others) (MECA 2001). The uncertainties increase when we consider the risk of more frequent and/or more intense hurricanes and other extra-tropical storms. Given these uncertainties and the lack of recent hydrological data, any estimate of the amount (and therefore the value) of New Jersey's water resources must be considered tentative. This entire analysis will need to be revisited once the NJGS withdrawal and use data and the SWSP have been updated.

D. Commercial Value of Water

The other two pieces of information needed for valuation of our water resources are estimates of the market value of water (gallons of water supplied times dollars per gallon[20]) and the elasticity of demand for water; we treat the former first. In developing an estimate of market value, we first need to avoid double counting the value of water "embodied" in goods that require water for their production. For example, food crops need water and are economically valuable; however, their value *includes* the value of the water used to produce them just as it includes the value of fertilizer, tractor fuel, farm labor, etc. (In this context, economists would call water used on crops an "intermediate" good and food a "final" good.) Counting both the water and the food represents double-counting and is to be avoided; the same applies to timber, farm animals, freshwater fish, etc.

Through the analysis on the preceding pages, we have determined the amount of water assumed to be supplied by New Jersey's natural hydrological capital. Therefore, to calculate market value, we merely need an estimate of the market value per unit, e.g., per thousand gallons (one commonly used quantity). However, valuing "raw" (i.e., untreated) water at its source presents other difficulties besides double-counting, as will appear below.

Since a number of studies of the economic value of water have used the actual price paid by consumers for water at the tap to estimate market value (see e.g. Young 2005), the most obvious source of data for this would appear to be the rates end users of water are charged by New

[20] The value of water is determined by local and regional site-specific characteristics and options for use, so in theory water value should be estimated on a regional or local basis. Such a detailed analysis is beyond the scope of this project, which focuses on the average statewide value.

Jersey's water purveyors. The New Jersey Board of Public Utilities (BPU) sets rates for water purveyors serving 1.1 million of the state's residential and commercial[21] customers or roughly a fourth to a third of that market; as of July 1, 2005, the average rate for these 1.1 million customers (weighted by the number of customers of each purveyor) was about $3.51 per 1,000 gallons (excluding meter charges), or about $3.39 in 2004 dollars.

A less obvious source of price data are the Purchased Water Adjustments Clauses (PWACs), which set the amounts included in retail rates to enable purveyors to recover the costs they incur when they themselves have to purchase water to meet end-user demand. For regulated purveyors, those amounts are also set by BPU. As part of this research, we reviewed BPU rate orders involving PWACs from 2000 forward, focusing on the seven purveyors that serve 5% or more of the 1.1 million customers whose water rates are set by BPU; as a group these seven accounted for over 87% of those 1.1 million customers. The PWACs we found established rate adjustments for purchased water ranging from $0.906 to $2.573 per thousand gallons in 2004 dollars, with an average of $1.50/1,000 gallons[22] for the orders reviewed.[23] We also reviewed data from the 2000 Community Water System Survey conducted by USEPA, a national survey with more than a thousand respondents; however, that source did not provide price data of the type needed.

While these kinds of price data are more or less readily available, they fail to distinguish between the value of raw water at its source (an aquifer or surface water body) and the value of water at the tap (Young 2005). The latter, sometimes called the "delivered price", includes the value not only of the raw water itself but also the value added to the raw water by purveyors in the form of delivery infrastructure (pipes, pumping stations), treatment facilities (plants, chemicals), labor, and so forth.

Valuing water at the delivered price thus entails valuing much more than just the water. This can be seen most easily if we break down the process that makes water available into distinct component parts and imagine that different companies are involved at each stage of the process:

- Company A pumps raw water from underground aquifers or surface water bodies and delivers it to a water treatment firm, which pays A an amount that reflects A's costs and profit margin (producer surplus).

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[21] Data for other classes of water users, e.g., industrial, is less readily available than for residential customers, and we have therefore generalized from the residential sector. Except for some industrial users that require high-quality water, quality standards are generally higher for potable (i.e., residential and commercial) water. Therefore, generalizing from the residential sector may overstate the prices actually paid for water by non-residential customers; however, the extent of that overstatement (if any) is not readily determinable.

[22] It is important to note a PWAC allocates the purveyor's cost of purchased water over the entire amount of water that the purveyor's supplies. Therefore, PWAC amounts *understate* a purveyor's actual cost per thousand gallons purchased.

[23] The PWACs of most purveyors did not come before BPU during the time period surveyed because those purveyors did not request increases in their retail rates to reflect increased costs for purchased water. The figures in the text therefore do not represent the complete universe of PWACs.

- Company B treats the raw water to conform to water quality standards and delivers it to a regional "wholesale" purveyor that pays B an amount reflecting B's costs (including the amount that B paid to A) and profit. The value added by B consists of the price at which it sells the water minus the price it paid Company A.

- Company C distributes treated water to retail purveyors that pay for it in a similar fashion. Assume for present purposes that C also temporarily stores some amount of water so that it can meet surges in demand during peak use periods. The value added by C consists of the price at which it sells the water minus the price it paid B.

- Finally,[24] D delivers treated water on demand to individual users, again paying for the water it purchases and selling it at a price that reflects its cost of purchased water and the value it adds by delivering it to end users (including D's profit margin).

In paying D for the water it uses, the end user is thus paying for the water extracted from natural sources by A, the treatment provided by B, the availability on demand provided by C and D, and the delivery services provided by D. To say that the value of the water as *natural* capital includes the value of the essential services provided by B, C and D is to attribute to nature values that are created by human and physical capital.

To further clarify this point, we could also imagine an end user (one who does not have a private well) by-passing this entire process by driving to a spring, filling a 50-gallon drum with water, bringing the drum home, adding treatment chemicals to the water, etc. While this alternative might cost less than the "normal" process of obtaining water, even including the value of the time spent by the end user, it would represent an enormous inconvenience for most people, an inconvenience that we willingly pay water purveyors to avoid. However, while convenience has clear economic value (since we willingly pay for it), it does not represent natural capital.

A final shortcoming of rate-setting information as a source of market values is the fact that rates represent administratively established prices rather than market prices.[25] Because of this, their relationship to Total Willingness to Pay is unclear. For all of the above reasons, delivered prices or rates set for purveyor-supplied water clearly have serious limitations in terms of their ability to quantify the true economic value of water and are not an appropriate basis for estimating the value of natural hydrological capital.

E. Economic Value of Water

There is another source of data that are less subject to these problems, namely the prices charged by the New Jersey Water Supply Authority (NJWSA), a public agency. In 2004, the Authority sold raw water to forty-two customers, including both purveyors and ultimate users; the Elizabethtown Water Company was the Authority's largest customer, accounting for 62.5%

[24] In this example we ignore the cost of treating and disposing of wastewater.
[25] This does *not* mean that rate-setting is an inappropriate way of establishing the prices end users must pay for water; that issue is not relevant to the present analysis.

of total 2004 contracts. In that year,[26] the Authority had contracts to supply a total of 198.562 MGD (72,475 MGY) from its Raritan and Manasquan systems at a weighted average price of $0.283 per thousand gallons.[27]

The magnitude of this price (in relation to both the retail rate and the rate adjustment for purchased water) suggests that it represents a closer approximation to the true economic value of raw water, because it clearly has much less room to include producer costs not related to natural capital than the rates discussed above. Finally, the NJWSA prices arguably represent the amount that its customers are willing to pay for raw water, since the Authority's customers include a major utility (the Elizabethtown Water Company) that purchases over half of the water contracted for by the Authority and Princeton University, a contractee that clearly does not suffer from a lack of bargaining power.

As a public agency, NJWSA sets its prices to cover its projected costs, as shown by its published rate schedules and the explanations of its rates (available at www.njwsa.org/html/publications.html). Its prices do *not* reflect what in the for-profit sector would be termed return on equity (ROE), i.e., the owners' profit or producer surplus. For 2004-2005, BPU used a standard return on *common* equity of 9.75% for regulated water utilities, representing the level determined by BPU to be needed for such utilities to earn a competitive rate of return on their common equity capital.[28] (Non-common equity would include such things as *preferred* stock.) In more recent (2006) water rate proceedings before the Board, BPU Staff recommended an increase in the return on common equity above the 9.75% level. The Board has yet to make a determination as to whether or not it will accept that recommendation, and in the absence of a Board decision, this analysis will use the 9.75% rate.

For the Authority, the equivalent to return on equity would be return on net assets. According to the NJWSA 2005 Annual Report, the Authority's net assets as of 6/30/03 were as follows:

Table 8: Net Assets of the New Jersey Water Supply Authority

Type of net asset	Value at 6/30/03
Unrestricted	$46,738,915
Invested in capital assets*	35,978,635
Subtotal	**82,717,550**
Restricted	11,721,789
Total net assets	**94,439,339**

*net of related debt

[26] The Authority operates on a June 30 fiscal year; for simplicity, FY 2004 will be taken as the relevant year for this analysis.

[27] A weighted average was used because the contract price for water supplied from the Manasquan system is much higher than the price for water from the Raritan system ($0.922 vs. $0.215 per thousand gallons).

[28] See, e.g., rate orders for New Jersey-American, Mount Holly, Gordon's Corner, Shorelands, Middlesex, Crestwood Village, and Montague Water Companies at http://www.state.nj.us/bpu/home/rincrease.shtml.

These three types of nets assets merit separate consideration in the context of determining a market rate of return to be included in the market value of raw water:

- Unrestricted net assets correspond most closely to common equity, and it is assumed here that the true 2004 market value of the raw water sold by NJWSA would include a return of 9.75% of these assets.

- While the net assets invested in capital assets are not available for other uses, it seems reasonable that those assets would be expected to earn a suitable return, and this analysis assumes that the market value of the Authority's raw water sales would also include a 9.75% return on these assets.

- Restricted net assets might be considered as the NJWSA equivalent of non-common, since such assets would not necessarily be expected to earn a market rate of return.

A return of 9.75% on the $82.7 million of unrestricted net assets and investment in capital assets equals $8,064,961; dividing this by the 72,475.13 MG of contracts in effect in 2004 gives $0.1113 per 1,000 gallons, and adding that result to the average contract price of $0.2827 per 1,000 gallons gives a total estimated for-profit equivalent *market* price (including producer surplus) of $0.3940 per 1,000 gallons.

This estimated market price is about 11.6% of the 2004 retail rate of $3.39 per 1,000 gal. for customers of regulated purveyors. This low percentage reflects the fact that, as many economists have noted, U.S. water markets treat raw (i.e., untreated and undelivered) water almost as a free good (see, e.g., Young 2005 and Tietenberg 2000), at least in the comparatively water-rich Eastern states. This implies that the only commercially important costs in those states are felt to be those for treatment and delivery.

The *potential* market value of raw water is clearly much higher than this analysis would suggest, since if prolonged drought were to become the norm as a result of climate change,[29] the price of water would presumably increase well beyond current levels. Even without prolonged drought, where underground aquifers are the source of the water used, and where the rate of withdrawal from those aquifers exceeds the recharge rate (as appears to be the case in some parts of South Jersey), the low prices currently charged reflect the partial depletion of our endowment of natural groundwater capital.

Elasticity of Demand and Leakage

The other main determinant of Total Willingness to Pay for raw water besides the quantity and value per thousand gallons is the elasticity of demand for that water. It might seem that the demand for water should be highly inelastic, since water is essential for life for most economic activities. However, empirical studies have documented the existence of some elasticity based on the fact that not all uses of water are truly essential, e.g., lawn watering and car washing. In effect, there are multiple uses of water and therefore multiple elasticities of demand.

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[29] Decreased precipitation in New Jersey has been identified as a possible consequence of global and regional climate change.

According to Young (2005, p. 269), most estimates in the literature for the price elasticity of demand for water fall into the range from -0.2 to -0.6, meaning that a 1% increase in price would lead to a decrease in demand of between 0.2% and 0.6%. Some studies have found an even wider range, e.g., -0.1 to –1.57, depending on the use, time period, etc. (WSDE 2005). This study will use the narrower range cited by Young; as in many other studies, elasticity here is assumed to be constant.

A final valuation factor not mentioned so far is the amount of water lost during delivery from the purveyor's facilities to the end user due to leaks and other causes. Water that is lost due to such causes provides no value to the end user, and Young (2005) and others state that the value of water should be reduced to reflect this. Based on the analysis of BPU data presented in Exhibit A, we estimate the loss percentage for New Jersey at between 12.8% and 26.4%, with a central estimate of 19.6%.

Calculation of Total Willingness to Pay

Based on the methodology described in Section II and Appendix A, we estimate the Total Willingness to Pay for the raw water supplied by New Jersey's hydrological capital to be as shown below; because of the range of estimates for certain key parameters, we present low-end, central, and high-end estimates.

Table 9: Total Willingness to Pay for Raw Water (2004 $)

Parameter ↓ or Estimate →	Low-end	Central	High-end
Key assumptions:			
Elasticity of demand	-0.6	-0.4	-0.2
Leakage rate (see Exhibit A)	26.4%	19.6%	12.8%
Total NJ supply (MGY)	547,000	592,000	641,000
% not for agriculture/irrigation[30]	90.2%	90.2%	90.2%
Adjusted total supply (MGY)	493,394	533,984	578,182
% delivered (1-leakage)	73.6%	80.4%	87.2%
Amount of water delivered (MGY)	363,138	429,323	504,175
Market value per 1,000 gal.	$0.394	$0.394	$0.394
Market value/year $MM	$143.1	$169.2	$198.6
Consumer Surplus/Market Value	83%	125%	250%
Consumer surplus/year $MM	$118.8	$211.4	$496.6
TEV/year $MM	$261.8	$380.6	$695.3
Present value at 3%/yr $Bn	$8.728	$12.686	$23.175
Natural capital (acres)	3,224,539	3,224,539	3,224,539
TEV/acre/year $	$81	$118	$216
Present value/acre $	$2,707	$3,934	$7,187

Key: CS = consumer surplus; MV = market value; TEV = total economic value

[30] As discussed earlier, the average of 9.8% of total supply used for agriculture and irrigation is deducted here to avoid double-counting the benefits of that water, since those benefits are reflected in the value of New Jersey's agricultural products (see Sec. V).

There is obviously an element of uncertainty in these estimates, but they indicate the probable order of magnitude relevant to valuation of New Jersey's water resources under current market and environmental conditions. Of course, since water is essential for life, the "true" value of water, defined as what users would be prepared to pay to obtain an adequate water supply in a severe drought, may be an order of magnitude or more *greater* than these figures suggest. If future climate change leads to reduced precipitation in New Jersey (as some climate modeling results suggest), those higher values may become more relevant than the conservative estimates presented here.

Section IV: Mineral Resources

The other major abiotic natural goods produced in New Jersey are certain non-fuel raw minerals. While New Jersey is not usually considered a major mining state, it contains deposits of commercially valuable construction and industrial sand and gravel and crushed stone.[31] Data published by the U.S. Geological Survey (USGS) indicate that for the 10-year period from 1995 to 2004 (the most recent year available), New Jersey's mining companies extracted minerals with a total market value of about $342 million in 2004 (see Table 10 and Figure 3 below).

Reflecting the fact that most quarries in New Jersey are classified as barren land, this report considers the natural capital relevant to mineral production to consist of New Jersey's 51,796 acres of barren land (see Sec. I, Table 1). This figure does not reflect the portion of the coastal shelf sites that provide sand for beach replenishment, since most of that sand is extracted by the Army Corps of Engineers for use in beach replenishment and neither the tonnage nor the value are part of the data set on which this analysis is based.

As Table 10 shows, the three mineral products for which USGS data are available have followed very different production and price trends, although in general, output and prices tended to move in opposite directions during these years.

- Production of *construction sand and gravel* generally trended upwards from 1995 to 2004. Over the same period, prices generally declined. According to NJGS staff, these figures include offshore sand dredged by a private partnership but exclude offshore sand dredged by the Army Corps of Engineers for purposes of beach nourishment. Since the valuation analysis presented below is based on the USGS figures, it therefore understates the total value of the sand-and-gravel component of New Jersey's natural capital.

- Production of *industrial sand and gravel,* a much more expensive product, fluctuated widely, declining through 2002 and rising sharply in 2003 and 2004. In contrast, prices rose steadily through 2002, then dropped sharply in 2003 and again in 2004.

- Production of *crushed stone* showed small but steady increases through 2001, plunged steeply in 2002, and recovered in 2003-2004. The price trended slowly downwards through 2001, plunged steeply in 2002, and returned to previous levels in 2003-2004.

The USGS dollar amounts represent the estimated FOB (free on board) plant prices.[32]

(text continues after table and figure)

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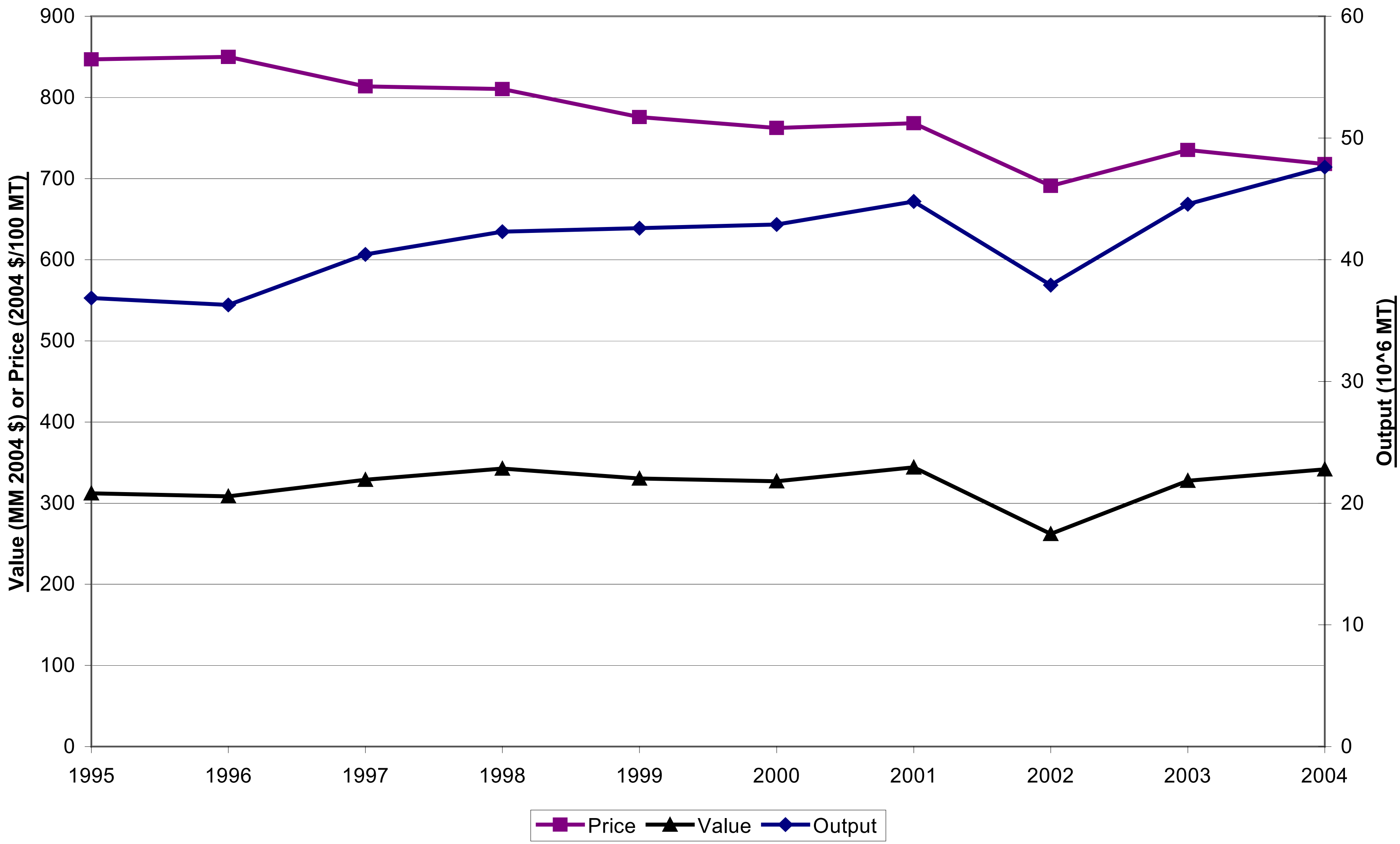
[31] The U.S. Geological Survey defines these materials as "minerals"; an industry term used for these three materials is "aggregates". While each of the three is itself a class containing multiple related minerals, the three terms will be used here as though each of the three is a single mineral product or natural good.

[32] FOB plant means the prices at the first point of sale or "captive" use, as reported by the production company, including all costs of mining, processing, in-plant transportation, overhead, and profit, but excluding transportation from the plant or yard to the customer.

Table 10: Nonfuel Raw Mineral Production in New Jersey (current $) (excl. $1,000/yr of gemstones; 2003 = prelim.; MT = metric tons)				
	Construction sand & gravel	**Industrial sand & gravel**	**Crushed Stone**	**Total excl. clays & misc.**
000 MT (1 MT = approximately 2,200 lb.)				
1995	14,100	1,760	21,000	36,860
1996	13,200	1,680	21,400	36,280
1997	16,100	1,530	22,800	40,430
1998	16,600	1,800	23,900	42,300
1999	16,500	1,580	24,500	42,580
2000	16,300	1,690	24,900	42,890
2001	16,800	1,580	26,400	44,780
2002	16,000	1,420	20,500	37,920
2003	18,200	1,570	24,800	44,570
2004	20,100	2,020	25,500	47,620
2004 $ per MT				
1995	$7.34	$21.98	$8.10	$8.47
1996	$6.71	$22.11	$8.53	$8.50
1997	$6.55	$22.33	$8.30	$8.14
1998	$6.56	$22.53	$8.08	$8.10
1999	$6.47	$23.47	$7.61	$7.76
2000	$5.86	$23.91	$7.67	$7.62
2001	$6.34	$23.92	$7.57	$7.68
2002	$6.38	$24.55	$6.10	$6.91
2003	$5.97	$21.47	$7.47	$7.35
2004	$5.97	$17.72	$7.29	$7.18
Value $000 (2004 $)				
1995	103,426	38,688	170,016	312,130
1996	88,634	37,148	182,555	308,336
1997	105,516	34,158	189,261	328,935
1998	108,960	40,558	193,200	342,718
1999	106,689	37,076	186,560	330,325
2000	95,540	40,412	191,080	327,032
2001	106,428	37,793	199,824	344,045
2002	102,078	34,858	125,080	262,016
2003	108,675	33,714	185,265	327,654
2004	120,000	35,800	186,000	341,800
Source: U.S. Geological Survey, Mineral Yearbook: The Mineral Industry in New Jersey, http://minerals.usgs.gov/minerals/pubs/state/nj.html and calculations by NJDEP. Current dollars as reported by USGS converted to 2004 dollars using the US Bureau of Labor Statistics Producer Price Index for construction sand/gravel/crushed stone and for industrial sand. Available at http://data.bls.gov/PDQ/outside.jsp?survey=wp. Accessed 10/25/06.				

Figure 3: Aggregate New Jersey Mineral Production



The markets for all three of New Jersey's commercially valuable minerals are strongly affected by demand in the construction industry. According to USGS, "[d]emand for industrial minerals was strong [in 2004] because of the continuing construction boom and a particularly strong housing sector. The demand for new home construction remained very strong [throughout the year], with little sign of letting up at the end of 2004" (USGS 2004). Indeed, in commenting on 2004, USGS stated that "it has become increasingly difficult to keep pace with demand" (USGS 2004). However, the 2004 figures do not reflect the subsequent slowing of the New Jersey new homes market in 2005-2006 or the slowdown in highway construction projects in the state in recent years.

As Table 10 shows, the prices for these mineral products have fluctuated widely over the period 1995-2004. However, Fig. 3 shows that despite the many fluctuations in price and output for each of the three minerals, the total market value for the three as a group has been relatively stable over the period 1995-2004, with the single exception of 2002. In that year, aggregate market value dropped by 23% from the 2001 level before increasing by 25% in 2003. In no other year (of these ten) did aggregate market value change by more than 6% in either direction. It seems reasonable, therefore, to use the average for the nine years 1995-2001 and 2003-2004 as an estimate for the annual aggregate market value. That nine-year average comes to $320.9 million in 2004 dollars.

Unlike the other natural goods considered in this report, mineral resources are not renewable[33], and in theory, therefore, future extraction volumes will depend on the time frame over which the production level implied by the $320.9 million/yr rate can be maintained. However, while there appear to be no publicly available data on New Jersey's in-ground reserves for these minerals, sand, gravel, and crushed stone are virtually ubiquitous in New Jersey, and there is no apparent reason to assume a physical limit to future extraction. As with many other minerals, estimates of reserves are driven mainly by new discoveries (probably not applicable in the New Jersey context) and by economics. That is, as a mineral's value increases, deposits previously considered not worth extracting are reclassified as "economic reserves", and vice versa.

It is true that no new mines or quarries have been opened in New Jersey in over twenty years, except for off-shore operations to extract sand for construction uses (e.g., beach replenishment).[34] In fact, as the New Jersey Geological Survey (NJGS) stated in its review of 2004, "[r]ising real estate prices, environmental concerns, and government regulations pressured the industry to close many operations" (USGS 2004). This statement suggests that future production of minerals in New Jersey may be constrained by legal and economic factors before the mines or quarries themselves are physically exhausted; USGS says much the same thing in its annual Mineral Commodity Summaries (USGS 2006).

[33] Sand used for beach replenishment may later be washed back offshore by tidal and storm activity and then re-dredged and placed on the same beach; this cycle can be viewed as a type of resource reuse.

[34] The USGS data for New Jersey reflect the extraction of sand from offshore sources by private companies.

On the other hand, it seems to be generally accepted that, barring the unforeseen, New Jersey's population will continue to increase in the decades ahead, creating fresh demand for the three mineral types being studied here. In addition, when the New Jersey Transportation Trust Fund is replenished, an increase in highway repair and reconstruction can be expected, adding to the private demand.

Therefore, although there appears to be no rigorous way to estimate reserve levels (and therefore useful economic lives) for New Jersey's three commercially valuable minerals, there is also no apparent reason for rejecting the assumption of production in perpetuity used in the other sections of this report. Even if the physical amount extracted were to decrease, it seems reasonable to assume that future demand would offset this by generating upward pressure on per-ton prices, thereby maintaining annual market value, which is the relevant factor for valuation purposes.[35]

There appear to be few published estimates of the elasticity of demand for the types of minerals found in New Jersey; this may be in part because (as noted above) the markets for such products tend to be highly localized.

- According to Poulin (1996), demand for mineral aggregates is believed to be highly inelastic in the short run, as reflected in a non-peer reviewed study in Florida (Morrell 2006) which found a demand elasticity of –0.20 for crushed stone. This value is in line with the elasticities for the other abiotic natural good considered in this report (water) and with another non-food-related good (timber).

- In contrast, an EPA analysis (USEPA 1997) under the Clean Air Act cited demand elasticities of –1.0 and –0.9 for the *cut* stone and cement industry sectors, respectively. These goods are more highly processed and value-added products than *crushed* stone and could be expected to have more elastic demands.

In the absence of other information, this report adopts these estimates and the midpoint between them of –0.6 for the three New Jersey minerals while noting that a wider literature searchmight identify other relevant elasticity estimates.

Based on these elasticity values and the methodology described in Section II and Appendix A, the Total Willingness to Pay (TWP) and Consumer Surplus (CS) for this class of natural goods are estimated to be as follows:

(see table on next page)

[35] This type of (hypothetical) increase in *real* prices should be distinguished from general inflationary increases in *nominal* prices; as discussed in Section II, only the former are relevant to this study.

Table 11: Total Willingness to Pay for New Jersey Minerals (2004 $)			
Parameter ↓ or Estimate →	**Low-end**	**Middle**	**High-end**
Elasticity of demand	-1.00	-0.60	-0.20
Market value/year $MM	$320.9	$320.9	$320.9
Consumer Surplus/Market Value	50%	83%	250%
Consumer surplus/year $MM	$160.5	$266.3	$802.3
TEV/year $MM	$481.4	$587.2	$1,123.2
Present value at 3%/yr $Bn	$16.045	$19.575	$37.438
Natural capital (acres)	51,796	51,796	51,796
TEV/acre/year $	$9,293	$11,338	$21,684
Present value/acre $	$309,773	$377,923	$722,804

Key: CS = consumer surplus; MV = market value; TEV = total economic value

In terms of future supply, a factor not considered thus far is the potential for some parts of New Jersey to meet some of their stone and gravel needs from sources outside New Jersey, e.g., from quarries in eastern Pennsylvania and southern New York.[36] However, according to NJGS staff transportation costs are a major component of the total cost of mineral aggregates, and transportation by truck[37] beyond 20-30 miles or so is not economically competitive with more local production, especially since this type of surface mining use relatively simple technology.[38]

On the demand side, the key factors driving long-term economic value will undoubtedly be the levels of residential and commercial construction and of public spending on highway projects. These factors are in turn driven by interest rates, fiscal conditions, and other factors the consideration of which lies well outside the scope of this study. While demand will probably continue to fluctuate from year to year in line with these underlying conditions, the long-term trend seems likely to be upwards for the foreseeable future.

Given the factors just described, the estimated values in Table 11 should be regarded as first-order approximations; the exclusion of offshore sand dredged for beach replenishment, probably makes them conservative. The lack of more precise data on supply sources, in-state reserves, demand and price trends, and future legal constraints precludes developing a more authoritative estimate. However, even without such information, the values presented above represent plausible first-order estimates of the substantial economic benefits provided by New Jersey's mineral-related natural capital.

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[36] The movement of *sand* would more likely be in the opposite direction, since as a coastal state, New Jersey has larger deposits of sand than inland states.

[37] According to NJGS staff, however, barge transport is economically feasible over much longer distances, with much lower per-ton shipping costs, allowing some mineral aggregates to be brought to the New York City area from quarries as far away as Quebec. Transport by rail could be even more cost-effective if an adequate freight rail network existed.

[38] CEMEX, a major Mexican cement company, has reportedly made large inroads into the U.S. cement market during the past decade, suggesting the existence of a cost-competitive long-haul distribution network for such bulk products. However, cement is a manufactured product with high value-added and few sources of supply, so its relevance to the mineral products discussed here is limited.

Section V: Agricultural Products

Farming makes a highly valued contribution to New Jersey's economy and quality of life, a contribution that figures on agricultural income do not fully reflect. In 2004, agriculture contributed an estimated $467 million of value added to the Gross State Product (excluding forestry and other non-farming activities). This figure does not include the significant ecosystem services provided by farmland (see Part II of this report), nor does it reflect the scenic and other amenities provided by agricultural open space, amenities which contribute significantly to the quality of life and frequently to the value of near-by properties.

State and Federal estimates of the amount of farmland in New Jersey are in fairly close agreement, as the following table shows (USDA = United States Department of Agriculture; UVM = University of Vermont):

Table 12: Agricultural Land in New Jersey

Land Use	USDA 2002	DEP/UVM*
Cropland (1)	490,886	546,261
Pct. of subtotal	*81.1%*	*81.1%*
Pastureland (2)	114,309	127,203
Pct. of subtotal	*18.9%*	*18.9%*
Subtotal	605,194	673,464
Other Farmland (3)	66,066	allocated to above
Total**	**671,260**	**673,464**
Woodlands (4)	134,422	included in Forests
Grand Total	805,682	n/a

Notes:
* revised to reflect USDA percentage allocation of Subtotal.
** numbers include agricultural wetlands.
1. excludes cropland used as pastureland at time of survey.
2. includes cropland and woodland used as pastureland.
3. includes house lots, roads, ponds, wasteland, etc.
4. excludes woodland used as pastureland at time of survey.

The USDA figures in Table 12 were obtained from an on-ground census of farms; the UVM figures are based on a 2005-2006 UVM analysis of 1995-1997 NJDEP data obtained from aerial photographs.[39] The DEP/UVM figures for cropland and pastureland include a pro rata allocation of Other Farmland, which therefore does not appear as a separate line item in the last column. The UVM analysis classifies woodland on farms under Forests. Part II of this report presents a more detailed description of the UVM methodology, and the relevant GIS metadata are available from NJDEP.

[39] The original DEP and UVM data classify a substantial amount of grassland as pastureland even though it consists of cropland planted with row crops; the DEP/UVM Subtotal of 673,464 acres shown above has therefore been reallocated to reflect the 2002 USDA breakdown between cropland and pastureland.

Since NJDEP's updated land use/land cover estimates for 2002 will not be available until early in 2007, this study will use the UVM estimate of 673,464 acres of farmland from Part II of this report; doing so will provide consistency between Parts II and III.

Market Value of Farm Products

In valuing New Jersey's agricultural natural capital, it is important to distinguish between the value of the food and other goods produced on farms and the value of the farmland itself; only the latter can be considered natural capital. The production of food requires many kinds of inputs, e.g., land, human labor, machinery, fuel, seeds, etc., and it would not be defensible to attribute the entire market value of food products to land alone. Nature's contributions to food production are essential, but so are those of farmers and the human and physical assets they deploy.

Therefore, to get to the value of the natural capital considered by itself, we must deduct farm expenses from farm revenues, since those expenses mainly represent the cost of inputs other than land. There are two main sources of farm revenue and expense data, both of which are units of the U.S. Department of Agriculture (USDA): USDA's Economics Research Service (ERS) and its National Agricultural Statistics Services (NASS). ERS prepares annual state-level estimates of farm revenues and expenses, while NASS conducts a state and county-level Census of Agriculture every five years (the most recent census was for 2002). For 2002, the two reported the following financial data:

Table 13: New Jersey Farm Revenues and Expenses for 2002 (millions of 2002 dollars)

	NASS	**ERS***
Sales of agricultural products	$749.9	$869.6
Other farm revenue	0.0	53.6
Total farm revenue	749.9	923.2
Cash expenses	$647.0	$793.2
Non-cash expenses**	43.9	67.1
Total expenses	690.9	860.3
Net farm income	**$59.0**	**$62.9**

*excluding imputed rental income and related expenses for farm dwellings.
**mainly depreciation (NASS) or capital consumption (ERS).

As Table 13 shows, the two sources show similar figures for 2002 net farm income; however, given the wide differences in revenues and expenses, the agreement may be a coincidence. ERS uses national income accounting principles, which differ substantially from the principles used in this report for other natural goods; for example, ERS includes an estimate of the imputed rental value of farm dwellings and uses a capital consumption allowance rather than the more familiar depreciation expense. In addition, the ERS revenue figures for 2002 include roughly $100 million for horse semen (i.e., stud fees), a factor that seems of questionable relevance to the current inquiry.

For these reasons, this study will use the NASS figures as a basis for analysis. Table 14 present a more detailed breakdown of the NASS data from Table 13.

Table 14: NASS Revenues and Expenses for 2002

Revenue or Expense Item	MM 2002 $	MM 2004 $
Plant products (87.68%)	$ 657.5	$ 690.4
Animal products (12.32%)	92.4	97.0
Market value of agric. products	749.9	787.4
Farm production expenses	647.2	679.6
Net farm income	102.7	107.8
Non-cash exps. (depreciation etc.)	46.9	49.2
Net *cash* farm income	149.5	157.0
Cash flow/acre/year	$222	$233

Source: USDA/NASS. Inflator of 1.05 based on CPI for all urban consumers.

NASS data are only available at five-year intervals; ERS data (available annually) show that net farm income for New Jersey plummeted in 2001-2002 from the 2000 level but rebounded sharply in 2003-2004 (with a much smaller gain in 2005). However, even 2005 was almost 15% below the 2000 level, possibly reflecting higher energy prices, further conversion of farmland to residential and commercial uses, the severe 2001 drought, or other factors. In short, 2002 data (even when translated into 2004 dollars) represent a conservative basis for estimating the value of New Jersey farm income, based on the amount of farmland shown in Table 12.

The figures in Tables 13 and 14 distinguish between cash and non-cash expenses, with depreciation of physical capital (equipment, structures, etc.) being by far the most important example of the latter (almost 94% in 2002). While some would use the Net Cash Farm Income of $157 million (in 2004 dollars) as a basis for further analysis, this study uses the more conservative Net Farm Income of about $108 million (in 2004 dollars). Maintenance and replacement of physical capital are essential for modern agricultural production, and omitting them from the analysis overstates the productivity and value of raw farmland.

Market Value of Farmland

Given an assumed annual farm income of about $108 million, the other factor needed to estimate the economic value of New Jersey's farmland is the elasticity of demand for the various farm products. The U.S. Department of Agriculture has published demand elasticities for broad food categories, e.g., meat, dairy, produce, etc.; and, using those figures we have calculated weighted average elasticities for New Jersey's farm output (see Exhibit B). The resulting elasticities are –0.067 for crops, -0.092 for animal products, and –0.069 overall.

Based on these figures, the table below shows the calculation of Total Willingness to Pay for the annual flow of farm products from New Jersey's agricultural natural capital:

Table 15: Total Willingness to Pay for New Jersey Farm Products (2004 $)			
Parameter ↓ or Sector →	**Cropland**	**Pastureland**	**Total**
Elasticity of demand	-0.067	-0.092	-0.069
Market value/year $MM	$95	$13	$108
Consumer Surplus/Market Value	746%	543%	721%
Consumer surplus/year $MM	$705	$72	$778
TEV/year $MM	$800	$85	$885
Present value at 3%/yr $Bn	$26.7	$2.8	$29.5
Natural capital (acres)	546,261	127,203	673,464
TEV/acre/year $	$1,464	$672	$1,315
Present value/acre $	$48,812	$22,394	$43,822

Key: CS = consumer surplus; MV = market value; TEV = total economic value

In this table, annual market values were allocated to cropland and pastureland based on ERS data and the overall ratio of net farm income to revenue. Because the elasticity of demand for food is much lower than the elasticity for other natural goods, Consumer Surplus makes up a relatively small portion of Total Willingness to Pay. All figures were independently rounded.

While the analysis in Table 15 presents the estimates of net benefit to society most consistent with economic theory, those estimates are not strictly comparable to the estimates for the other natural goods. The NASS data make it possible to deduct production costs from market value to obtain net farm income, which is closer than market value to the net benefit to society of agricultural natural capital. However, as Table 3 in Section II indicates, the valuation data available for the other natural goods represent the producer's sale price, which *includes* production costs. As a consequence of being more accurate, the value of farmland from Table 15 will automatically be *lower than* the estimated values for those other natural goods.

To provide figures for agricultural natural captial that are more comparable in derivation to those for the other natural goods, Table 15A presents estimates based not on net farm income but on the market value of agricultural products sold.

Table 15A: Alternate Valuation of New Jersey Farm Products (2004 $)			
Parameter ↓ or Sector →	**Cropland**	**Pastureland**	**Total**
Elasticity of demand	-0.067	-0.092	-0.069
Market value/year $MM	$690	$97	$787
Consumer Surplus/Market Value	746%	543%	721%
Consumer surplus/year $MM	$5,152	$527	$5,679
TEV/year $MM	$5,842	$624	$6,467
Present value at 3%/yr $Bn	$194.7	$20.8	$215.6
Natural capital (acres)	546,261	127,203	673,464
TEV/acre/year $	$10,695	$4,907	$9,602
Present value/acre $	$356,507	$163,559	$320,063

Key: CS = consumer surplus; MV = market value; TEV = total economic value

The foregoing analysis values New Jersey farmland based solely on its use as farmland. However, Plantinga et al. (2002) found that 82% of the value of New Jersey farmland stems from its development potential, implying that only 18% is due to the land's continued use for farming. In that regard, Appendix C presents USDA valuations for New Jersey farmland that reportedly reflect development potential as well as farming output. The data are difficult to reconcile with the above analysis, and further work in this area is clearly needed.

Uncertainties in the Analysis

The sustainable level of agricultural output depends on natural and societal forces, and an obvious question at this point is whether NFI of $222/acre/year is sustainable. Natural forces include weather, climate change, change in plant or animal diseases, etc. Projections of the impacts of climate change on New Jersey show that temperature increases are likely, but precipitation could either increase or decrease. Increased precipitation could come from fewer but more intense rainfall events, which would mean less water actually available for farming due to the rapid runoff from such storms. Seasonal patterns of precipitation could also shift so that while total rainfall increased, the amount during critical parts of the growing season might decrease. In addition, different parts of the state and different crops could experience different impacts. We are not aware of any analyses of these possibilities at a sufficiently detailed level to provide a basis for estimating the economic impact of climate change on New Jersey agriculture.

The most important societal force that will affect the future of agriculture in New Jersey is undoubtedly the conversion of farmland to residential and comercial uses, and the impacts of that force are likely to be felt sooner than those of climate change. NJDEP's land use/land cover database shows a loss of over 85,000 acres or about 11.5% of agricultural land between 1986 and 1995/97. Data on land use/land cover change through 2002 are expected to be available in the near future, but it is probable that farmland is still being lost to development and to reforestation of abandoned farms.

In theory, more intensive cultivation of the remaining farmland and/or a shift to higher-value crops might make up for such losses of farmland in terms of the dollar value of agricultural output, although such changes might also entail higher production costs. However, USDA data from previous years show that the value of New Jersey's farm output is not keeping up with inflation, which means that it is actually declining in real terms. For example, between 1997 and 2002, the market value of New Jersey's farm output rose by 6.0% in nominal terms according to the 2002 Census of Agriculture while consumer prices (as represented by the US Urban Consumer Price Index) rose by 12.1%; as a result, the real value of New Jersey's agricultural output decreased by 5.4%. (Output per farm did somewhat better, increasing by 7.3% in nominal terms, while declining by 4.2% in real terms.)

Other important societal forces affecting agriculture's future in New Jersey will include any changes in U.S. agricultural subsidy policies and levels, changes in State or Federal regulations relating to pollution from agricultural runoff, efforts to reforest farmland to sequester and store carbon dioxide as a means of combatting climate change, introduction of genetically-modified seeds, changes in consumer dietary preferences, etc.

Given the many influences (some of which could be either positive or negative), it is difficult to project the monetary value of New Jersey's future agricultural output, although if farmland continues to be converted to other uses it is probably safe to say that the total value will decrease, even if the value per acre remains the same. For purposes of this study, we assume that the value per acre will remain at $233/year (in 2004 dollars), that the acreage devoted to agriculture will remain at the estimated 2004 level of 673,464 acres, and that there will be no major adverse changes in climate or crop disease patterns or in the other factors cited above. These assumptions result in annual net farm income of $157 million in 2004 dollars, the figure used for market value in Table 15. However, the presence of so many important qualifiers makes this (and perhaps any) valuation figure an uncertain basis for extrapolation to future years, especially over an extended time horizon.

The sustainability of this flow of economic benefits from New Jersey's agricultural natural capital is perhaps more subject to future land use decisions than the benefit flows for any of the other types of natural capital discussed in this report. Farmland is often the first choice of developers for new residential and commercial projects, and it is also seen by some as a potential location for reforestation projects designed to sequester carbon dioxide, a major greenhouse gas. In addition, the usual caveats apply to the above estimates, including their vulnerability to climate change, invasive species (including plant and animal diseases), changes in consumer tastes, etc. Farmland makes an important contribution to New Jersey's wealth; but it is a contribution under constant stress and one that could well decline in coming years.

Section VI: Non-Farm Animals

In addition to farm animals, New Jersey is home to a number of game and non-game species, and the economic value of the related goods can be estimated. The most important game animals are white-tailed deer and black bears; according to NJDEP's Division of Fish and Wildlife, other game animals include rabbit, squirrel, woodchuck, raccoon, fox, coyote, and opossum. (Fish and shellfish are considered separately in Section VII below.) Game birds include pheasant, quail, chukar, crow, American woodcock, ruffled grouse, and wild turkey. New Jersey's non-game animals include a number of species classified as rare, threatened, or endangered under State or Federal law; information on these can be found in Niles et al. (2001).

Game and non-game animals and birds as a group are found in a variety of habitats (see, e.g., Niles et al. 2001 for habitat data for selected non-game species). Determining the total habitat area for each of the game species analyzed here is beyond the scope of the current report. For present purposes, the relevant natural capital is considered to include the following:

Table 16
Natural Capital for Non-Farm Animals

Ecosystem Type	Area (acres)
Forest	1,465,668
Freshwater wetland	814,479
Cropland	546,261
Saltwater wetland	190,520
Pastureland	127,203
Open fresh water	86,232
Riparian buffer	15,146
Total	**3,245,509**

Game animals (used from this point on to include game birds) are a potential source of food, and a number of ecosystems provide habitat for such animals, although hunting is legally permitted only in certain areas of the state. While comprehensive data on game harvests are not readily available, there is enough information to estimate a value for this type of ecosystem good.

Based on information from NJDEP's Division of Fish and Wildlife,[40] the total harvest of game animals in recent years has been about 3 million pounds, broken down as follows:

Table 17: Game Animal Harvests

Type of Game	Year(s) of Data	Harvest (lbs.)
Deer	1999	2,700,000
Game birds*	2003-2004	194,206
Small game*	2003-2004	99,227
Bear	2003 and 2005	69,040
Total		**3,062,473**

*Animal and bird counts were converted to weight basis assuming 1 lb./animal.

[40] Formerly the Division of Fish, Game and Wildlife.

There is obviously uncertainty in combining data for different years and in combining reported and estimated weights; in particular, a more recent estimate of the deer harvest would be helpful. Moreover, some game animals are less likely to provide food than others, e.g., coyotes. Absent such data, the above can only be viewed as a rough first approximation of the actual harvest.

The value of game animals is difficult to determine, since most such animals are taken for home consumption, and the utility derived from the hunt is part of the hunter's valuation of the hunting experience. In estimating market values, this study therefore uses retail prices for the Northeastern US for various meat products as reported by the US Bureau of Labor Statistics; since game animals tend to have less body fat than domesticated animals, we used lean beef products as a surrogate and used USDA estimates to translate retail prices into wholesale prices.

Table 18: Estimated 2004 Market Value of New Jersey Game Animals

Ground chuck, 100% beef*	$2.419
Ground chuck, lean/extra lean*	3.017
Round roast, USDA choice, boneless*	3.741
Average retail price	$3.059
Assumed farm/retail ratio**	1/3
Assumed price/lb for valuation	$1.020
Annual harvest (lb.)	3,062,473
Annual harvest value	**$3,123,722**

*average 2004 price for the Northeastern US from http://data.bls.gov, 8/16/06.
**defined here as ratio of price received by farmer to retail price; value of 1/3 based on 1997 USDA estimate for beef (ERS 2002)

As the table shows, price estimates for three related meat products were used to generate alternative estimates of the annual market value of the game animal harvest.

Trapping is not a major activity in New Jersey, but the Division of Fish and Wildlife collects data on the annual harvests of muskrat, raccoon, red and gray fox, mink, opossum, skunk, weasel, beaver, river otter, and coyote. As with game animals, a variety of ecosystems provide habitats for these species; for simplicity, the total relevant acreage is assumed to be the same as that used for game animals. The New Jersey Trapper Harvest, Recreational, and Economic Surveys for 2003-2004 and 2004-2005 provide market value estimates of $282,033 and $210,143 respectively for fur-bearing animals, with a two-year average of $246,088.

Given the heterogeneity of the game animal-fur harvest category, significant further research would be needed to determine whether species-specific elasticity of demand estimates are available; given the small number of animals for each species, the gain in accuracy from such research would probably not be significant. Since this class of natural goods is being analyzed primarily as a source of food, this study uses the US Department of Agriculture's estimated elasticity of demand for meat of –0.089 for the entire class except for fur, for which USDA's estimated elasticity of demand of –0.691 for clothing is used.

Based on these elasticities and the methods from Sec. II and App. A, Total Willingness to Pay (TWP) and Consumer Surplus (CS) for these natural goods are estimated as follows:

Table 19: Total Willingness to Pay for Game and Fur Animals (2004 $)			
Parameter ↓ or Sector →	**Game**	**Fur**	**Total**
Elasticity of demand	-0.089	-0.691	-0.134
Market value/year $MM	$3.12	$0.25	$3.37 M
Consumer Surplus/Market Value	562%	72%	524%
Consumer surplus/year $MM	$17.56	$0.18	$17.74
TEV/year $MM	$20.68	$0.42	$21.10
Present value at 3%/yr $MM	$689.23	$14.10	$703.33
Natural capital (acres)	3,245,509	3,245,509	3,245,509
TEV/acre/year $	$6.37	$0.13	$6.50
Present value/acre $	$212.36	$4.35	$216.71

Key: CS = consumer surplus; MV = market value; TEV = total economic value

As expected, these values are not especially large, since the provision of game and fur is not known as a major source of value for New Jersey's natural capital.

As with most of the natural goods discussed in Part III of this report, these estimates assume that the quantities and prices of these natural goods will continue at their 2004 levels in perpetuity. Such stability is unlikely for a number of reasons, including the following:

1. changes in land use that destroy or shrink the habitats for the animals in question,
2. changes in cultural norms regarding the ethical status of hunting and trapping,
3. changes in the legal status of individual species as rare, threatened, or endangered under State or Federal law,
4. reductions or geographic shifts in available habitat due to climate change,
5. changes in species populations and species mix due to predation, disease, changes in food supply, etc.,
6. long-term changes in consumer preferences for these natural goods,
7. other legal changes affecting the permitted extent of hunting and harvesting, e.g., the length of hunting seasons, permitted hunting methods, etc., and
8. other factors not identified.

Factors 1-4 seem more likely than not to *reduce* the sustainable harvest of these natural goods, while Factors 5-8 are indeterminate in their effects. Since deer account for almost 90% by weight of the annual game harvest, future rules regarding deer hunting are a major unknown, with public opinion apparently divided in terms of support for different methods of reducing the State's deer population. The rules regarding bear hunting also receive a great deal of public and regulatory attention, although bear account for a much smaller share by weight of the total game harvest. Given the many unknowns, the estimates presented above are necessarily subject to a large degree of uncertainty; however, they appear to represent the best estimates available given our current knowledge.

Section VII: Non-Farm Plants

As used here, "non-farm plants" includes grasses, wildflowers, herbs, medicinal plants, and other types of plants found in New Jersey, excluding trees, which are considered in Section VIII.[41] The focus here is on the plants themselves considered as ecosystem goods rather than on the pleasure many people obtain from viewing rare or aesthetically pleasing plants in their native habitats; the latter type of aesthetic and recreational benefit is treated in Part II as an ecosystem service provided by specific landscape types.

Plants obviously play an essential role in sustaining all of New Jersey's ecosystems. However, that role is not considered separately in this study, since the ecosystems themselves are treated directly in terms of their production of economically valuable goods and services. To count this "ecosystem maintenance" role of plants as a separate source of value would be to engage in double-counting; from the standpoint of economics, this function of plant life is treated as an "input" to the production of goods and services, which are then valued directly.

Relatively little quantitative information is available on the uses of New Jersey's non-agricultural plants (other than trees). This contrasts with the considerable attention paid to rare, threatened, and endangered animal species (see, e.g., Niles et al. 2001).[42] However, two of the values provided by plants have received attention in the economics literature: 1) the use of plants for medicinal and pharmaceutical purposes, and 2) the general importance of plants in terms of biodiversity and genetic resources. These uses are discussed briefly below.

Medicinal plants are a subject of great interest to some of the economists who work in the area of ecosystem valuation, especially those who work on tropical rainforest issues. As is well known, some of our most important medicines are derived or were first extracted from naturally occurring plants, including aspirin, cocaine, and quinine. The value of such compounds, as measured by sales, is extremely large in some cases. The problem in estimating the value of this type of natural capital is our inability to predict where, when, and whether similar discoveries will be made in the future and, if so, how valuable those discoveries will prove to be.

One study that sought to quantify this pharmaceutical value these is Simpson et al. (1996). That study attempted to determine the private *in situ* value of the marginal[43] species for use in pharmaceutical research and private value of the marginal acre of threatened habitat for pharmaceutical research. Using demand analysis for a limited sample of pharmaceutical researchers, the study obtained one-time generic values of $12,040 for the "marginal" species and $10 per acre for threatened habitat (values in 2004 $). The researchers sought to explain what they viewed as relatively low values by citing the following factors:

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[41] We can include fungi here, even thought they are no longer considered to be plants.

[42] In this regard, plant species are covered under the federal Endangered Species Act but not under current state law.

[43] In studies that ascertain values for genetic resources *in situ*, every "unit" (species or habitat area) of biodiversity is viewed as making an equal *marginal* contribution to the success of the bio-prospecting enterprise; that is, one species or one acre of habitat is about as valuable as any other.

- individual redundancy, i.e., if all representatives of a species produce a particular compound, individuals in excess of the number needed to maintain a viable population are redundant;

- species redundancy, i.e., instances in which identical drugs, or drugs with similar clinical properties, have been isolated from different species; and

- medical redundancy, where different therapeutic mechanisms may be effective in treating the same symptoms.

Given these caveats, the results of Simpson et al. (1996) at best provide indications of the order of magnitude of the benefits. Other studies have pointed to different approaches that could yield substantially different results. At this point, there is no generally accepted approach or methodology for assessing biodiversity value, and for this reason, no attempt is made here to estimate the potential pharmaceutical value of New Jersey's non-agricultural plants.

Plant species can also be considered more generally from the standpoint of biodiversity, although this takes us beyond the narrow focus on ecosystem goods.[44] Biodiversity is probably essential for habitat maintenance, since healthy ecosystems are usually characterized by containing a variety of species with population sizes sufficient to ensure long-term viability, all else being equal, e.g., climate, human development of natural lands, absence of invasive species, etc. Individual species also represent repositories of genetic data that can prove critical for ecosystem survival when habitats are subjected to stress from climate change, habitat fragmentation, entrance of invasive species (including disease-causing organisms) into the habitat, etc.

While biodiversity is unquestionably valuable, the study of the economics of biodiversity is still in its early stages, and only a few studies have attempted to quantify its value. Given the absence of data on New Jersey's endowment of plant species and the lack of a generally accepted valuation method, this study does not attempt to estimate a value for the natural capital represented by New Jersey's non-agricultural plant resources.

The conservation of biodiversity and genetic data is sometimes distinguished from the protection of rare, threatened, and endangered species. The latter has value in its own right, including the willingness of many people to pay for such protection even if they have never seen the species in question. However, the evidence for such willingness comes mainly from studies involving animals rather than plants and thus affords very little on which to base an analysis of New Jersey's plant resources. The aesthetic and recreational enjoyment that many people derive from viewing such species is considered in Part II as a service provided by the state's ecosystems.

[44] Some use the term biodiversity to mean the *number of species* in a given geographic area; others use it to mean the *population sizes* for the species in that area. These uses are not distinguished in this discussion.

Section VIII: Fish and Shellfish

Since they involve different types of data and different valuation issues, the products of commercial and recreational fishing will be treated separately below. The natural capital relevant to this class of natural goods is considered to be as follows:

- For commercial fishing, New Jersey's 299,835 acres of coastal shelf and 455,700 acres of estuaries and tidal bays, for a total of 755,535 acres.

- For recreational saltwater fishing, the same two marine ecosystems plus 190,520 acres of saltwater wetlands, for a total of 946,055 acres.

- For recreational freshwater fishing, 86,232 acres of open fresh water and 181,099 acres of unforested freshwater wetlands, for a total of 267,331 acres.

Certain wetlands are included in the above to reflect their role as fish nurseries and sources of bait fish. In effect, these wetlands are grouped in an integrated system with the waters where the fish are actually harvested, and the value of the harvest is allocated pro rata across the entire system. Forested freshwater wetlands are not included in these numbers based on the assumption that such wetlands are more important for hunting than for fishing.

Commercial Fishing

Fishing (including shellfishing) is an important industry in New Jersey. Six major fishing ports are located in the state, including Atlantic City, Barnegat Light, Belford, Cape May, Point Pleasant, and Port Norris, with a commercial fleet totaling more than 1,500 vessels and employing nearly 3,000 fishermen. The state also has 15 seafood processing plants and 81 wholesalers employing more than 2,200 workers (NJDA 2005). Recreational fishing is also significant with an estimated 806,000 participants in 2001 according to the U.S. Fish and Wildlife Service (USFWS 2003).

Fishery statistics are available from the National Marine Fisheries Service (NMFS) mainly in terms of commercial fisheries and to a certain extent marine recreational fisheries. Data on the latter are also compiled periodically by the U.S. Fish and Wildlife Service through its National Survey of Fishing, Hunting and Wildlife-Associated Recreation.

According to NMFS, over 100 species of finfish and shellfish are harvested in the waters off New Jersey. In 2004, vessels based in New Jersey ports landed over 187 million pounds of fish (finfish and shellfish), valued at almost $146 million paid to fishermen at the dock (the "ex-vessel" price) (NMFS 2005).

The two tables below present information from NMFS on the weight and value for the most important finfish and shellfish species harvested in 2004. The first table presents the 2004 finfish data, with species ranked by estimated value:

(see next page for tables)

Table 20: NMFS 2004 Finfish Landings Data for New Jersey				
Finfish Species	**Weight (lb)**	**% of Total**	**Value ($)**	**% of Total**
Flounder, Summer	2,830,565	3.9%	$ 4,430,704	20.3%
Goosefish	4,226,846	5.9%	3,496,170	16.0%
Mackerel, Atlantic	36,090,862	50.3%	3,398,195	15.6%
Sea Bass, Black	704,128	1.0%	1,293,393	5.9%
Menhaden, Atlantic	18,023,688	25.1%	1,177,226	5.4%
Scups or Porgies	1,900,801	2.7%	1,087,509	5.0%
Swordfish	404,265	0.6%	997,693	4.6%
Tilefish	721,347	1.0%	897,297	4.1%
Croaker, Atlantic	2,096,305	2.9%	850,751	3.9%
Tuna, Bigeye	219,847	0.3%	849,376	3.9%
Tuna, Yellowfin	387,305	0.5%	739,985	3.4%
All Other Finfish	4,107,526	5.7%	2,615,847	12.0%
Finfish Totals	**71,713,485**	**100.0%**	**$ 21,834,146**	**100.0%**

As this table shows, two species (Atlantic mackerel and Atlantic menhaden) accounted for 75% of total 2004 finfish landings by weight. The distribution by value was less concentrated, with the top three species accounting for about 52% of total dockside value as estimated by NMFS.

The next table presents the 2004 NMFS data for the most important shellfish species:

Table 21: NMFS 2004 Shellfish Landings Data for New Jersey				
Shellfish Species	**Weight (lb)**	**% of Total**	**Value ($)**	**% of Total**
Scallop, Sea	13,737,072	11.8%	67,497,047	54.4%
Clam, Atlantic Surf	43,521,704	37.5%	22,284,335	18.0%
Clam, Ocean Quahog	17,633,600	15.2%	9,094,961	7.3%
Clam, Quahog	1,795,538	1.5%	7,409,304	6.0%
Squid, Northern Shortfin	30,973,571	26.7%	6,742,682	5.4%
Crab, Blue	4,115,940	3.5%	4,845,982	3.9%
Lobster, American	370,536	0.3%	1,801,550	1.5%
Squid, Longfin	2,886,634	2.5%	1,780,912	1.4%
Oyster, Eastern	323,049	0.3%	1,558,136	1.3%
All other shellfish	756,144	0.7%	1,088,362	0.9%
Shellfish totals	**116,113,788**	**100.0%**	**124,103,271**	**100.0%**

As this table shows, four species accounted for over 90% of the 2004 shellfish landings by weight, while two species accounted for about 72% of the estimated dockside market value, with sea scallops alone accounting for about 54%.

A comparison of Tables 20 and 21 shows clearly that New Jersey fish landings in 2004 were heavily concentrated in terms of both weight and volume, with shellfish accounting for 62% of total landings by weight and 85% by dockside value. While this indicates that New Jersey has access to some valuable fish species (especially shellfish species), it also shows that the state's commercial fishing industry depends heavily on a few species, especially the top five shellfish species, which together accounted for over 77% of dockside value for all commercial landings.

To estimate the economic value of New Jersey's fish harvest, we first need to estimate the size of the annual harvest and its market value. Since the harvest weight varies from year to year for biological, meteorological, and other reasons, we obtained NMFS landing data for the 10-year period 1995-2004 (see Table 22 on next page).[45] Since finfish and shellfish clearly represent different classes of natural goods, the two are analyzed separately below.

Fig. 4 (follows Table 22) shows the changes in finfish landings, prices, and market value from 1995 to 2004 (the latter two expressed in 2004 dollars). The overall pattern is as follows:

- From 1995 to about 1998, finfish landings and prices moved in opposite directions, but on the whole, market value remained stable. This pattern may indicate that increased landings depress prices, that reduced prices motivate vessel owners to increase landings to cover fixed costs, or some combination of the two.
- From 1999 to 2001, landings, prices, and market value all decreased.
- From 2002 to 2004, landings and prices resumed the inverse correlation of the late 1990s, and market value again stabilized.

Based on this pattern, the years 2001-2004 appear to provide the best basis in recent years for further analysis; the annual market value of finfish landings averaged $21,527,000 in 2004 dollars, with only small variations above and below that figure.

Fig. 5 (after Fig. 4) shows the changes in shellfish landings and in prices, and market values (both in 2004 dollars) from 1995 to 2004. The overall pattern can be characterized as follows:

- From 1995 to 1998, shellfish landings and prices moved in opposite directions, but on the whole, market declined. This pattern again suggests that increased landings depress prices, that reduced prices motivate vessel owners to increase landings to cover fixed costs, or some combination of the two.
- From 1999 to 2003, landings declined, but prices market value increased.
- In 2004, prices leveled off but landings increased by 22% over the 2003 level), possibly reflecting attempts by vessel owners to take advantage of the high prices.

Based on this pattern, 2003 is the best basis in recent years for analysis, with a market value for shellfish in that year of $101,482,000 in 2004 dollars. Given the absence of any clear trend in shellfish landings from 1999 to 2003, the price trend in those years probably reflected increased demand, reduced competitive supply, or both; there is no obvious reason for a demand trend to reverse itself. Therefore, using average market value for a period of increasing prices such as 1999-2003 probably *understates* likely market value for years after 2004. On the other hand, 2004 could be an atypical year or one with inaccurate data, and it seems risky to base a value analysis on an average which reflects a sharp and possibly unsustainable increase in landings.

(text continues following table and figures)

[45] Periods much longer than ten years could include data that is no longer relevant; periods much shorter than ten years could unduly emphasize recent departures from basic trends.

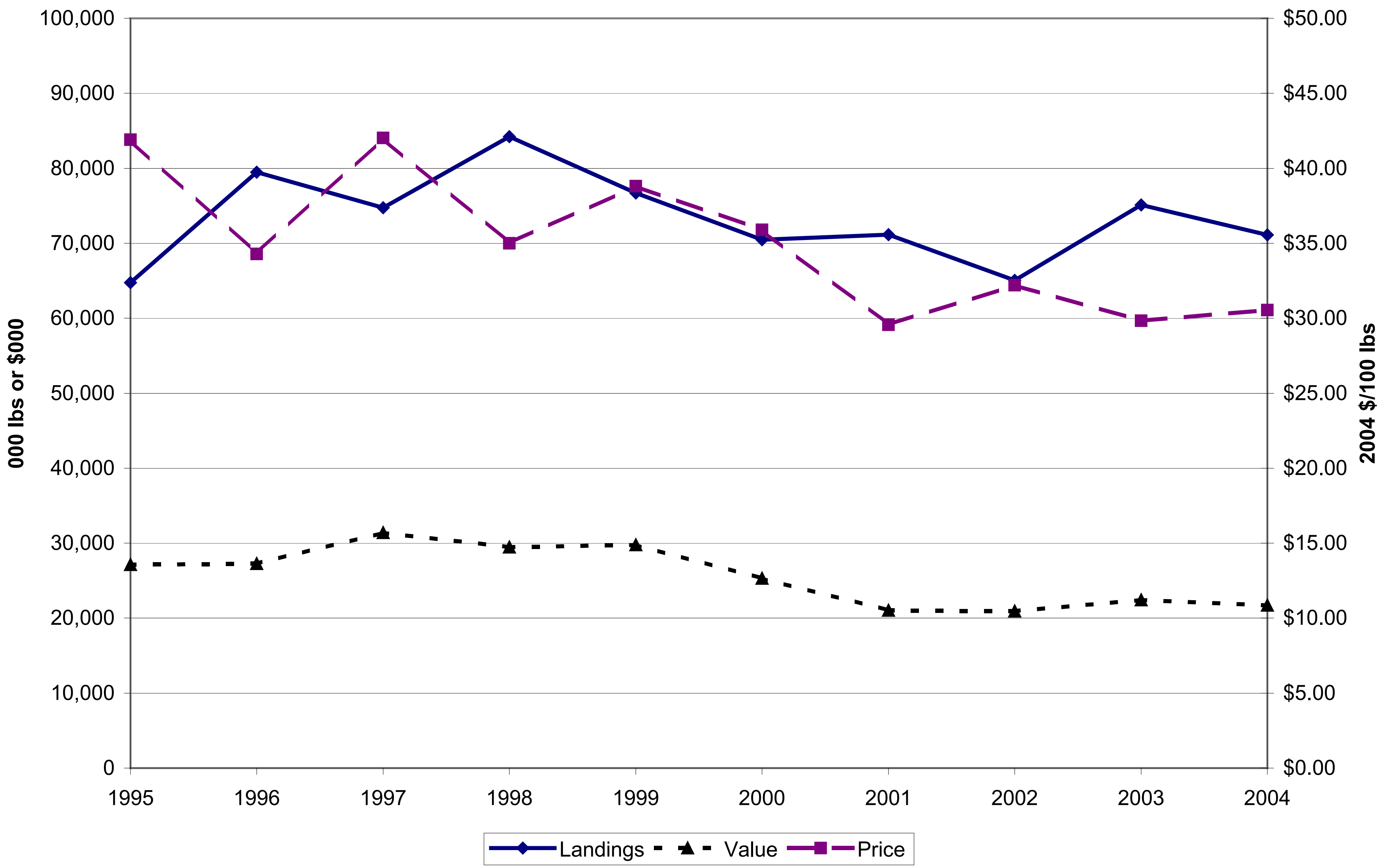
Table 22: New Jersey Commercial Fishery Landings 1995 – 2004

Year	Finfish Wt (000 lb)	Price $/100 lb.	Ex-vessel value $000	Shellfish Wt (000 lb)	Price $/100 lb.	Ex-vessel value $000	Total Wt (000 lb)	Price $/100 lb.	Ex-vessel value $000
1995	64,755	41.90	27,132	112,131	81.08	90,916	176,886	66.74	118,048
1996	79,466	34.29	27,249	103,348	83.94	86,750	182,813	62.36	113,999
1997	74,723	42.02	31,399	100,134	85.74	85,855	174,857	67.06	117,253
1998	84,221	35.00	29,477	112,922	73.69	83,212	197,143	57.16	112,689
1999	76,703	38.80	29,761	91,954	88.31	81,205	168,658	65.79	110,966
2000	70,475	35.90	25,301	101,328	91.05	92,259	171,803	68.43	117,560
2001	71,141	29.57	21,036	97,400	99.13	96,552	168,541	69.77	117,589
2002	65,046	32.20	20,945	97,093	100.32	97,404	162,139	72.99	118,348
2003	75,102	29.83	22,403	95,030	106.79	101,482	170,132	72.82	123,885
2004	71,107	30.55	21,723	116,073	106.87	124,048	187,180	77.88	145,771

Source: National Marine Fishery Service, US Dept. of Commerce

Note: prices and ex-vessel values are based on conversion of historical dollars to 2004 dollars using the US Bureau of Labor Statistics, All-Items Urban Consumer Price Index (CPI-U), 1982-1984 = 100, not seasonally adjusted.

Fig. 4: Commercial Finfish Landings, Price, and Value



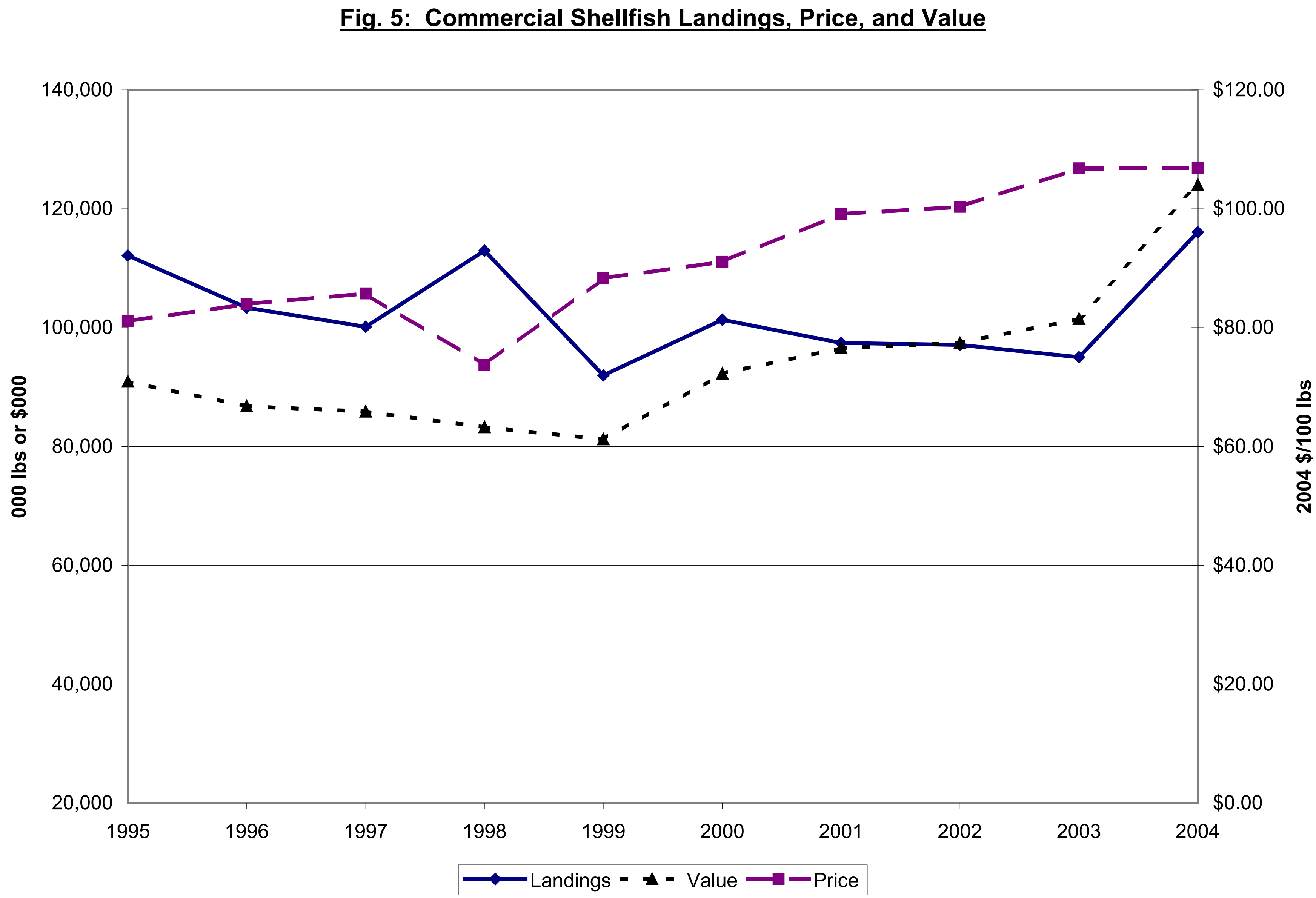


Fig. 5: Commercial Shellfish Landings, Price, and Value
140,000
120,000
100,000
80,000
60,000
40,000
20,000
000 lbs or $000
$120.00
$100.00
$80.00
$60.00
$40.00
$20.00
$0.00
2004 $/100 lbs
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Landings
Value
Price

To summarize, the analysis that follows assumes annual commercial landings with a market value of about $123 million, comprised of 17.5% or $21,527,000 for finfish and 82.5% or $101,482,000 for shellfish (all figures in 2004 dollars). It must be emphasized that these are not forecasts of the sustainable yield for New Jersey's commercial ocean fisheries but rather estimates based on historical data. Similarly, the prices implicit in these figures are not based on projections of future consumer demand or future alternative supplies but reflect actual historical prices calculated from NMFS data.

Given the heterogeneity of the commercial fish harvest, significant further research would be needed to determine whether species-specific elasticity of demand estimates are available; given the similarities among fish species, the gain in accuracy from such research would not necessarily be significant. For simplicity, this class of natural goods is analyzed as a single source of food, using the US Department of Agriculture's estimated elasticity of demand for fish of –0.098. Non-food uses of fish products are not addressed.

Based on that elasticity value and on the formulas described in Section II and Appendix A,[46] the Total Willingness to Pay (TWP) and Consumer Surplus (CS) for this class of natural goods are estimated to be as follows:

Table 23: Total Willingness to Pay for Commercial Fish Harvest (2004 $)

Parameter ↓ or Sector →	**Finfish**	**Shellfish**	**Total**
Elasticity of demand	-0.098	-0.098	-0.098
Market value/year $MM	$21.5	$101.5	$123.0
Consumer Surplus/Market Value	510%	510%	510%
Consumer surplus/year $MM	$109.7	$517.7	$627.3
TEV/year $MM	$131.2	$619.2	$750.3
Present value at 3%/yr $Bn	$4.372	$20.638	$25.010
Natural capital (acres)	755,535	755,535	755,535
TEV/acre/year $	$174	$819	$993
Present value/acre $	$5,786	$27,316	$33,102

Key: CS = consumer surplus; MV = market value; TEV = total economic value

The above discussions focuses on sales at the docks, i.e., sales from fishing boats to wholesale distributors. Subsequent sales to retail fish outlets, restaurants and ultimate consumers

[46] An alternative known as the "current rent" method has been widely employed in the construction of natural resource asset accounts by the U.S. Bureau of Economic Analysis and other researchers. The current rent from an additional fish harvested is its contribution to total revenue less the marginal cost of catching it and bringing it ashore in salable condition. Using current rents for valuing the entire fish stock essentially means estimating the current liquidation price for the stock. The method has the advantage that, under certain assumptions, only data on current market prices and costs are needed, i.e., the analyst need not attempt to forecast future market conditions. However, the method requires estimates of current stock sizes for commercially important species, which are not available for New Jersey. For some relatively well-understood fisheries, it has been proposed that bioeconomic models be used to assess likely future stocks, costs of fishing, and net rent under different management regimes. Again, as far as is known, no such models have been developed for New Jersey's commercial fish species.

will involve other costs and mark-ups, and for that reason, the estimated dockside price affords a better measure of the value to society of the fish themselves, apart from the processing and distribution chains that lead to the ultimate consumers.

Based on the assumed market value of the annual harvest, the economic value of New Jersey's commercial fisheries is clearly substantial. However, that value will be affected by changes in fish populations, species mix, consumer preferences, competition for supplies with other fishing nations, demand for fish from overseas markets, and other factors. In this regard, it is well-known that many commercially important fish species have been overfished in recent years to the point where some fisheries are no longer commercially viable. There are powerful forces working to prolong this trend, including rising incomes in many countries (making it possible to consume more expensive sources of protein such as fish), fears about the safety of other protein sources such as beef and poultry, publicity on the health benefits of fish consumption, improvements in fishing technology, increases in the scale of commercial fishing operations, etc. Increases in commercial fish farming may be a partially offsetting factor.

It is also becoming apparent that greenhouse gas-induced lake, stream and ocean warming and acidification and other pollution-related threats to fish and *their* food supplies (mainly smaller fish species) now threaten the future commercial viability of an increasing number of fisheries, although we are not aware of specific information involving New Jersey fisheries. Since it is inherently difficult for climate models to project conditions for small geographic regions such as the fishing grounds off the New Jersey coast, it may take some time before such state-specific information becomes available.

Given all of these uncertainties, the estimated values could reflect overestimates of the likely volume and value of future landings. However, in the absence of a peer-reviewed forecasting methodology for New Jersey, history appears to provide the best basis for a quantitative valuation of New Jersey's commercial fish and shellfish resources.

Recreational Fishing

Although it operates at a much smaller scale than commercial fishing, recreational fishing also provides a source of food that may be important for some households. Data on recreational fishing is available from NMFS (for saltwater fishing) and from NJDEP's Division of Fish and Wildlife (for freshwater fishing). We consider each of these in turn.

Saltwater fish. The table on the next page shows the 2004 recreational harvest of saltwater fish for New Jersey and the value of that harvest as estimated by NMFS. According to NMFS, the 2004 harvest had an aggregate weight of 13.7 million pounds and an estimated landing value of $20.5 million, for an average landing price of $1.49/lb. The many uncertainties make it difficult to project future landings with any confidence, but in the absence of a better methodology and better data, the 2004 value will be taken as a recurring market value for this sub-sector.

Table 24: 2004 New Jersey Recreational Saltwater Harvest			
AFS Species Name	**Pounds**	**Dollars**	**Price/Lb.**
Striped Bass*	4,634,160	$ 12,234,182	$ 2.64
Flounder, Summer	3,413,126	5,358,608	1.57
Bluefish	2,714,608	1,004,405	0.37
Croaker, Atlantic	909,009	372,694	0.41
Tautog	183,185	351,715	1.92
Sea Bass, Black	166,284	305,963	1.84
Weakfish	259,722	225,958	0.87
Flounder, Winter	136,339	185,421	1.36
Mackerel, King And Cero	89,641	170,318	1.90
Drum, Black	783,418	109,679	0.14
Perch, White	77,620	59,767	0.77
Scups Or Porgies	60,111	34,263	0.57
Other Tuna/Mackerel	132,525	18,554	0.14
Bonito, Atlantic	10,035	17,561	1.75
Shark, Dogfish	29,290	11,130	0.38
Sea robins	85,642	9,421	0.11
Mackerel, Spanish	2,983	5,369	1.80
Flounder, Other	959	1,112	1.16
Herring	18,503	1,110	0.06
Skates	5,893	1,061	0.18
Hake, Red	842	497	0.59
Other Saltwater Species	1,109	1,652	1.49
Total	**13,715,004**	**$ 20,480,440**	**$ 1.49**
*price based on 2004 Middle Atlantic totals = NY+DE = $2,436,062/923,034 lbs.			
Note: does not include inland freshwater harvests			
Source: NMFS website accessed 8/15/06 (www.st.nmfs.gov)			

It should be noted that the average price for the recreational saltwater finfish[47] harvest is much higher than the average for the equivalent commercial catch due to a difference in the mix of species. For example, if we limit our attention to the saltwater finfish species harvested both recreationally and commercially, the top three recreational species by weight, accounting for 78.5% of the 2004 recreational saltwater finfish harvest, are striped bass ($2.64/lb), summer flounder ($1.57/lb), and bluefish ($0.37/lb). In contrast, tuna and Atlantic mackerel, with a weighted average price of $0.14/lb, account for 78.5% of the 2004 commercial saltwater finfish harvest for the same set of species. Based on the mix of these species in the commercial harvest, the average commercial price for all species in this set is $0.35/lb.—a figure that is still well below the 2004 recreational average of $1.49/lb.[48] (all prices are in 2004 dollars).

Freshwater fish. The table on the next page shows the 2004 recreational harvest for freshwater fish, based on a 2003 survey of anglers fishing in New Jersey. An earlier 2001 study by the US Fish and Wildlife Service estimated total anglers in New Jersey at about 806,000, and the 2003 study used a sample of 0.1% of that amount or 860 anglers. The 2003 study found that

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[47] The NMFS recreational harvest data do not include shellfish.

[48] The average 2004 price for saltwater finfish species harvested commercially but not recreationally was lower still at $0.21/lb.

the average angler kept 11.23 fish during the fishing season, which extrapolates to about 9 million fish over the total population of 806,000 anglers.

Table 25: New Jersey Recreational Freshwater Harvest				
Species	**% Sample**	**# Fishers***	**Avg # kept**	**# Fish kept**
brook/brown/rainbow trout	36%	310	9.85	3,050
crappie	25%	215	7.74	1,664
lake trout	17%	146	9.85	1,440
largemouth bass	65%	559	0.63	352
striped bass (freshwater)	30%	258	1.33	343
channel catfish	15%	129	1.41	182
smallmouth bass	46%	396	0.37	146
walleye	9%	77	1.34	104
pickerel	32%	275	0.25	69
northern pike	18%	155	0.36	56
striped bass (hybrid)	14%	120	0.34	41
other**	25%	215	7.45	1,602
Total or average	**100%**	**806**	**11.23**	**9,049**

*based on an 0.1% sample of NJ anglers; includes multiple responses

**bluegill, sunfish, other, or no species specified

Total # fishers	805,870
Avg # fish kept/person	11.23
Total # fish kept/yr	9,047,229
Assumed avg value/fish	$1.49
Total value/yr	**$13,480,371**

Sources: New Jersey Anglers' Participation in Fishing, Harvest Success, and Opinions on Fishing Regulations, survey conducted by Responsive Management for the New Jersey Division of Fish and Wildlife, 2003.

The 2003 study did not estimate the market value of the recreational freshwater catch, and there appears to be no official source for this information.[49] Since the recreational saltwater and freshwater data are both for finfish only, we have used the average recreational saltwater price of $1.49/lb to estimate the value of the recreational freshwater catch as $13.48 million/yr. Combining this with the saltwater harvest of $20.48 million/yr gives a total market value of about $34 million/yr.[50]

Based on the assumed continuation of these annual harvest levels, the elasticity of demand of –0.098 assumed for the commercially harvested fish, and the formulas described in Section II and Appendix A, the Total Willingness to Pay (TWP) and Consumer Surplus (CS) for this class of natural goods are estimated to be as follows:

[49] NMFS does not report this information, since freshwater fishing is not within its jurisdiction; sources such as the Fulton Fish Market in New York City report prices only for commercially harvested *saltwater* species. Retail restaurant prices for freshwater species vary widely and reflect cost and profit components whose relationship to the value of the raw fish is unknown.

[50] Because this part of the natural capital report deals solely with ecosystem and abiotic goods, these figures do not reflect the value of the recreational services provided by fishing in New Jersey; such services were dealt with in Part II of this report on an ecosystem-specific basis.

Table 26: Total Willingness to Pay for Recreational Fish Harvest (2004 $)			
Parameter ↓ or Sector →	**Saltwater**	**Freshwater**	**Total**
Elasticity of demand	-0.098	-0.098	-0.098
Market value/year $MM	$20.5	$13.5	$34.0
Consumer Surplus/Market Value	510%	510%	510%
Consumer surplus/year $MM	$104.6	$68.9	$173.4
TEV/year $MM	$125.1	$82.4	$207.4
Present value at 3%/yr $Bn	$4.168	$2.745	$6.913
Natural capital (acres)	946,055	267,331	1,213,386
TEV/acre/year $	$132	$308	$171
Present value/acre $	$4,406	$10,268	$5,697

Key: CS = consumer surplus; MV = market value; TEV = total economic value

Limitations and caveats similar to those discussed above for commercial fisheries apply to the recreational fish harvest. Given these unknowns, the estimated economic values presented above are necessarily subject to a large degree of uncertainty; however, they appear to represent the best estimates available given our current knowledge.

Section IX: Fuelwood and Sawtimber

In this section, we consider two different types of natural goods provided by New Jersey's forested lands (including forested wetlands): wood used as a *fuel*, i.e., the combustion of wood and wood wastes to produce energy for space heating, steam heating, process steam, and electricity generation, and timber used as a *material*, i.e., the use of timber for construction, manufacturing of plywood and other wood products, manufacturing of paper and paper products, production of furniture, etc. (The use of trees to stock tree nurseries is included in the analysis of agriculture above.) Fuelwood and timber present different valuation issues and are treated separately below.

The natural capital relevant to this section includes 1,465,668 acres of forest (including wooded farmland) and 633,380 acres of forested freshwater wetland, for a total of 2,129,048 acres. Urban greenspace is not considered as available for producing fuelwood or timber, and there is apparently no information on the forested portion of New Jersey's saltwater wetlands. Some riparian corridors are also forested, but even without counting that ecosystem, the total acreage essentially equals the total of 2.132 million acres reported by the U.S. Forest Service in its 1999 inventory of New Jersey's forests.

Fuelwood

All of the major energy-using sectors in New Jersey except transportation use wood and wood wastes for energy generation:

- The residential sector burns wood for direct *space heating*.
- The commercial sector uses wood for *space heating*, and wood, wood-containing municipal waste, and landfill gas from decay of wood and other substances for *steam heat and electricity generation*.
- The industrial sector uses combustible industrial by-products and wood chips for *electricity generation and process steam*.
- The electric power sector uses wood, industrial wood waste and related waste gas, and wood-containing municipal waste as *cofiring fuels or primary fuels to produce electricity*.

Wood sold or gathered for residential use is normally measured in cords; one cord equals 128 cubic feet of wood (4 x 4 x 8 ft.) according to the standard definition.[51] Wood used by other sectors is measured in a variety of units, including tons, kilowatt-hours of electricity, and others. Because of the multiplicity and varying definitions of units, wood and wood waste used as fuel are often reported in terms of the energy produced. The usual unit used for this purpose in the United States is the British Thermal Unit; one BTU equals approximately 252 calories; one million BTU is equivalent to about 293 kilowatt-hours.

[51] Non-standard cords equal to 80 or 85 cubic feet are also employed for certain purposes.

The US Energy Information Administration (EIA) of the US Department of Energy estimates the energy content of wood and wood waste used as fuel in New Jersey to be about 20 million BTU per cord.[52] Based on that value, the table below summarizes New Jersey's use of wood and wood waste as a fuel in 2003, the most recent year for which such data are available.

TABLE 27: USE OF WOOD AS A FUEL IN NEW JERSEY IN 2003			
Sector	**000 cords**	**Billion BTU**	**Share of total**
Electric power	1,025	20,500	62.6%
Residential	422	8,440	25.8%
Industrial	115	2,300	7.0%
Commercial	75	1,500	4.6%
Total*	**1,640**	**32,800**	**100.0%**

*detail does not sum to totals due to rounding.

The total of 32.8 trillion BTUs represented about 1.3 % of New Jersey's energy consumption in 2003. The underlying data is collected by EIA from a variety of sources, including the US Census, other official surveys, reports filed by electricity generators, etc. The information necessarily excludes an unknown amount of unreported gathering of fuelwood by individual homeowners and others for their own use.

The price of fuelwood depends on a variety of factors, including the quality of the wood, the area where the wood is harvested, transportation costs to the locality where the wood is sold, whether the wood is sold as logs or as wood chips, whether it is sold at wholesale or at retail, etc. In New Jersey, retail prices per cord of firewood sold to residential customers ranged from $150/cord to $230/cord in 2004 (Murray 2004). However, some quoted prices include transportation to the buyer's residence and stacking, while others do not; the prices reflect the retailer's costs, including the cost of transporting the wood from the harvest site to the sale site and possibly stacking it there.

EIA reported total New Jersey end-user purchases of wood and wood wastes in 2003 of $37.5 million which comes to $22.87/cord based on the consumption shown in Table 27 or $23.48/cord in 2004 dollars.[53] This is an *average* price; residential and commercial customers paid substantially more, while industrial and electric power users paid substantially less. [54] As described at length in the discussion of water resources in Section III, the most appropriate figure for natural capital valuation is the value at the point of harvest or *in situ value* rather than the retailer's or end user's *delivered price*. However, even EIA's reported average residential cost of

[52] The heat content of wood actually varies from 15 to 20 million BTU per cord depending on the type of wood, moisture content, method of combustion, and other factors. Using the upper end of this range results in a lower estimate of the number of cords used in New Jersey and is therefore conservative from the standpoint of natural capital valuation.

[53] This calculation includes 1.35 million cords with an average 2003 cost of $27.80/cord and 290,000 cords of what EIA calls "uncosted" fuel with an assumed cost of zero.

[54] This may reflect in part the fact that the fuelwood used by residential and commercial customers tends to be in the form of small logs, while industrial and utility users tend to use wood chips and other wood wastes.

$44.08/cord is so far below actual New Jersey retail firewood prices that it clearly represents a value at or close to the point of harvest; therefore, EIA's overall average of $23.48/cord in 2004 dollars will be used to as the market value per cord in this analysis.

It should be noted that EIA does not publish information on the geographic source(s) of fuelwood used in New Jersey, and no other source has been found for this data. Therefore, there is no way of determining what portion (if any) of New Jersey's total fuelwood usage represents wood imported into New Jersey. In the absence of other information, the analysis below assumes that 100% of the wood used in New Jersey comes from in-state sources.

The elasticity of demand for fuelwood has been found to vary by type of end user (Skog 2003), as the next table indicates:

Table 28: New Jersey Fuelwood Consumption in 2003 (based on 20 MMBtu/cord)

Sector	000 Cords*	Shares	Elasticity	Weighted
Residential	422	25.8%	-0.87	-0.224
Commercial	75	4.6%	-0.15	-0.007
Industrial	115	7.0%	-0.39	-0.027
Electric power	1,025	62.6%	-0.13	-0.081
Total	**1,640**	**100.0%**		**-0.340**

*details do not sum to total due to rounding.

If we weight each sector's elasticity by that sector's share of total New Jersey consumption, we obtain an average elasticity of -0.340.

Based on the above, we can estimate the value of New Jersey's fuelwood as follows:

Table 29: Total Willingness to Pay for Fuelwood (2004 $)

Parameter	Value
Key assumptions:	
Pct. of fuelwood from NJ	100%
Elasticity of demand	-0.340
Total NJ supply (000 cords/year)	1,640
Market value per cord (2004 $)	$23.48
Market value/year $MM	$38.507
Consumer Surplus/Market Value	147%
Consumer surplus/year $MM	$56.606
TEV/year $MM	$95.112
Present value at 3%/yr $Bn	$3.170
Natural capital (acres)	2,129,048
TEV/acre/year $	$45
Present value/acre $	$1,489

Key: CS = consumer surplus; MV = market value; TEV = total economic value

The estimated annual value of $58.7 million is based on the assumption that future consumption will remain constant at the 2003 level reported by EIA, which in turn implies that this level is the maximum that is both ecologically sustainable and economically feasible.

As with the other goods provided by New Jersey's natural capital, the continued provision of this level of benefits depends on climate, land use patterns, energy consumption, fuel preferences among energy users, the mix of end-user sectors, etc. None of these factors can be predicted with much confidence, and the valuation presented above arguably represents the best estimate that can be derived given the available data.

Sawtimber

The other main category of wood resources in New Jersey is sawtimber, i.e., timber intended for use in furniture, home-building, etc. Sawtimber consists of trees that are larger than those harvested for fuelwood; unlike fuelwood, sawtimber does not include standing and fallen dead trees or wood wastes. Cubic foot for cubic foot, the value of wood as a construction and manufacturing material is much greater than its value as fuel.

Forests and forested wetlands cover about 2.1 million acres or 45% of New Jersey's total land area, a remarkable figure for a state that has experienced substantial population growth and economic development since World War II. About 1.9 million acres or 90% of the 2.1 million acres are classified by the United States Forest Service (USFS) as "timberland", i.e., forested land containing resources suitable for commercial timber harvesting under a regime of sustained yield management. The other 10% (referred to as Other Forestland) consists of preserved lands where timber harvesting is administratively restricted and unproductive forests where timber harvesting is economically impractical. Most Other Forestland is publicly owned.

Forests contain a wide variety of trees, including live trees of various species, ages, and sizes, standing and fallen dead trees, etc. Commercial interest focuses on live trees ("growing stock") that meet certain standards of size and wood quality ("sawtimber")[55]. At its simplest, the monetary value of the timber contained in the state's forests equals the volume of merchantable (commercially valuable) sawtimber times the price per unit volume. (Appendix D describes several other timber valuation methods.) Sawtimber volume is conventionally measured in board-feet; a sawtimber log measuring 1 foot x 1 foot x 1 inch contains 1 board-foot of wood. Since timber prices vary by tree species, the volume data used in valuation must reflect the mix of tree species or forest types in New Jersey's forests.[56]

The principal sources of detailed information on New Jersey's forest resources are the periodic inventories conducted by USFS; the most recent such inventories took place in 1987 and 1999. According to these inventories, the volume of sawtimber on New Jersey's timberland increased from 5.6 billion board-feet in 1987 to 8.1 billion in 1999, an increase of 2.4 billion or

[55] In addition to growing stock, topwood (wood and bark of above merchantable height), cull (rotten or rough trees) and non-growing stock may also have commercial value. Due to lack of data, these values are not estimated here.

[56] A "forest type" contains multiple species found growing in close proximity; a "forest type group" include several forest types.

43.6%. The average annual increase of 204 million bd-ft/year, if continued through 2004, would result in a sawtimber inventory of 9.1 billion bd-ft in that year. Table 30 on the next page presents a detailed breakdown of the above totals.

Table 30 also shows the 2004 stumpage prices (in 2004 dollars per 1,000 board-feet) for the tree species present in New Jersey. Those prices were obtained from a variety of sources since no single source had prices for all of the species present in New Jersey; New Jersey itself apparently has no published source for stumpage prices. Where several states reported price data, preference was given to the states closest to New Jersey; as a result, about two-thirds of the prices are from Pennsylvania or other Northeastern states.

Based on the 2004 prices, Table 30 presents an estimated value for the assumed annual increase in New Jersey's sawtimber inventory of about $49 million/year. It should be emphasized that this figure does not necessarily represent the value of the *sustainable* sawtimber yield from New Jersey's timberland. The estimate is simply based on an annual yield of about 204 million-board feet, obtained by dividing the total increase in estimated sawtimber volume of 2.4 billion bd-ft from 1987 to 1999 by twelve.[57]

It can be argued that 204 million bd-ft/yr overstates the sustainable yield because of New Jersey's loss of forests and forested wetlands to development. However, such losses may be balanced in part by growth of existing trees, increases in the number of trees per acre (as occurred from 1987 to 1999), and reforestation of abandoned agricultural land. Moreover, while 204 million bd-ft represented 3.6% of the 1987 sawtimber inventory, it represents 2.5% of the 1999 inventory and only 2.2% of the projected 2004 inventory. For these reasons, this study does not include an acreage adjustment.

A number of empirical studies provide estimates of the elasticity of demand for sawtimber and related products (see Exhibit C). The estimates span a fairly wide range, reflecting the multiple uses of timber; in effect, there are multiple timber markets and multiple elasticities of demand. Therefore, Table 31 (following Table 30) uses both the first and third quartiles and the median to develop a range of estimated valuations.

(text continues after tables)

[57] According to the New Jersey Forest Service, only 4.7 million board-feet were harvested on privately-owned timberland during the period from July 2003 to June 2004, based on unaudited reports submitted by certified consulting foresters. If the figure of 4.7 million bd-ft is representative of other years, it is clear that private landowners, who owned 69% of New Jersey's timberland in 1999, have been harvesting far less than the average annual increase reported by USFS; the reasons for this difference are not obvious.

Table 30: Estimated Value of New Jersey's Sawtimber									
Tree Species	**1987 Volume MM bd-ft**	**1999 Volume MM bd-ft**	**Net Change in Volume MM bd-ft**	**Annual Change MM bd-ft/yr**	**Projected 2004 Vol. MM bd-ft**	**Stumpage Price '04 $/000 bd-ft**	**Source of Prices (state)**	**Value of Ann. Chge. MM $/yr**	**Value of '04 Stock MM $**
Atlantic White Cedar	145.1	236.2	91.1	7.6	274.2	$445	AL	$3.4	$122.0
Shortleaf Pine	72.5	36.8	-35.7	-3.0	21.9	$326	MD/DE	-$1.0	$7.1
Pitch Pine	722.9	928.9	206.0	17.2	1,014.7	$86	various	$1.5	$87.3
Virginia Pine	13.3	47.1	33.8	2.8	61.2	$86	various	$0.2	$5.3
Other Pine	89.3	41.0	-48.3	-4.0	20.9	$88	PA	-$0.4	$1.8
Eastern Red Cedar	32.3	51.2	18.9	1.6	59.1	$61	ME	$0.1	$3.6
Softwood Total	**1,075.4**	**1,341.2**	**265.8**	**22.2**	**1,452.0**			**$3.9**	**$227.1**
Red Maple	441.8	861.2	419.4	35.0	1,036.0	$199	PA	$7.0	$206.2
Sugar Maple	104.8	116.4	11.6	1.0	121.2	$508	PA	$0.5	$61.6
Hickory	119.5	254.7	135.2	11.3	311.0	$71	NY	$0.8	$22.1
Beech	121.6	163.7	42.1	3.5	181.2	$39	NY	$0.1	$7.1
Ash	406.9	553.9	147.0	12.3	615.2	$252	PA	$3.1	$155.0
Sweetgum	292.7	412.3	119.6	10.0	462.1	$84	IL	$0.8	$38.8
Yellow Poplar	646.8	1,066.4	419.6	35.0	1,241.2	$223	PA	$7.8	$276.8
Blackgum	78.5	100.6	22.1	1.8	109.8	$152	PA	$0.3	$16.7
Black Cherry	16.2	44.0	27.8	2.3	55.6	$1,143	PA	$2.6	$63.5
Select White Oaks	403.1	495.7	92.6	7.7	534.3	$270	PA	$2.1	$144.3
Select Red Oaks	524.6	836.2	311.6	26.0	966.0	$533	PA	$13.8	$514.9
Other Red Oaks	690.3	866.8	176.5	14.7	940.3	$158	IL	$2.3	$148.6
Other White Oaks	334.2	432.1	97.9	8.2	472.9	$217	various	$1.8	$102.6
Other Hardwoods	355.5	512.1	156.6	13.1	577.4	$152	PA	$2.0	$87.8
Hardwood Total	**4,536.5**	**6,716.1**	**2,179.6**	**181.6**	**7,624.3**			**$45.0**	**$1,845.8**
GRAND TOTAL	**5,611.9**	**8,057.3**	**2,445.4**	**203.8**	**9,076.2**			**$48.9**	**$2,073.0**

Source of 1987 and 1999 volume data: USDA Forest Service, 2001, Forest Statistics for New Jersey: 1987 and 1999, Northeastern Research Station Resource Bulletin NE-152. Projected 2004 volume = 1999 volume + 5 x avg. increase/yr. from 1987 to 1999.

Note 1: Sawtimber is commercial-grade timber that meets minimum size criteria for diameter at breast height (dbh); the minimums are 9 in. dbh for softwoods and 11 in. dbh for hardwoods. Breast height is defined as 4.5 ft. above ground level.

Note 2: The board-foot is a unit of lumber measurement equal to the amount of wood in a sawtimber log 1 ft. long, 1 ft. wide, and 1 in. thick.

Note 3: The stumpage price is the price landowners receive from loggers for the right to cut down standing trees. The prices are intended to serve as a general guide for the marketing of standing timber; the actual value of a specific stand of timber depends on timber quality etc.

Table 31: Total Willingness to Pay for Sawtimber (2004 $)			
Parameter ↓ or Estimate →	**Low-end**	**Central**	**High-end**
Key assumptions:			
Elasticity of demand	-0.520	-0.250	-0.100
Total annual supply (MM bd-ft)	203.783	203.783	203.783
Avg. price ($/000 bd-ft)	$240	$240	$240
Market value/year $MM	$48.9	$48.9	$48.9
Consumer Surplus/Market Value	96%	200%	500%
Consumer surplus/year $000	$46.9	$97.8	$244.5
TEV/year $000	$95.8	$146.7	$293.4
Present value at 3%/yr $Bn	$3.195	$4.890	$9.780
Natural capital (acres)	2,129,048	2,129,048	2,129,048
TEV/acre/year $	$45	$69	$138
Present value/acre $	$1,501	$2,297	$4,594

Key: CS = consumer surplus; MV = market value; TEV = total economic value

A more precise estimate of New Jersey's sustainable sawtimber yield and value would require more detailed modeling by tree species of such factors as growth of previously established trees, colonization of new acreage, deliberate tree plantings and removals, tree diseases, normal tree mortality, and other factors. Those variables are in turn affected by such things as climate change, spread of disease vectors, crowding-induced tree morbidity and mortality, etc. Such modeling would require an ecological analysis which is beyond the scope of this study.

As with all of the other natural capital value estimates presented in this report, these figures are subject to change as a result of changes in land use (e.g., conversion of forested land to residential and commercial uses and reforestation of abandoned farmland), climate, tree disease patterns, timber harvest policies, the relative prices of different tree species, and numerous other factors. The above estimates reflect a snapshot at a point in time; their future relevance will depend on a combination of human decisions and natural forces. As of 2004, however, New Jersey's forests clearly made a significant contribution to the state's collective income and wealth.

Section X: Summary and Conclusions

Table 32 below and the tables on the following pages summarize the conclusions reached in this study of New Jersey's ecosystem and abiotic natural goods. Based on those results, this report concludes that the natural goods provided by New Jersey's natural capital have economic values of about $5.9 billion on an annual basis; the natural capital that provides those goods has a present value of about $196billion.

As the various tables show, farm goods and fish have the highest shares of these totals, followed by minerals and water; wood and non-farm animals have the lowest shares, and the value of non-farm plants cannot be estimated. All of these estimates are subject to various uncertainties as described throughout this report.

The value provided varies by ecosystem, depending on the types of natural goods provided, the total acreage of the ecosystem, and the average value per acre. Farmland and marine ecosystems generate the highest values in terms of total value, followed by barren land (which includes mines and quarries), forests, and freshwater wetlands. In terms of value per acre, barren land ranks first, followed by farmland, marine ecosystems, and open fresh waters.

As emphasized in Section II, total economic value has two components: market value and consumer surplus. The relative contribution of each to TEV depends on the type of good in question, as the following table shows:

Table 32: Components of Total Economic Value (middle estimates; MM 2004 $)

Natural Good	MV	CS	TEV	Share	CS/TEV
Farm products	$448	$3,228	$3,676	62.7%	88%
Fish (total)*	157	801	958	16.3%	84%
Minerals	321	266	587	10.0%	45%
Raw water	169	211	381	6.5%	56%
Sawtimber	49	98	147	2.5%	67%
Fuelwood	39	57	95	1.6%	60%
Game/fur animals	3	18	21	0.4%	84%
Total or avg.	**$1,186**	**$4,679**	**$5,864**	**100.0%**	**80%**
Commercial fish	123	627	750	12.8%	84%
Recreational fish	34	173	207	3.5%	84%

Key: TEV = total economic value; MV = market value; CS = consumer surplus.

The final column in Table 32 gives the Consumer Surplus share of Total Economic Value. The variations among classes of goods reflects the varying estimates of elasticity of demand as obtained from prior empirical studies or official sources. For the reasons described in Appendix A (use of linear rather than constant elasticity; assignment of estimated elasticity to right end of demand curve), the above estimates of consumer surplus are more likely to be conservative (i.e., low) than aggressive.

(text continues after tables)

Table 33: Economic Value of New Jersey's Natural Goods (middle estimates; 2004 $)				
Middle Estimates	**Annual Market Value $MM**	**Annual Consumer Surplus $MM**	**Total Economic Value per year $MM**	**Present Value $Bn****
Farm products*	$448	$3,228	$3,676	$122.5
Minerals	321	266	587	19.6
Raw water	169	211	381	12.7
Sawtimber	49	98	147	4.9
Subtotal	**987**	**3,804**	**4,791**	**159.7**
Commercial fish	123	627	750	25.0
Recreational fish	34	173	207	6.9
Fuelwood	39	57	95	3.2
Game/fur animals	3	18	21	0.7
Total	**1,185**	**4,679**	**5,864**	**195.5**
Low-end totals	820	1,979	2,798	93.3
High-end totals	1,555	8,098	9,652	321.7

**middle estimate = low-end estimate + 50% of the difference between the high and low estimates (see Section V).*
***present value at 3% per year in perpetuity.*

Low-End Estimates:				
Farm products	$108	$778	$885	$29.5
Minerals	321	161	481	16.0
Raw water	143	119	262	8.7
Sawtimber	49	47	96	3.2
Total	**621**	**1,104**	**1,724**	**57.5**

High-End Estimates:				
Farm products	$787	$5,679	$6,647	$215.6
Minerals	321	802	1,123	37.4
Raw water	199	497	695	23.2
Sawtimber	49	245	293	9.8
Total	**1,356**	**7,223**	**8,579**	**285.9**

Table 34: Annual Value of New Jersey's Natural Capital by Ecosystem (2004 $MM/year) (middle estimate)

Ecosystem	Area (acres)	Farm Goods	Fish - All*	Minerals - All	Raw Water	Wood - All	Game + Fur	TEV/yr $Mm	TEV/yr $/ac	PV TEV $Bn	PV TEV $/ac
Farmland[1]	673,464	3,676			79			$3,760	$5,583	$125.3	$186,095
Marine[2]	755,535		850					850	1,125	28.3	37.512
Barren land	51,796			587				587	11,337	19.6	377,893
Forest land**	1,465,668				173	166	12	349	238	11.6	7,934
Freshwater wetland[3]	814,479		14		96	75	7	191	234	6.4	7,801
Open fresh water	86,232		69		10		1	79	921	2.6	30,698
Saltwater wetland	190,520		25				2	26	139	0.9	4,617
Urban[4]	1,483,496				20			20	13	0.7	450
Riparian buffer	15,146				2			2	118	0.1	3,934
Beach/dune	7,837							0	0	0.0	0
TOTAL	**5,544,173**	**3,676**	**$958**	**$587**	**$381**	**$242**	**$21**	**$5,864**	**$1,058**	**$195.5**	**$35,259**

1. Farmland:											
Cropland	546,261	3,223			64			3,291	6,025	109.7	200,828
Pasture/grassland	127,203	453			15			469	3,685	15.6	122,827
2. Marine:											
Estuary/tidal bay	455,700		513					513	1,125	17.1	37,505
Coastal shelf	299,835		338					338	1,126	11.3	37,524
3. Freshwater wetland:											
Forested	633,380				75	75	5	154	244	5.1	8,122
Other	181,099		14		21		1	36	200	1.2	6,679
4. Urban:											
Urban (impervious)	1,313,946										
Urban green space	169,550				20			20	118	0.7	3,934

*recreational saltwater fishing includes saltwater wetlands; recreational freshwater fishing includes unforested freshwater wetlands.
**includes wooded farmland.

Table 35: Annual Value of New Jersey's Natural Capital by Ecosystem (2004 $MM/year) (low and high-end estimates)									
		Low-End				**High-End**			
Ecosystem	**Area (acres)**	**TEV/yr $Mm**	**TEV/yr $/ac**	**PV TEV $Bn**	**PV TEV $/ac**	**TEV/yr $Mm**	**TEV/yr $/ac**	**PV TEV $Bn**	**PV TEV $/ac**
Farmland	673,464	$944	$1,402	$31.48	$46,746				
Marine	755,535	850	1,125	28.34	37,512	850	1,125	28.34	37,512
Barren	51,796	481	9,294	16.05	309,805	1,123	21,685	37.44	722,836
Forest	1,465,668	260	177	8.66	5,910	593	404	19.76	13,483
Freshwater wetland	814,479	145	178	4.82	5,923	316	388	10.53	12,927
Open fresh water	86,232	76	884	2.54	29,470	88	1,019	2.93	33,951
Saltwater wetland	190,520	26	139	0.88	4,617	26	139	0.88	4,617
Urban	1,483,496	14	9	0.46	309	37	25	1.22	821
Riparian buffer	15,146	1	81	0.04	2,706	3	216	0.11	7,188
Beach/dune	7,837	0	0	0.00	0	0	0	0.00	0
TOTAL	**5,544,173**	**$2,798**	**$505**	**$93.28**	**$16,824**	**$9,652**	**$1,741**	**$321.75**	**$58,033**

**TEV = total economic value*

Limitations of the Study

The future flows of these natural goods are impossible to predict with confidence because they depend heavily on "natural" factors such as climate change and on social policies such as land use conversion that are themselves impossible to project with much precision. Despite the high level of uncertainty, however, it seems likely that these factors will tend to operate over time so as to decrease the value of the goods-producing natural capital in New Jersey.

Two other limitations on the results of this study need to be mentioned. First, *total* willingness to pay (i.e., *total* economic value) differs from *net* willingness to pay (*net* economic value). The difference is the *cost* of producing the goods in question and bringing them to market, i.e., to the consumer. Even though nature (conceived of as natural capital) provides the goods we are discussing, human effort and physical capital (tools, equipment, vehicles, roads, etc.) are required for the goods to actually be used. The net benefit to society is therefore the total benefit (or total WTP) minus the costs of production and distribution.

While cost information is thus essential to determining net economic value, market prices do not clearly indicate costs. What they show is the amount actually paid for something. That amount in turn consists of the producer's or supplier's *costs* and his or her return or *profit*, termed producer surplus (see Sec. II). The net benefit to society equals consumer surplus plus producer surplus. By including producer costs, market values thus overstate the net benefits to society.

To estimate producer costs for each natural good so that we can deduct them from total economic value to obtain net economic value would require detailed investigations of each of the industries involved—mining, fishing, logging, etc.—and such investigations are beyond the scope of this report. In this respect, the estimated values of natural goods summarized above are comparable to the estimated values of ecosystem services presented in Part II in that they are "gross" (before costs) rather than net.

There is another factor, however, that offsets this overstatement to some extent. When costs are incurred to produce and distribute natural goods (or when costs are avoided because natural ecosystem services eliminate the need for investment in artificial substitutes), the expenditures made on the natural goods (or the expenditures made with the funds saved on replacing natural ecoservices) stimulate "secondary" economic activity, e.g., as when farmers purchase supplies or equipment or when employees of mining companies spend their wages on goods and services. In regional economics and macroeconomics, this stimulation of secondary activity is known as the "multiplier effect".

While secondary activities can result in economic benefits to society that may partially compensate for the fact that market values include producer costs, it is beyond the scope of this report to analyze the secondary benefits to New Jersey related to each of the industries involved in producing and distributing natural goods. As a result, the "total" economic values derived in this report thus represent only the total *direct* values and therefore understate the true value by the amount of the secondary benefits.

Directions for Future Research

Whether producer costs are completely offset by the unquantified secondary benefits is an empirical matter, and the answer may differ from industry to industry, e.g., from agriculture to logging to mining to fishing. [58] Nonetheless, given the available data and other constraints, total (direct) willingness to pay, defined as Market Value + Consumer Surplus, is a valid, albeit incomplete, first-order approximation of the true economic value of the natural goods produced in New Jersey.

Future research in the following areas could help improve the accuracy and precision of the estimates in this report:

- All ecosystems: more current land use/land cover data.
- All ecosystems: relationships between production of services and goods.
- Water: more current data on supplies and leakage rates.
- Minerals: tonnage and market value of sand dredged offshore.
- Farm products: more recent data on the amount of farmland by type.
- Fish: prices for recreational freshwater species; role of wetlands.
- Non-farm plants: data and methods for preparing rough valuations.
- Fuelwood: share of wood harvested in-state; estimated sustainable yield.
- Timber: more current annual growth data; estimates of sustainable yield.
- All natural goods: further research on relative per-acre ecosystem productivity.
- All natural goods: further research on elasticity of demand.

Within the limits imposed by nature, New Jersey has a measure of control over the future capacity of its natural capital to produce valuable natural goods. To the extent of that control, the quantities of those goods available in the future should be a matter for informed and deliberate public choice. In combination with the findings in Part II on ecosystem services, this report documents the considerable economic value provided by New Jersey's ecosystems and thereby helps provide a more scientific basis for those decisions.

[58] In most situations, the offset is probably only partial because a dollar's worth of spending by New Jersey producers will usually generate less than a dollar of secondary activity in the state. This is so for several reasons, including the fact that some of the spending flows to out-of-state suppliers (e.g., manufacturers of farm implements and mining equipment); the same is true when employees spend their income on goods produced out-of-state. In addition, unless the suppliers were operating below capacity and unless the employees were otherwise unemployed or underemployed, the secondary activity merely displaces other New Jersey activity that would have occurred anyway. Only the net secondary effects represent real contributions to the Net Benefit to New Jersey from producing natural goods.

Appendix A: Estimation of Total Economic Value

This appendix presents the derivation of the formula used to obtain the estimates of Consumer Surplus (CS) and Total Economic Value (TEV) presented in Sections III-VIII. The derivation of the valuation formula is general and does not depend on the type of natural good being analyzed. The only required input data are the Market Value (MV) of the good when the quantity demanded equals 100% of the annual output and an estimate of the price elasticity of demand for that good obtained from the economics literature or official sources.

As suggested in Figures 1-2, Sec. II, determining CS is tantamount to estimating the total area TEV between the demand curve[59] and the horizontal axis and then subtracting MV from that total. To estimate that area, we need to know three things:

- the functional form, i.e., the general shape of the demand curve;
- the slope of the curve, i.e., its relative "steepness"; and
- the y-intercept or asymptote, i.e., the values the demand curve takes on as it approaches and reaches the y-axis (i.e., the vertical axis).

for the range from Q_0 to Q_1 (see Fig. 1 of Section II).

In general, these factors can be derived in two ways: empirically and analytically. In an empirical study, the investigator has multiple data points available, either from existing databases or from an original study, e.g. a stated preference study (in essence, a sophisticated consumer survey in which respondents state how much they would be willing to pay for a given good under various circumstances). Using various econometric (i.e., statistical) techniques, the investigator can determine the functional form that appears (with varying degrees of certainty) to fit the data most closely.

In our case, we have only one known data point, namely the point where $Q = Q_1 = 100\%$ of annual output and $P = MP$ = the average market price of that output, e.g., dollars per thousand gallons of water. (For various technical reasons, values of Q and P from prior years are not a suitable basis for this type of empirical study.) Given this lack of data, we need to turn to a more analytic approach. In developing such an approach, we will need to make use of information on the elasticity of demand for each type of natural good being considered[60], and that concept is discussed next.

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[59] In Figs. 1-2, the horizontal axis represents quantity (demand) and the vertical axis represents price, suggesting that price is being graphed as a function of quantity. In fact, the concept of elasticity on which critical parts of this analysis are based defines quantity (demand) as a function of price; however, it is standard practice in economics to show the independent variable price on the vertical axis and the dependent variable quantity on the horizontal. For convenience, we ignore these details and refer simply to the demand curve. The line defined by the demand function is traditionally termed the demand "curve" even if it is in fact a straight line.

[60] More precisely, the type of elasticity we will use is the own-price short-run price elasticity of demand. There are also "cross-price", long-run, income, and supply elasticities.

Elasticity of Demand

Elasticity of demand is the percentage change in the quantity demanded associated with a one percent change in price: $E = (\Delta Q/Q) / (\Delta P/P)$. For example, if price increases by 1% and demand falls by 0.5%, the elasticity of demand equals –0.5% / +1% = –0.5. As the example shows, elasticities are unit-less numbers because they are the ratio of two percentages; the minus sign indicates that price and demand move in opposite directions, as we would expect for typical goods like those we are considering.

Estimates of elasticity derived from prior studies are available for each of the broad classes of natural goods analyzed in this report. Those elasticities represent *point* estimates (i.e., single values) for the types of natural goods being considered, e.g., -0.098 for fish. Technically, a point estimate applies only to the relatively small portion of the demand curve covered by the original empirical study; since we are interested in the economic value represented by the *entire* area under that curve, we theoretically need separate estimates of elasticity all along the demand curve.

It is rarely if ever feasible to obtain such comprehensive information on elasticities. However, as will be demonstrated below, elasticity is a critical variable because if its value is known, a demand function can be derived, making it possible to estimate CS and TEV. In the absence of detailed information on the relevant elasticities and the appropriate demand function for a given situation, economists often make simplifying assumptions, of which the following are probably the most common (Nicholson 2002):

- One common assumption is that elasticity is constant all along the demand curve. This assumption leads to a type of non-linear demand function discussed below.

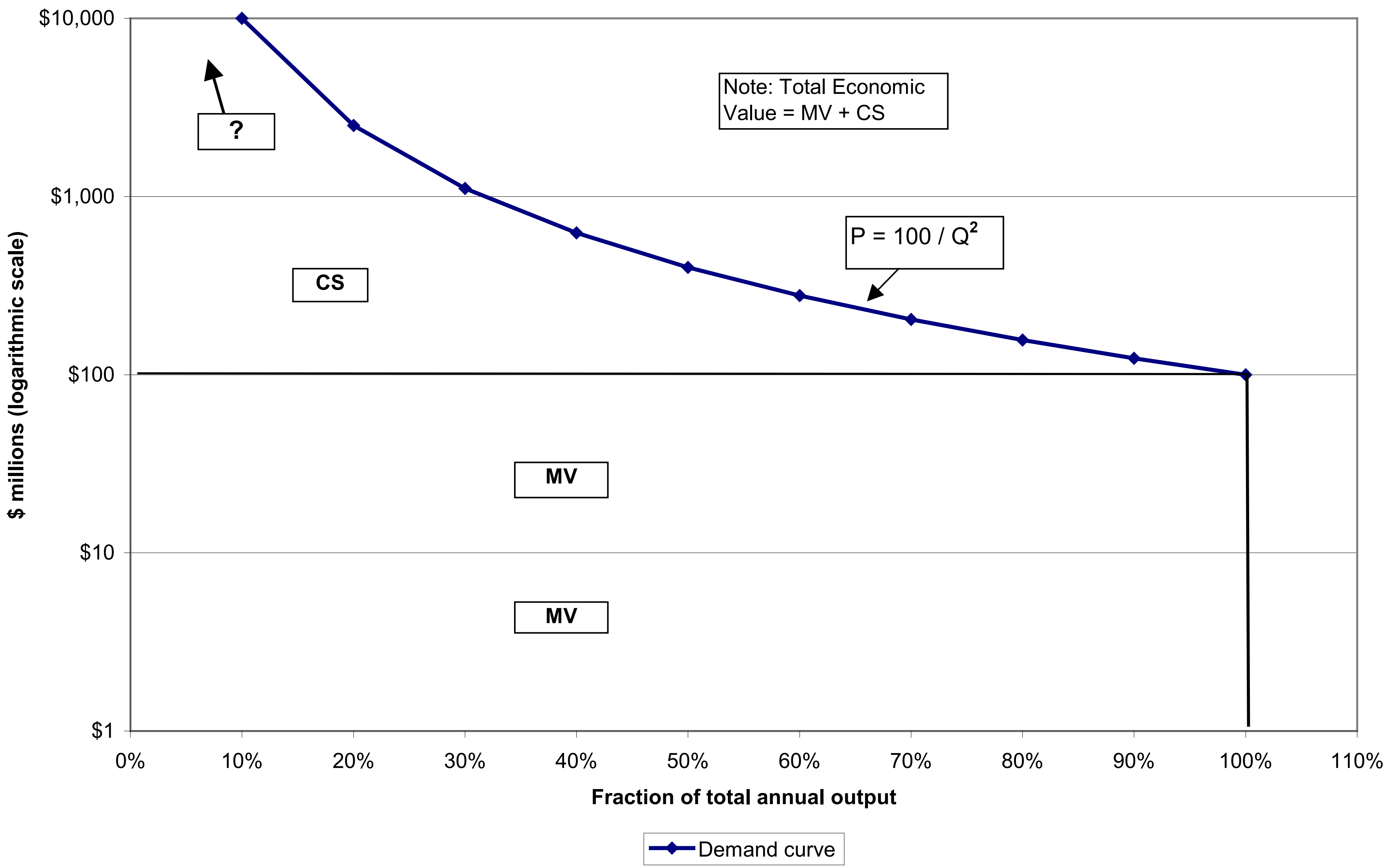
- Another common assumption is that the demand function is linear. As will be seen below, this assumption leads to varying elasticities along the demand curve, but those elasticities can easily be calculated.

These two approaches are discussed below; for reasons that will be indicated, linear demand functions were chosen for this study.

Non-Linear Demand Functions

As just noted, economists often assume for convenience that elasticity is constant at every point on the demand curve. The demand functions associated with constant elasticity are non-linear functions of the form $Q = A \times P^E$, where Q, P, and E represent respectively quantity, price, and elasticity, and A is an empirically-derived parameter. Fig. 6 shows an example of such a function, and Nicholson (2002) presents a more detailed discussion of constant elasticity demand functions. Such demand functions have been used extensively in the field of water economics, e.g., in Young (2005) and other sources cited in the References.

Fig. 6: Non-Linear Demand Function (log scale)



While constant elasticity functions of this type are often used by economists, there is no a priori reason that elasticity *must* be constant: isoelasticity (i.e., constant elasticity) is merely a convenient assumption made to address the absence of detailed empirical estimates of elasticities along the demand curve.[61] In fact, constant elasticity demand functions create difficult calculation problems if demand is relatively inelastic (i.e., close to zero), because as shown in Fig. 6, as the value of Q approaches zero, the area under such a demand curve increases exponentially without limit; at Q = 0, the demand function is mathematically undefined. This makes it impossible to calculate CS and TEV, because the area under the demand curve is "open-ended".

Linear Demand Functions

Given the somewhat arbitrary nature of the assumption of constant elasticity and the mathematical problems presented by non-linear demand functions, economists often use instead a linear demand function of the form Q = A x P + B, where A is the slope of the linear demand "curve" and B is the value of Q when P = 0. Fig. 7 presents an example of such a function, and Appendix B shows that while elasticity of demand is not constant with a linear demand function, it can readily be calculated for any interval along the demand curve.

The next question is how to estimate the parameters A and B. It turns out that we can develop a linear estimate of the demand function if we can determine either the y-intercept for the demand curve or the slope of that curve. The approach used here begins by determining the y-intercept. First, we define a function for Price in terms of Quantity:

1. $\boxed{\mathbf{P = P_0 - Q * (P_0 - MV)}}$

where P, Q, and MV represent respectively price, quantity, and market value, and P_0 is the y-intercept of the demand curve, i.e., the value of P when Q = 0. In Eq. 1, when Q = 1, P becomes $P_0 - 1 * (P_0 - MV) = MV$. (As noted earlier, although Eq. 1 defines P in terms of Q, it will still be referred to for simplicity as a demand function.)

Given the above, a formula for estimating P_0 can be derived as follows:

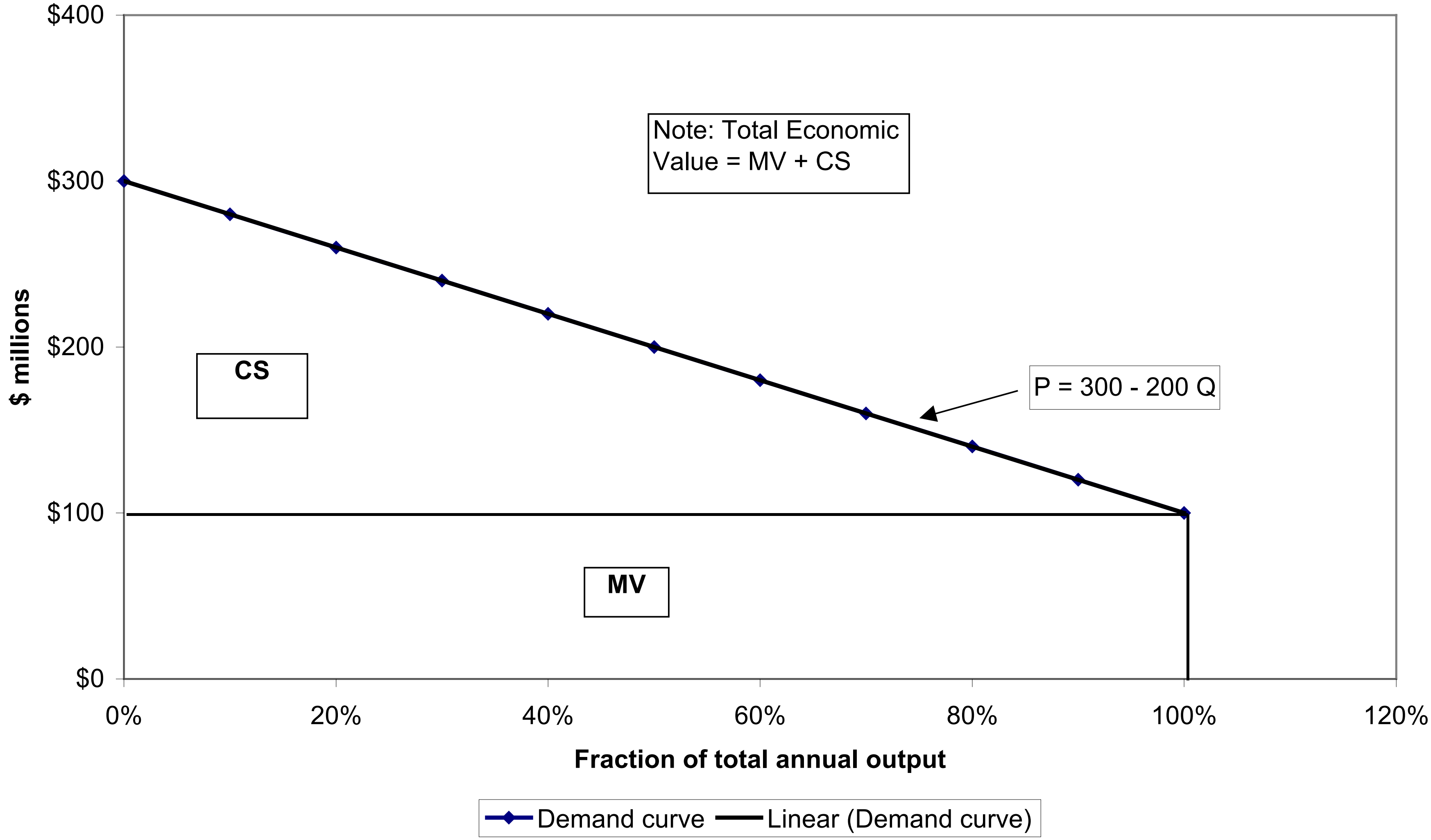
2. From the definition of elasticity, E = dQ/Q / dP/P.
3. Rearranging terms in Eq. 2, we get P = E * Q * dP/dQ.
4. Evaluating Eq. 3 at Q = 100%, we get MP (Market Price) = $E_1 * Q_1 * dP/dQ$.[62]
5. We note next that MV = MP * Q_1 = MP * 1 = MP.
6. Since MP = MV and Q_1 = 100% = 1, Eq. 4 becomes MV = $E_1 * dP/dQ$.

(text continues after Fig. 7)

[61] As long ago as 1974, Fisher, Krutilla and Cicchetti concluded that "there is no theoretical argument advanced in support of nonlinearity anywhere in the [economics] literature". Cited in Bockstael and McConnell (1980), p. 60.

[62] Eq. 4 assumes that the point elasticity estimate E_1 available for a given natural good applies at point Q_1.

Fig. 7: Linear Demand Function and Consumer Surplus



7. Now dP/dQ is the slope of the demand function, and for a linear function the slope is constant over any portion of the curve or indeed for the curve as a whole.
8. Therefore, $dP/dQ = \Delta P / \Delta Q = (MP - P_0) / (Q_1 - Q_0)$.
9. Substituting for MP, Q_1, and Q_0 in Eq. 8, we get $dP/dQ = (MV-P_0) / (1 - 0) = MV - P_0$.
10. Plugging Eq. 9 back into Eq. 6, we get $MV = E_1 * (MV-P_0)$.
11. Solving Eq. 10 for P_0, we obtain $\boxed{\mathbf{P_0 = MV * [(E_1 - 1) / E_1]}}$

We can now derive a linear equation for Total Economic Value TEV as follows:

12. TEV equals the rectangular area MV plus the right triangular area CS (see Fig. 2, Sec. II).
13. Area of the rectangle = height x width; area of the right triangle = ½ x height x width.
14. Substituting these formulas in Eq. 12, we obtain $TEV = (MP*Q_1) + (P_0-MV)*(Q_1-Q_0) / 2$.
15. Plugging Eq. 11 into Eq. 14 and simplifying, $TEV=MV+\{MV*[(E_1-1)/E_1]-MV\}/2$.
16. Eq. 15 then simplifies to $\boxed{\mathbf{TEV = MV * (1 - 1 / 2E)}}$

In addition to mathematical simplicity,[63] the approach described above has the advantage of providing estimated values for TEV that are more conservative (i.e., lower) than those provided by non-linear demand functions. Fig. 8 (next page) compares the demand functions in Fig. 6 and Fig. 7; to fit both demand curves on the same page, a logarithmic scale had to be used for the vertical axis.

What Figs. 6 and 8 clearly show is that TEV for a non-linear demand function increases without limit; at Q = 10%, P has already reached $10 *billion*, compared with a value at Q = 100% of only $100 *million*. Except possibly under extreme circumstances, it is unlikely that TEV would reach such high levels when Market Value equals only $100 million. The linear demand function is clearly the more conservative of the two by a wide margin.

For any natural good for which we have an elasticity value, we can compute the ratio of TEV or CS to MV using Equation 16 above. Table 36 below shows the calculations for eight types of natural goods covered in this study. As Table 36 shows, the excess of TEV over MV grows in a non-linear fashion as elasticity increases towards zero, i.e., as demand becomes less elastic (more inelastic). An increasingly inelastic demand is exactly what we would expect as the natural good becomes more of a necessity (more essential) than a luxury good. Figure 9 (following Table 36) shows this relationship graphically.

(text continues following figures and table)

[63] While the derivations presented above may appear complex, those involving non-linear functions tend to be even more complex and require calculus techniques for their solution.

Fig. 8: Linear vs. Non-Linear Demand Curves (log scale)

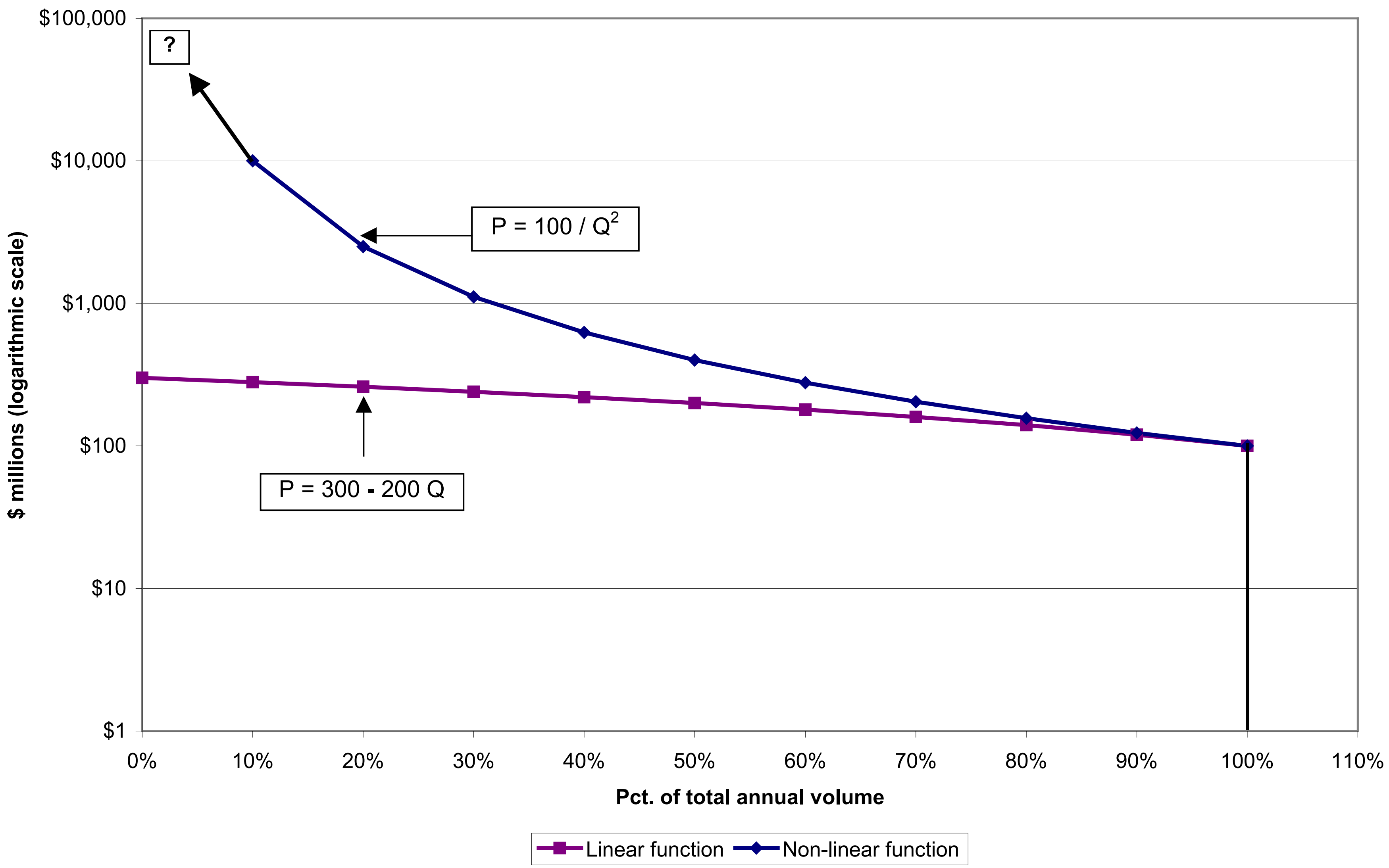


Table 36: Elasticity, Consumer Surplus, and Economic Value			
Type of Natural Good	**Elasticity***	**TEV / TMV**	**CS / TMV**
Farm products-weighted avg (1)	-0.069	8.21	721%
Game animals	-0.089	6.62	562%
Fish (finfish and shellfish)	-0.098	6.10	510%
Timber-median (2)	-0.250	3.00	200%
Fuelwood	-0.340	2.47	147%
Water-midpoint (3)	-0.400	2.25	125%
Minerals-midpoint (4)	-0.600	1.83	83%
Fur-bearing animals	-0.691	1.72	72%

**own-price short-run elasticity of demand.*

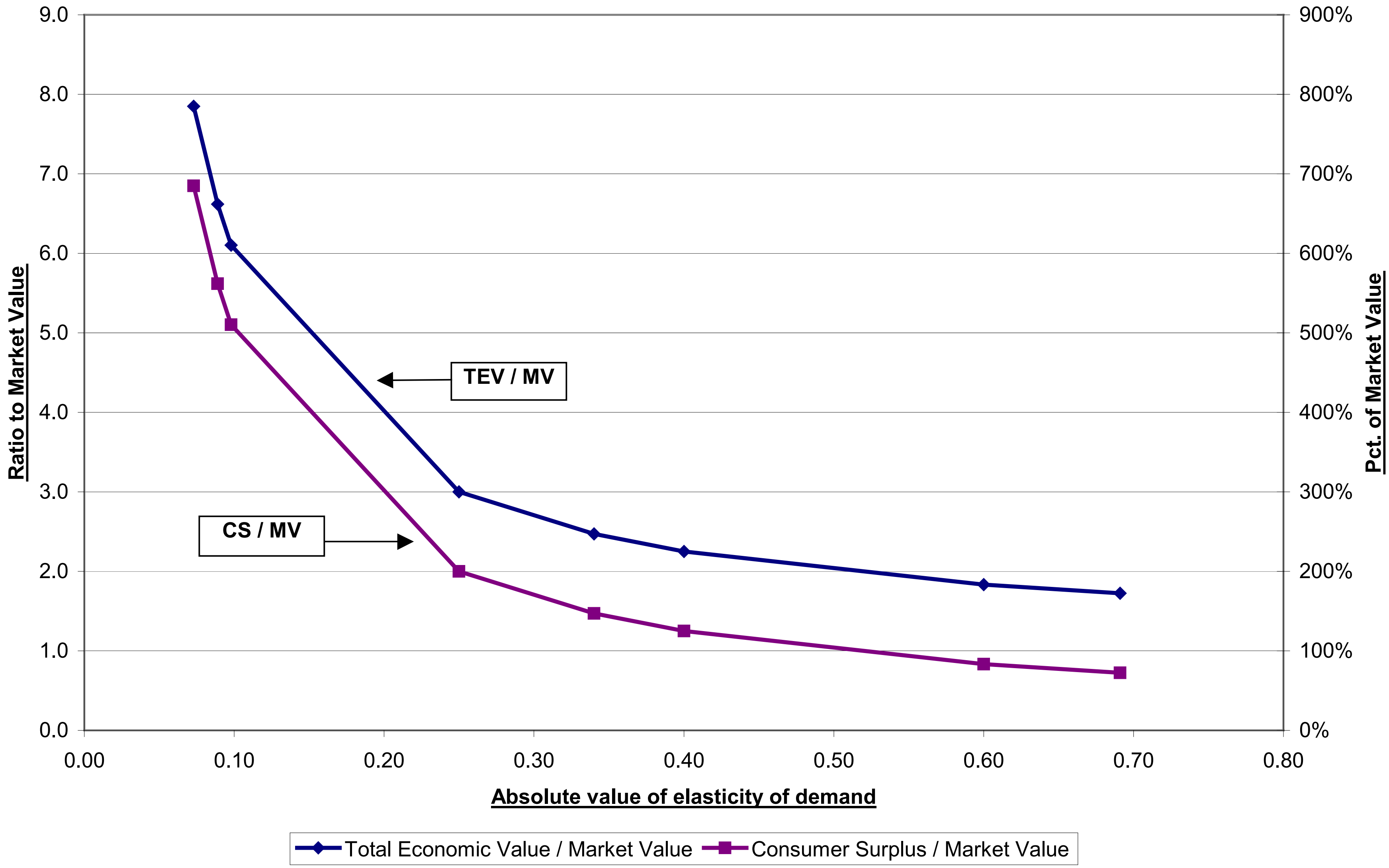
TEV = Total Economic Value = TMV + CS
TMV = Total Market Value = TEV - CS
CS = Consumer Surplus = TEV – MV

1.	Farm products-crops (87.68%)	-0.067	8.46	746%
	Farm products-animals (12.32%)	-0.092	6.43	543%
2.	Timber-1st quartile	-0.520	1.96	96%
	Timber-median	-0.250	3.00	200%
	Timber-3rd quartile	-0.100	6.00	500%
3.	Water-low end	-0.600	1.83	83%
	Water-middle	-0.400	2.25	125%
	Water-high end	-0.200	3.50	250%
4.	Minerals-low end	-1.000	1.50	50%
	Minerals-middle	-0.600	1.83	83%
	Minerals-low end	-0.200	3.50	250%

<u>Sources of elasticity estimates:</u>

Farm products	See Exhibit B
Game animals	USDA/Economics Research Service (meat)
Fish	USDA/Economics Research Service (fish)
Timber	Daigneault (2006)
Fuelwood	Skog (1993)
Water	Young (2005)
Mineral aggregates	Morrell (2006); USEPA (1997)
Fur products	USDA/ERS (clothing)

Fig. 9: Elasticity, Consumer Surplus, and Economic Value



It should be noted that the market values and the elasticity estimates used in this study come from different sources, and there is a difficult-to-quantify risk that elasticities estimated using non-New Jersey data might differ from elasticities based on New Jersey-specific data. For example, Equation 4 above assumes that our point estimates of elasticity E_1 apply at the Q_1 ends of the related demand curves, i.e., the ends where demand is *greatest*. However, Nicholson (2002) points out that a common practice in empirical work is to report estimated elasticities based on the *average* price for the good in question. This could mean that the elasticity estimates on which this study relies apply somewhere in the *middle* of the various demand curves rather than at their maximum-demand ends.

Even if it applies, however, this possibility may not pose a significant problem for our purposes. Suppose, for example, that an empirical study derived an elasticity of –0.5 based on a "price point" halfway between Q_0 and Q_1. It can easily be shown that for a linear demand curve, elasticities are lower at the Q_1 end (where the marginal percentage changes in Q are smaller and those in P larger) and higher at the Q_0 end (where the marginal percentage changes in Q are larger and those in P smaller). Therefore, the elasticities above (to the right of) the halfway point in this case should be *smaller than* –0.5. However, as Fig. 9 shows, the lower the elasticity, the greater the add-on for CS and therefore the higher the TEV. The assumption in Equation 4 that the –0.5 elasticity applies at the Q_1 end of the curve is therefore *conservative*, i.e., it results in lower estimates for CS and TEV.

If the elasticities of any of our natural goods were close to zero, we would face the problem of demand functions whose values increase exponentially without limit and become undefined when quantity equals zero. For example, if $E = -0.001$, the ratio of TEV to MV becomes 501, and the CS add-on becomes 50,000% of MV. There are only two natural goods "produced" in New Jersey whose elasticities might be that low, namely air and water. The above method might indeed not work well for air, and this study does not attempt to estimate a value for that "good".

As to water, most empirical studies have found elasticities ranging from –0.2 to –0.6 rather than closer to zero (Young 2005). While these findings may seem surprising for such a clearly essential good, they reflect in part the existence of multiple uses for. While the elasticity of demand for drinking water may in fact be close to zero, most uses of water are not as essential, and some, such as watering lawns and other green spaces, are *much* less essential and therefore much more likely to be influences by price changes.[64] The empirically-determined elasticity range for water may indicate that a substantial part of our use of water is in fact non-essential.

In conclusion, the approach developed in this appendix allows us to calculate reasonable and conservative first-order linear estimates of the Total Economic Values of the provisioning services delivered by New Jersey's natural capital. Sections III-IX of the main report apply the approach to specific types of natural goods.

[64] This suggests that the demand for water is not completely linear, since linear demand implies the existence of a price above which *no* water is demanded. As noted above, the assumption of linearity is a first-order approximation of the "true" demand curve.

Appendix B: Elasticity in Linear Demand Functions

As noted in Appendix A, while a linear demand function is easy to manipulate mathematically, elasticity is not constant along the demand curve, as shown in the following example based on the linear demand function shown in Fig. 7. The example uses the concept of "arc" elasticity, in which the midpoints of the Q and P intervals are used to calculate the percentage changes in Q and P respectively.

- If demand drops from 100 units to 90 units, the change is -10 units; the midpoint of the arc is (100+90)/2 = 95, and the percentage change in demand is –10/95 = -10.5%. If the price related to the demand change increases from $100 to $120, the change is +$20; the arc midpoint is (100+120)/2 = $110, and the percentage change in price is +20/110 = +18.2%. The elasticity of demand over this range is therefore –10.5% / +18.2% = **-0.58**.

- If demand drops again from 90 units to 80 units, the change equals -10 units; the midpoint is (90+80)/2 = 85, and the percentage change in demand is –10/85 = –11.8%. If the unit price increases from $120 to $140, the change is +$20; the midpoint of the arc is (120+140)/2 = $130, and the percentage change in price is +20/130 = +15.4%. The price elasticity of demand over *this* range is therefore –11.8% / +15.4% = **-0.77**.

In each case, price increases by $20 and quantity demanded decreases by 10 units; however, the significance of those changes in *percentage* terms depends on the absolute levels from which the percentage changes are measured. Constant elasticity means that the marginal elasticity is constant *everywhere* on the demand curve.

Although the linear demand function shown in Fig. 7 does not exhibit such constant elasticity, it does have the property that over larger intervals, "overall elasticity" is constant as long as the percentage changes in P and Q are measured from MP and Q_1 respectively. For example, for the same linear demand function:

- If demand drops from 100 units to 90 units, the percentage change in demand is –10/100 = -10%. If the related price change is from $100 to $120, the percentage price change is +$20/$100 = +20%. Overall elasticity for this range is –10%/+20% = **-0.5**.

- Similarly, if demand drops to 80 units, the percentage change in demand measured from Q_1 is –20/100 = -20%. If the related price increases to $140, the percentage price change measured from P_1 is +$40/$100 = +40%. Overall elasticity for this range equals –20%/+40% = **-0.5**.

It is easy to show that for the demand function in Fig. 7, overall elasticity remains at –0.5 for any value of Q between 1.0 and 0.0 as long as the percentage changes in P and Q are measured from MP and Q_1 respectively. While overall elasticity is not a recognized concept in standard economics, it does show that a weaker type of constancy exists for linear demand "elasticity".

Appendix C: Alternate Farmland Valuations

The estimates of farmland value presented in Section V are based on the land's continued use for farming and on net farm income as the metric for the annual flow of value from farming.[65] In the New Jersey real estate market, however, there are probably few sales of farmland in which a substantial portion of the sale price is not due to the land's potential as a site for commercial or residential development. That is, the market value of farmland reflects both its continued use to produce agricultural products and its development potential.

In that regard, NASS and ERS have reported different estimates for the market value of New Jersey farmland as Table 37 shows (COA = Census of Agriculture; NFI = net farm income).

Table 37: Estimated Market Value of New Jersey Farmland ($/acre)

Source	Coverage	2002	2004	Calculation
NASS Census of Agric.	Land + all bldgs.	9,137	n/a	Note A
NASS Census of Agric.	Land + all bldgs.	9,245	n/a	Note B
NASS Land Values	All farmland	8,600	9,750	Note C
NASS Land Values	Cropland	9,000	9,900	Note C
NASS Land Values	Pastureland	9,700	10,600	Note C
NASS Land Values	All farmland	9,224	10,124	Note D
ERS Balance Sheet	Land + farm bldgs.	7,615	8,487	Note E

A. As reported by NASS in the 2002 Census of Agriculture (COA); includes dwellings.

B. Market value/farm (including dwellings) / acres/farm from 2002 COA.

C. As reported by NASS in Land Values and Cash Rents 2004 Summary, August 2004.

D. NASS 2002 or 2004 cropland and pastureland values/acre x 2002 COA cropland and pastureland shares of total acreage.

E. ERS 2002 or 2003 balance sheet figure for real estate assets (excluding dwellings) / total farm acreage from 2002 COA or 2003 acreage estimate; 2003 price/acre is inflated to 2004.

The large differences between the ERS and NASS estimates may be due to the fact that NASS includes the value of farm dwellings in its farm balance sheet estimates; since dwellings constitute physical or "built" capital, ERS's figures might seem to come closer to the "pure" natural capital value we are seeking.

As stated in Section V, a 2002 study by Plantinga et al. using 1997 data concluded that 82% of the value of New Jersey farmland could be attributed to development potential. Based on that figure, we might multiply the 2004 ERS land value estimate of $8,487/acre by 18% to obtain $1,528/acre as an estimate for the market value of New Jersey farmland *as farmland*, i.e., net of

[65] Some portion of net farm income could be attributed to the cost of the owner's or operator's human and financial capital and another portion to a premium for risk-taking (Pearce 1992), i.e., to bearing the risk of loss inherent in agriculture (other than risks covered by crop insurance or similar safeguards).

both dwellings and development potential.[66] This figure is much lower than the average present value of $9,570 presented in Section V, a figure that is based solely on the value of farm output in perpetuity.

The estimated land value from farming of $1,528/acre is potentially compatible with the actual average cash flow from farming (net cash farm income) of $222/acre/year calculated in Section V. In principle, the value of land attributable to farming should equal the present value of the annual cash flows from farming. That present value depends on two factors—the discount rate and the time horizon; since we are now examining actual price data (or estimates thereof), discounting by 3%/yr in perpetuity is not the only possibility.

We can shed some light on this by using a plausible range of time horizons and discount rates to calculate the present value of the annual cash flow of $233/ac/yr (see Table 14, Section V), which in principle should equal the value of the land from farming. The results for selected discount rates are as follows (NCFI = net cash farm income):

Table 38: Net Farm Income and Agricultural Value of Farmland

Years	NCFI/ac/yr	PV rate	PV of NCFI	Assumed price
10	$233	8.50%	$1,529	$1,528
11	233	9.80%	1,527	1,528
12	233	10.80%	1,527	1,528
13	233	11.60%	1,526	1,528
14	233	12.20%	1,529	1,528
15	233	12.70%	1,529	1,528
16	233	13.15%	1,526	1,528
17	233	13.45%	1,530	1,528
18	233	13.75%	1,528	1,528
19	233	14.00%	1,526	1,528
20	233	14.15%	1,530	1,528

The values in this table represent the type of analysis that owners of farmland might engage in to estimate the present value of their land based solely on the annual flow of net income from farming, the owners' time horizons, and their projected or desired rates of return. In effect, landowners with different time horizons could in principle arrive at the same estimated value of $1,528/acre from farming if they also had different rates of return in mind.

For periods shorter than about ten years, the discount rates needed to equate the present value of the annual cash flow from farming to the estimated market price of $1,528/acre become implausibly low, meaning that owners of farmland would probably demand higher rates of return from their investment in agriculture. Similarly, as the time horizon increases, the discount rates needed to equate the present value of the annual cash flow from farming to the estimated market

[66] The resulting estimate would still include non-residential farm structures such as barns, silos, etc. and would therefore still somewhat overestimate the value of the land itself. Presumably such structures only have value if the land continues to be farmed.

price of $1,528/acre may become implausibly high, meaning that they may exceed the rates of return that such landowners could expect to realize.

This analysis suggests that USDA's estimated values for New Jersey farmland—which rely on self-reported estimates provided by farmers themselves and by other sources—are based on the assumption of a fairly short time horizon for the continuation of agricultural activities. This is probably not unreasonable in the New Jersey context, especially given that the average age of farmers was 55 according to the 2002 Census of Agriculture. [67]

The cash flow and land price methods as presented in this study can thus be made consistent if we assume that the landowner's valuation of agricultural income is based on a relatively short time horizon. However, since the focus of this study is on the value of goods provided by New Jersey's natural capital, the estimated per-acre value presented in Section V is based solely on continued use of farmland as farmland rather than on future development potential and the sale of development options.

[67] A possible implication of this assumption is that the option to sell farmland for development is valued as though it would not be exercised until the current farm owner or operator retires, which again may be a reasonable assumption in the New Jersey context.

Appendix D: Valuation of Standing Sawtimber

Forest economics recognizes two theoretical methods for valuing standing timber on forested land, both involving present value techniques. The first values the standing timber at a moment in time, assuming that no regeneration will take place as trees mature and die or are cut (harvested); in effect, harvesting of timber is assumed to be restricted to the current rotation cycle. The unit values are based on biomass growth (wood volume) as modified by economic factors such as timber price. In this case, the value of standing timber equals the timber volume (at a specific point in time) multiplied by the stumpage price multiplied by the discount factor.

The second theoretical valuation method assumes that harvesting can be sustained indefinitely, so that the value of the forest asset can be calculated as the present value of an indefinite annual stream of rent generated from harvesting the timber stock. In effect, this approach values the forest "estate" composed of timber and land combined. In this method, the value of standing timber is equal to the discounted future stumpage price for mature timber after deducting the costs of bringing the timber to maturity. The stumpage price is the price paid by the logger to the owner of the forest for the right to log standing timber. The costs include thinning (net of any receipts), other forest management costs and rent on the forestland. For natural (or non-cultivated) forests the management costs are very low or minimal. For this case**,** the value of standing timber equals the discounted future stumpage price minus the costs.

Applying either of the two present value methods to actual forests is relatively complicated and requires a great deal of data on the age structure and growth rate of the forest, forest management costs, and the rent on forest land. As a result, various simplified methods have been developed and are applied. Two such valuation approaches are the stumpage valuation and consumption value methods.

The *stumpage valuation method*, also known as the net price method, assumes that the discount rate is equal to the forest's natural growth rate. Since the two rates then cancel each other out, this assumption eliminates the need for discounting, so the value of the stock can be obtained simply by multiplying the current volumes of standing timber by the stumpage prices (neglecting costs).[68] In many applications, the value of the standing timber is based on the receipts from harvesting mature timber only, while costs are neglected. The assumption is that receipts are only realized when the timber reaches maturity. Maturity depends on physical growth but also involves economic factors in its definition. The stumpage prices are reflected in the receipts and therefore directly obtainable. The average stumpage price is calculated dividing the stumpage value by the volume of the removals.

An advantage of the stumpage value method is that it can be used to value all the items related to physical timber accounting in a simple way, including stocks, removals, natural growth, and other changes. This is not the case for other valuation methods. In the stumpage valuation method an average stumpage price is obtained and applied to the whole stock of standing timber. In its simplest formulation, no discrimination is made for the age of the timber

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[68] This approach is somewhat similar to the Hotelling method except that the discounting is offset by physical growth rather than by price increases. For a further discussion, see Hotelling, J. (1931). "The Economics of Exhaustible Resources," *Journal of Political Economy,* 39, pp. 137 – 175.

at the valuation date. Other methods require data for different age or diameter classes, which complicate the calculation of the value of the timber stocks, and consequently, of other items in the physical timber accounts since the valuation of these items should be consistent with that used for stocks.

The *consumption value method* uses different stumpage prices not only for different tree species but also for different age or diameter classes. These prices are applied to the stock of timber based on information on species mix and age or diameter classes obtained from forest inventories. The consumption value method measures the value of the timber as if it were all cut now, hence its name. Which of the methods gives reasonably accurate results depends on the characteristics of the forest stock to be valued and the current and expected exploitation conditions and harvesting patterns. The stumpage valuation method gives good results when the current stock and harvesting structure can be assumed to continue in the future. The consumption value method yields good results for old growth forests, a category which generally does not include New Jersey's forests.

List of Exhibits

Exhibit A: Water Losses for Major Regulated Water Utilities in New Jersey

Utility	Loss Pct.	000 Gal. Lost	000 Gal. Demand	# Customers
Elizabethtown Water	16.80%	9,057,621	53,914,411	206,583
Gordon's Corner	7.98%	163,715	2,051,566	14,526
Middlesex Water	11.09%	1,933,924	17,438,449	58,354
Mount Holly Water	21.70%	399,977	1,843,212	16,064
New Jersey American	23.10%	9,721,539	42,084,584	361,502
Shorelands Water	3.44%	64,782	1,883,198	11,091
United Water NJ	23.10%	9,721,539	42,084,584	193,379
United Water Toms River	12.97%	599,888	4,625,197	48,557
Subtotal	**19.08%**	**31,662,985**	**165,925,201**	**910,056**
Avg. gal./customer (000)			182	
Aqua NJ:				
Northern division	23.43%	318,759	1,360,474	38,097
Central division*	10.10%	386,355	3,825,293	
Southern division	3.37%	59,320	1,760,237	
Subtotal	**11.01%**	**764,434**	**6,946,004**	**38,097**
Avg. gal./customer (000)			182	
Total or average	**18.76%**	**32,427,419**	**172,871,205**	**948,153**
NJ total per 1996 NJSWSP (based on 1,499.1 MGD)			547,171,500	
Share of above in NJ total			31.6%	
		Weighted avg.	Excluded share	
NJ avg. if excluded sources =	*10.0%*	*12.8%*	*68.4%*	
NJ avg. if excluded sources =	*20.0%*	*19.6%*	*68.4%*	
NJ avg. if excluded sources =	*30.0%*	*26.4%*	*68.4%*	
Major utilities not included (no data):				
Trenton Water				61,873
Village of Ridgewood				19,857
Wildwood Water Utility				13,197
Total customers of regulated utilities				1,118,500

* demand inferred from no. of customers and avg. demand per customer for other major utilities; loss pct. obtained by NJBPU staff from utility annual report.

Note: regulated utilities are those for which NJBPU sets rates; major utilities are those with 10,000 or more customers as of 7/1/05. Figures do not include unregulated water purveyors, self-supplied demand (e.g., private wells), etc. Loss percentages may not apply to excluded sources.

Sources: information obtained by NJBPU staff from utility annual reports and rate orders and calculations by NJDEP. N/a = not available.

Exhibit B: Market Value and Elasticity of Demand for New Jersey Agricultural Products			
Type of Agricultural Product	**2002 $000**	**Elasticity**	**Weights**
Nursery, greenhouse, floriculture, sod	$ 356,863	n/a	n/a
Vegetables, melons, potatoes	167,956	-0.070	-11,757
Fruits, tree nuts, and berries	87,148	-0.070	-6,100
Oilseed, dry beans, dry peas	20,352	-0.047	-957
Hay, holiday trees, SRWC*, other	15,643	n/a	n/a
Grains	9,533	-0.040	-381
Total crops (87.68%)	**657,494**	**-0.067**	**-19,195**
Milk / other dairy products from cows	$ 29,154	-0.095	-2,770
Poultry & eggs	26,041	-0.092	-2,396
Other livestock & animal products**	18,870	-0.089	-1,679
Horses/ponies/mules/burros/donkeys	18,314	n/a	n/a
Total animal products (12.32%)	**92,378**	**-0.092**	**-6,845**
Total current production for sale* **	**$ 749,872**	**-0.069**	**-26,040**

* SRWC = short-rotation woody crops. N/a = not available.

** includes cattle & calves; hogs & pigs; sheep, goats, & their products; aquaculture; and other animals and animal products.

*** excludes machine hire & customwork, forest products sold, other farm income, & gross imputed rental value of farm dwellings.

NASS 2002 = US Department of Agriculture, National Agricultural Statistics Service, 2002 Census of Agriculture.

Elasticities from USDA, Economics Research Service. Weights = market value x elasticity.

n/a = not available

Exhibit C: Econometric Estimates of Timber Demand Elasticity

Study	Region	Product	Elasticity*
Adams et al. (2002)	Western OR	Sawlogs	-2.00
Polyakov et al. (2004)	Alabama	Pulpwood	-1.72
Adams et al. (2002)	Western OR	Private timber	-1.58
Merrifield and Haynes (1985)	Pacific NW	Plywood	-0.85
Connaughton et al. (1988)	Montana	Stumpage	-0.65
Newman (1987)	South	Sawtimber	-0.57
Robinson (1974)	South	Softwood	**-0.52**
Abt et al. (2000)	Southeast	Timber products	-0.50
Newman (1987)	South	Pulpwood	-0.43
Carter (1992)	Texas	Pulpwood	-0.41
Adams et al. (2002)	Western OR	Timber for plywood	-0.36
Adams et al. (2002)	Western OR	Timber for lumber	-0.26
Abt (1987)	South	Lumber	-0.25
Median			***-0.25***
Robinson and Fey (1990)	South	Softwood	-0.25
Abt (1987)	West	Lumber	-0.20
Haynes et al (1981)	Pacific NW	Softwood	-0.17
Haynes et al (1981)	Pacific NW	Softwood	-0.14
Haynes et al (1981)	South Central	Softwood	-0.13
Merrifield and Singleton (1986)	Pacific NW	Plywood	-0.10
Abt and Kelly (1991)	FL and GA	Softwood	**-0.10**
Connaughton et al. (1988)	Montana	Stumpage	-0.09
Merrifield and Haynes (1985)	Pacific NW	Lumber	-0.07
Haynes et al (1981)	Southeast	Softwood	-0.05
Daniels and Hyde (1986)	N. Carolina	Hard and Soft	-0.03
Merrifield and Singleton (1986)	Pacific NW	Lumber	-0.01
Merrifield and Haynes (1985)	Pacific NW	Lumber	-0.001

*Short-run own-price elasticity of demand

Sources: compiled by A. Daigneault, USEPA, and W. Mates, NJDEP

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