New England Forests: The Path to Sustainability

CHAPTER 6 • PURIFY OUR WATER

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A TECHNICAL REPORT BY NEW ENGLAND FORESTRY FOUNDATION

INTRODUCTION

This project documents both the existing value and potential of New England's working forest lands: Value – not only in terms of business opportunities, jobs and income – but also nonfinancial values, such as enhanced wildlife populations, recreation opportunities and a healthful environment. This project of the New England Forestry Foundation (NEFF) is aimed at enhancing the contribution the region's forests can make to sustainability, and is intended to complement other efforts aimed at not only conserving New England's forests, but also enhancing New England's agriculture and fisheries.

New England's forests have sustained the six-state region since colonial settlement. They have provided the wood for buildings, fuel to heat them, the fiber for papermaking, the lumber for ships, furniture, boxes and barrels and so much more. As Arizona is defined by its desert landscapes and Iowa by its farms, New England is defined by its forests. These forests provide a wide range of products beyond timber, including maple syrup; balsam fir tips for holiday decorations; paper birch bark for crafts; edibles such as berries, mushrooms and fiddleheads; and curatives made from medicinal plants. They are the home to diverse and abundant wildlife. They are the backdrop for hunting, fishing, hiking, skiing and camping. They also provide other important benefits that we take for granted, including clean air, potable water and carbon storage. In addition to tangible benefits that can be measured in board feet or cords, or miles of hiking trails, forests have been shown to be important to both physical and mental health.

Beyond their existing contributions, New England's forests have unrealized potential. For example, habitats for a wide variety of wildlife species could be enhanced by thoughtful forest management. Likewise, wood quantity could be increased and the quality improved through sustainable forest management. The virtues of improved forest management and buying locally produced goods are widely extolled, but what might that actually look like on the ground? More specifically, how could enhanced forest management make more locally produced forest products available to meet New Englander's own needs, as well as for export, improve the local and regional economies and provide the greatest social and environmental benefits?

The purpose of this project is to document that potential by analyzing what we know about how improved silviculture can enhance wildlife habitat, the quantity and quality of timber, recreational opportunities, and the environment. The best available data from the US Forest Service, state forestry agencies and universities was used to characterize this potential.

The technical reports produced for this project document the potential for:

- Mitigating climate change;
- Increasing timber production to support a more robust forest products industry;
- Restoring important wildlife habitat;
- Replacing fossil fuels with wood to produce thermal energy;
- Reducing greenhouse gas emissions, not only by substituting wood for other fuels, but also wood for other construction materials;
- Enhancing forest recreation opportunities and related tourism;

- Expanding production of nontimber forest products;
- Maintaining other forest values such as their role in providing clean air and potable water – taken for granted but not guaranteed;
- Enhancing the region's economy by meeting more of our own needs with New England products and retaining more of the region's wealth within the New England economy; and
- Other related topics.

These technical reports are viewed as "works in progress" because we invite each reader to bring their own contributions to this long term effort of protecting, managing and enhancing New England's forests. The entire set may be viewed at www.newenglandforestry.org. If you have suggested improvements please contact the New England Forestry Foundation to share your thoughts. These technical reports were used as the background to prepare a summary – *New England Forests: The Path to Sustainability*, which was released on June 5, 2014.

If you are not familiar with NEFF's work please visit www.newenglandforestry.org. Not already a member? Please consider joining NEFF – https://41820.thankyou4caring.org.

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The New England Forestry Foundation is a recognized leader in conserving working forests, educating the public about forestry, and assisting landowners in the long-term protection and stewardship of their properties. For almost 70 years, we have demonstrated that well-managed working forests can provide landowners and the community with the prime ingredients for healthy living: clean air and water, sustainable production of an array of forest products, healthy forests for hiking and relaxation, a diversity of wildlife and habitats, periodic income, and renewable natural resources that help support rural economies.

Our Mission is to conserve New England's working forests through conservation and ecologically sound management of privately owned forestlands in New England, throughout the Americas and beyond.

This mission encompasses:

- Educating landowners, foresters, forest products industries, and the general public about the benefits of forest stewardship and multi-generational forestland planning.
- Permanently protecting forests through gifts and acquisitions of land for the benefit of future generations.
- Actively managing Foundation lands as demonstration and educational forests.
- Conservation, through sustainable yield forestry, of a working landscape that supports economic welfare and quality of life.
- Supporting the development and implementation of forest policy and forest practices that encourage and sustain private ownership.


THE PATH TO
SUSTAINABILITY
KEEP NEW ENGLAND FORESTED
Conserve 90% of New England's existing forests
GIVE WILDLIFE HOMES
Provide critical habitat for 338 diverse species
PROVIDE MORE RECREATION
Contribute more than $5 billion to the New England economy
GROW AS MUCH AS WE USE
Meet our consumption with wood from local forests
YOU ARE HERE
SUSTAINABILITY
PROTECT US FROM CLIMATE CHANGE
Reduce extent and impacts of heat waves, floods, and drought
CLEAN & COOL THE AIR
Save $700 million per year in health costs and crop losses
REDUCE USE OF FOREIGN OIL
Displace $1.85 billion of oil annually with wood heat
GROW MORE WOOD
Enhance quality and double wood production
PURIFY OUR WATER
Save $6 billion in water treatment costs
PROVIDE MORE WOOD FOR BUILDINGS
Save 3.5 million metric tons of carbon
CULTIVATE NEW BUSINESSES
Create new cottage industries using non-timber resources
CREATE LOCAL JOBS
Retain 30k jobs and increase exports to more than $10 billion.
New England's forests have tremendous potential to provide economic, environmental, and social benefits to the citizens of the region. Right now, we're letting some of that potential slip away. Through 12 new research reports, New England Forestry Foundation has defined the benefits our region's forests could provide, and those benefits are summarized here along the Path to Sustainability, starting with the premise that we Keep New England Forested.
NEW ENGLAND FORESTRY FOUNDATION

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PURIFY OUR WATER: The Potential for Clean Water from New England Forests

Prepared by Aaron Paul

Part of a larger project on the potential of New England's forest lands coordinated by R. Alec Giffen for the New England Forestry Foundation. Component parts include the following of the larger effort:

1. KEEP NEW ENGLAND FORESTED: Assessing the Current Conservation Status of New England's Forests by Jerry A Bley
2. GIVE WILDLIFE HOMES: Potential of New England's Working Forests as Wildlife Habitat by Jerry A. Bley
3. PROVIDE MORE RECREATION: Forest Recreation Trends and Opportunities in New England: Implications for Recreationists, Outdoor Recreation Businesses, Forest Land Owners and Policy Makers by Craig Ten Broeck and Aaron Paul
4. PROTECT US FROM CLIMATE CHANGE by R. Alec Giffen and Frank Lowenstein
5. CLEAN AND COOL THE AIR: Forest Influence on Air Quality in New England: Present and Potential Value by Aaron Paul
6. PURIFY OUR WATER: The Potential for Clean Water from New England Forests by Aaron Paul
7. GROW MORE WOOD: The Potential of New England's Working Forests to Produce Wood by R. Alec Giffen, Craig Ten Broeck and Lloyd Irland
8. CREATE LOCAL JOBS: Vision for New England's Wood-Based Industries in 2060 by Innovative Natural Resource Solutions, LLC and The Irland Group
9. CULTIVATE NEW BUSINESSES: New England's Nontimber Forest Products: Practices and Prospects by Craig Ten Broeck
10. PROVIDE MORE WOOD FOR BUILDINGS: The Greenhouse Gas Benefits of Substituting Wood for Other Construction Materials in New England by Ann Gosline
11. REDUCE USE OF FOREIGN OIL: The Potential for Wood to Displace Fossil Fuels in New England by Innovative Natural Resource Solutions, LLC
12. GROW AS MUCH AS WE USE: Production versus Consumption of Wood Products in New England by Craig Ten Broeck

A. Overview

Forests provide several benefits in maintaining water supply, quality and habitats. Healthy, functioning watersheds naturally filter pollutants and moderate water quantity by slowing surface runoff and increasing the infiltration of water into the soil. The result is less flooding and soil erosion, cleaner water downstream and greater groundwater reserves. Some water treatment is unavoidable for virtually all municipalities. Pump stations inject fluoride into the supply, for example. However, additional chemical water treatment can be orders of magnitude more expensive than the minimum treatment required by regulation.

The diversity and extent of the New England water resource is a wonder of the natural world. Few other places have such limitless supplies of fresh water so close to population centers. Lakes and rivers abound throughout the region and have captured the imaginations of centuries of naturalists, conservationist and millions of more casual observers. A precious resource anywhere else in the country, except perhaps the Great Lakes states, an almost unfathomable number of flowing and standing water bodies dominate the landscape. Maine alone is home to over 32,000 miles of rivers, streams and brooks and nearly 6,000 lakes and ponds. Many of these water bodies provide drinking water, power for industry and irrigation for crops. These rivers and lakes are home to a world renowned cold water fishery. The convergence of temperate and boreal climates gives the region's sport fishery unparalleled ecological diversity. In the face of global climate change and increasing populations the value of this resource will only increase.

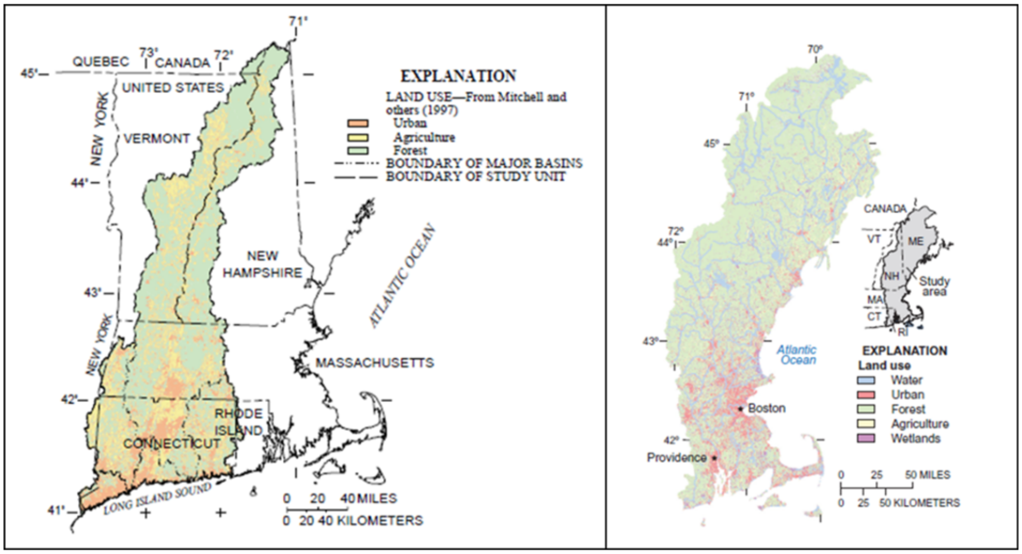
The forest's role in maintaining the quality of these waters is generally recognized but underappreciated. Using cost of replacement method and a quadratic regression model, we estimate the present value of water filtration from forestland in New England to be $157 million annually or $3.9 billion in perpetuity using a discount rate of 4.41%, which is the approximate cost of capital for New England states and municipalities (Moody's 2013). As population and water consumption grow over the 50 year time horizon of this report, we expect that value of water filtration to increase to $5.4 billion in current terms. The capital costs of building new plants to replace natural filtration services would be at least as large. Portland Maine, for example, has avoided constructing a $33.9 million filtration plant by spending $750K annually on forest conservation. The greater Boston area avoids constructing a $400 million treatment plant by keeping the land around the Quabbin and Wachussett reservoirs forested.

In addition to the public economic benefits associated with water filtration, the forests are also home to a rare cold water fishery, the most vibrant and diverse on the eastern seaboard. New England's streams are home to virtually all the wild populations of landlocked Atlantic salmon and brook trout in the country. The fishery is a major recreational asset as well. Anglers from around the world annually spend approximately $1.7 billion on fishing equipment in New England and trips to its waterways.

B. Water in New England

The USGS conducted comprehensive assessment of watersheds throughout the US as part of the National Water Quality Assessment Program. Most of New England's geography and over 95% of its population falls within two major watersheds: the Connecticut, River Basin and the New England Coastal Basin.

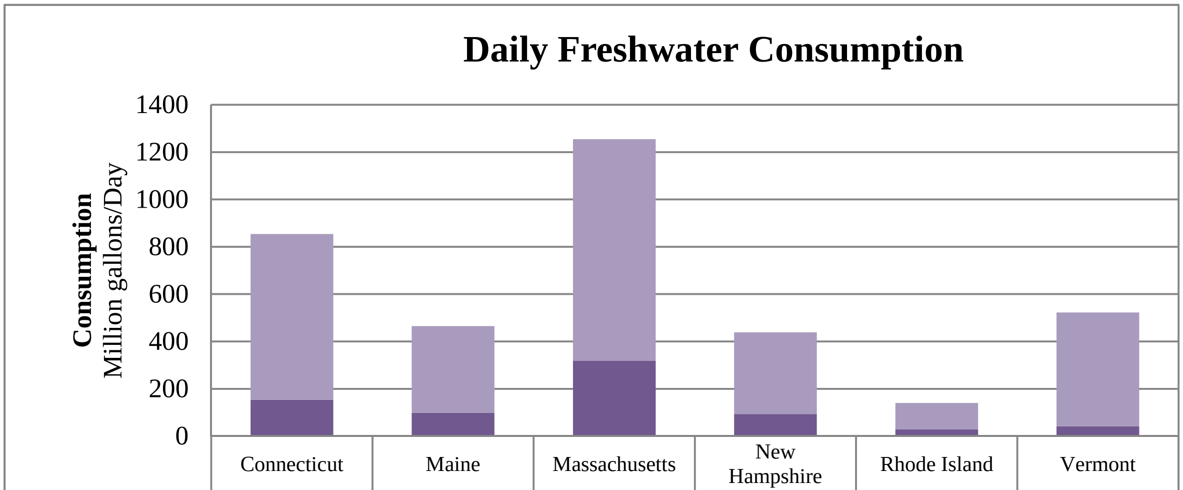
Figure 1. Connecticut Basin and New England Coastal Basin



Source: USGS (1998, 2004).

The Connecticut River, New England's largest and longest river, drains most of New Hampshire and Vermont and, with its tributaries, is the primary water source for Connecticut, eastern Vermont and western Massachusetts. Approximately 5 million people live within its basin. The New England Coastal Basin is comprised of dozens of rivers including the Penobscot, Kennebec, Androscoggin, Saco, Merrimack, and Piscataqua, which drain the northern two thirds of the basin. The Charles and Blackstone drain the southern third. Approximately 8.8 million people live within this basin. New England homes and businesses consume approximately 3.7 billion gallons of freshwater for all uses every day, 80% of which is from surface sources and 20% from groundwater (Figure 2).

Figure 2: New England states total fresh water

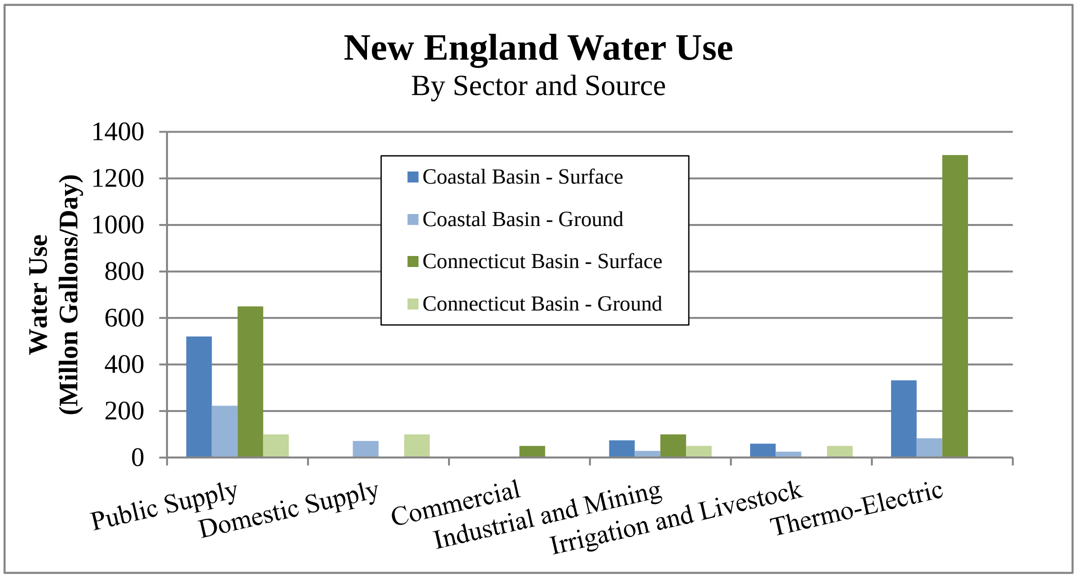


	Connecticut	Maine	Massachusetts	New Hampshire	Rhode Island	Vermont
Surface Water	700	366	937	345	111	480
Groundwater	154	99.2	318	93.8	29.4	42.3

Source: USGS (2005a).

New England's largest consumer of freshwater is power generation. All nuclear, natural gas and coal fired plants produce electricity by heating water into steam that drives a turbine. This use is concentrated in the southern part of New England where most of the region's power plants are located. Water use for thermo-electric power is followed by use for public drinking supply. In the Coastal Basin drinking water supply actually exceeds electricity generation and accounts for half of freshwater usage. Industry, mining, commerce and agriculture utilize little freshwater in this region (Figure 3). However, per-capita water consumption is always higher in the more rural northern states, in particular Vermont, reflecting the greater demand for irrigation use there. Nationally industry and agriculture dominate water usage, together these two sectors account for approximately 90 percent of freshwater withdrawals (GAO 2003). The trend is different in New England because agricultural lands cover only two million acres (American Farmland Trust 2010), and rainfall is more plentiful and evenly distributed over the year than in some other agricultural regions. New England's agricultural lands represent a minute fraction of the total US agricultural land area.

Figure 3. New England fresh water usage by sector



Source: USGS (1998, 2004).

Table 1. New England fresh water consumption all uses

State	Per capita freshwater use (gallons/day)
Connecticut	243.3
Maine	352.42
Massachusetts	196.09
New Hampshire	334.96
Rhode Island	130.00
Vermont	838.36

Source: USGS (2005b).

From 1991 to 2001 researchers sampled surface and groundwater for concentrations of excess nutrients (nitrogen, phosphorous, potassium etc.), heavy metals (lead, mercury etc.), toxic organic chemicals, pesticides, volatile organic compounds and radon. Unsurprisingly, they found New England water quality to be extremely heterogeneous from the headwaters in the north to the urban areas in the south. The rural northern forested areas had some of the least contaminated samples in the country, while the urban southern areas had some of the most contaminated samples. Southern New England leads the nation in concentrations of environmentally persistent inorganic chemicals like DDT, chlordane, PCBs and other vestiges of the region’s industrial heritage (USGS 1998). The surface water of the Boston area, Charles and Aberjona Rivers, had some of the highest concentrations of the gasoline additives MTBE and disinfection byproduct TCE. New England must also contend with toxic chemicals that arrive from out of region. Mercury, lead, zinc and other heavy metals from coal fired power plants accumulate in freshwater fish after they precipitate, which has resulted in consumption advisories throughout the region (USGS 2004).

Nutrient pollution, made famous by images of the hypoxic "dead zone" in the Gulf of Mexico, is a major problem on Long Island Sound where excess nitrogen and phosphorous create seasonal algae blooms. Unlike at the mouth of the Mississippi, Mekong, Nile or other rivers affected with this problem, in New England little of this runoff actually comes from agricultural landscapes. Rather in southern New England, suburban environments are the major source of excess nutrients. The nitrogen concentration of urban streams in the study area was twice as high as streams adjacent to agricultural lands and ten times as high as forested streams. Phosphorous concentrations reflected that same pattern, with urban streams having concentrations three and nine times higher than agricultural and forested streams, respectively. Nitrate concentrations in the groundwater of agricultural lands can be very high. Concentrations exceeded the EPA's Maximum Concentration Limit (MCL) in fifteen percent of shallow wells on agricultural lands. This comes from crop fertilization. The higher nitrogen concentrations in urban streams is largely due to discharges of treated sewage from wastewater treatment plants, which are usually found in urban areas (USGS 1998).

1. The Value of Forest Filtration

New England's forests are the source for all of the headwaters of the Northeast's major rivers, including the Connecticut River, New England's largest river system. These forests protect drinking water quality for millions of people, including public surface water supplies for 4.5 million people and public groundwater supplies for 4.3 million people (USGS 1998, 2004). The Quabbin Reservoir watershed alone provides the drinking water for 2.5 million residents of the greater Boston area. Approximately 40 inches of rain falls in New England every year. Forests consume roughly half of this precipitation through evapotranspiration and the rest enters surface or groundwater systems. The infiltration rates of forest soils are so high that they significantly attenuate surface runoff in the region. Virtually all the water in New England streams and rivers has passed through this forest cleansing process (Massachusetts DCR 2012).

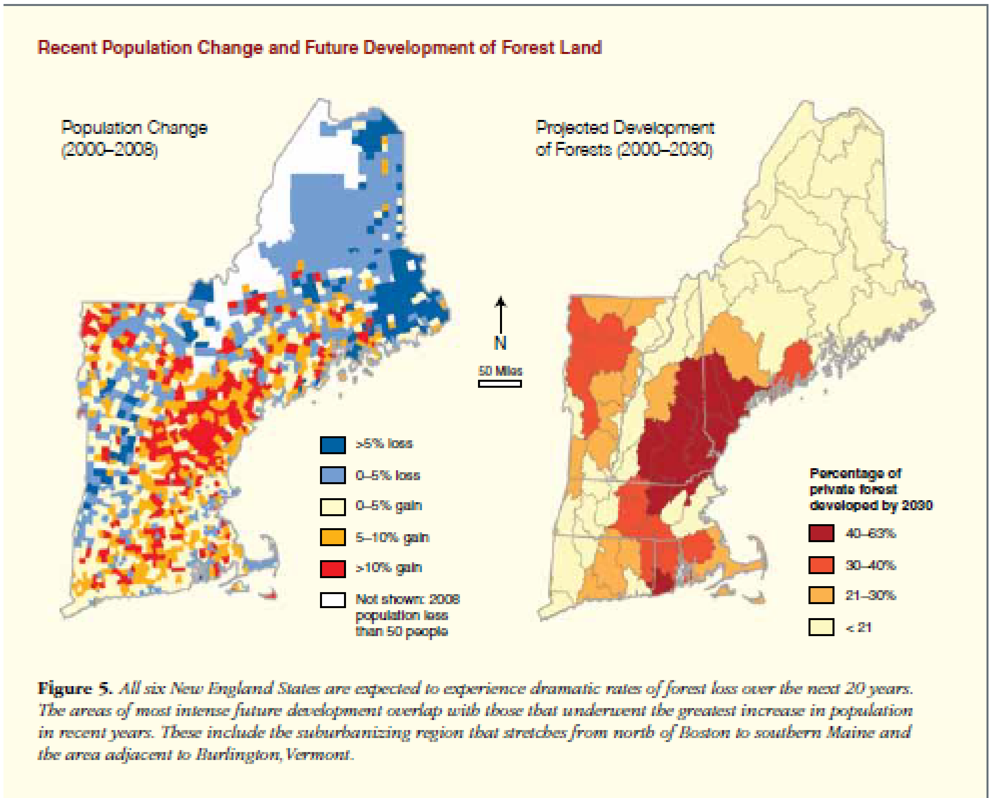
Forests have an impressive ability to filter excess nutrients, volatile organic compounds, pesticides and other toxins from the environment and prevent them from entering surface or ground water supplies. A single acre of temperate northern forest with loamy soil removes approximately eleven pounds of nitrogen from the environment every year (Groffman 1992). The northeastern temperate forests can still thrive with concentrations of toxic chemicals that would kill a vertebrate. An acre of forest can remove over a hundred pounds of airborne mercury each year, thereby keeping it out of the food chain and water supply. A study of oak trees (genus *Quercus*) near a Spanish mine found individual trees with concentrations of mercury four orders of magnitude higher than the EPA recommended maximum daily limit for humans (Huckabee 1988). Riparian forests are extremely effective at storing nutrients that runoff from adjacent agricultural or suburban landscapes. A single hectare of forestland can store fifty kilograms of nitrogen, forty kilograms of calcium, twenty kilograms of potassium, six kilograms of magnesium and four kilograms of phosphorous each year (Lowrance, et al. 1984). Due to the high levels of nutrient loading in New England's downstream water samples, this nutrient storage service saves municipalities from investing in additional chemical water filtration.

Conserved forestland surrounding drinking water supplies provides natural filtration that can reduce the need for additional levels of water treatment. Water supplies are therefore cleaner, flooding and erosion are minimized and groundwater reserves replenished. In the 1990s, New York City analyzed the costs of water purification provided by treatment plants versus that from forest lands and found that a $1.5 billion investment in land conservation in the Catskills would provide the same water quality as $8 billion invested in chemical treatment (TPL and AWWA 2004; Tercek and Adams 2013). Similarly, municipalities in northern New Jersey elected to spend $55 million conserving their watershed in Sterling Forest instead of spending $160 million on new treatment plants. Portland Oregon spends just under $1 million annually conserving land in the Bull Run watershed to avoid a $200 million plant upgrade. In New England, the city of Portland Maine spends $720,000 annually on land conservation in western Maine to avoid a $26 million expenditure on a plant upgrade and $750,000 in annual operating costs (Krieger 2001). In each instance, an investment in forest conservation saved the municipality from a major capital expenditure and increased operating costs.

A consortium of conservation groups and the Land for Maine's Future purchased a $3 million easement on a 1,200 acre preserve along Branch Lake in Hancock County Maine. Branch Lake serves as the reservoir for the City of Ellsworth and is within short driving distance of Acadia National Park and Bangor. As such, it faces considerable residential development pressure. The city waterworks and the state department of Health and Human Services indicated that a $4 million retrofit to the town's water treatment plant would be necessary to compensate for the loss of the parcel's natural purification capabilities if the land were converted to housing lots. This upgraded plant would then incur an additional $100 thousand in annual operating costs (LMF 2011).

The Harvard Forest sponsored "Wildlands and Woodlands" study (2010) projects that privately owned forest cover in southern New Hampshire, southern Maine and much of Vermont is likely to decrease by between 30% and 63% by 2030. Currently, most of these watersheds rely on natural filtration to provide their drinking water (Harvard Forest 2010). Since 1990, Maine has converted more rural land for residential purposes than any other state except rapidly suburbanizing Virginia (Brookings 2006). A Society for the Protection of New Hampshire Forests study (2001) found that the granite state converted an average 13,000 acres of forestland to development every year from 1980 to 2000. Decreasing forest cover could necessitate massive public investments in surface water treatment. Decreased forest cover will also reduce infiltration to ground water and diminish this source of municipal supply.

Figure 4. New England forest cover and population change



Source: Harvard Forest (2010).

2. Valuation: Methods

There are numerous methods available for estimating the value of water filtration services. They are all used to different degrees and effect in setting policies, making conservation decisions and in resolving legal disputes. Three commonly used tools include contingent valuation, hedonic price valuation and cost of replacement method.

Contingent valuation consists of surveying stakeholders within a geographical area about their willingness to pay to maintain or improve water quality or other environmental value. They are also surveyed for demographic and personal details (e.g. age, education, income) which are used as controls in the analysis of the responses. Contingent valuation has been used extensively to value water filtration services associated with the Chesapeake Bay, wetlands and riparian areas (Loomis, et al. 2000). This method is very effective for estimating public support for a given environmental policy. It is not effective for estimating the actual cash flows or cash savings from environmental services, and was therefore not used in this study. Furthermore, the survey process is extremely time consuming and expensive and therefore unpractical given this study's constraints.

Hedonic price method values non-market services, such as water views, gardens and suburban forest cover, by comparing asset prices based on their proximity to these non-market goods. For example, the value of public green space in a town can be estimated by comparing the prices of homes close to those spaces to those farther away, while controlling for a suite of different home attributes (e.g. square footage, number of rooms, house age, and luxury amenities). The data collection effort is onerous, as dozens of variables need to be collected for every asset. However, this method has the potential to accurately and persuasively value the cash flows associated with non-market, environmental resources (Bolitzer and Netusil 2000). That being said, hedonic price method has only been widely used for estimating the value of local scale non-market values. The value of water filtration services, by contrast, is experienced at the landscape scale.

Cost of replacement method is the most market based of all the methodologies. It consists of a cost-benefit analysis where the cost of providing an ecosystem service artificially is compared to the cost of preserving the natural service. For a non-water example, a South African team recently valued insect pollination to farmers by estimating the cost of hiring and equipping human labor to pollinate plants with dusting and hand pollination techniques (Allsopp 2008). These are actual costs that a person, corporation or municipality avoids by investing in resource conservation. Investing in forest conservation can therefore be thought of as purchasing an option on water treatment costs. New York City effectively paid $1.5 billion for the right to continue purchasing freshwater at a treatment cost of approximately $50/million gallons. Due to its ability to articulate actual cash flows associated with a natural capital asset, in this study cost of replacement method was used as one way to value the present and potential benefit forests provide in maintaining clean water.

The TPL and AWWA Model of Treatment Cost

As an alternative, The Trust for Public Land and the American Water Works Association did a study of treatment costs relative to the forest cover of the corresponding watershed. Using a quadratic form regression, they found forest cover significantly predicted treatments costs and that it explained 55% of the variation in treatment cost. The 45 to 50 percent of the variation in treatment costs that is not explained by forest cover is likely explained by varying treatment practices, the size of the facility, the location and intensity of the development and row crops in the watershed, and agricultural, urban and forestry management practices (TPL and AWWA 2004). The model is given below.

$$Treatment\ Cost = 0.01754 * Forest\ Coverage^2 - 2.7531 * Forest\ Coverage + 140.77$$

Forest coverage is percent of the watershed that is covered in forest. This suggests that a completely deforested watershed in the US will, on average, experience a treatment cost of $140.77/million gallons.

3. Valuation: Results

Given the current population of the New England states, forest cover of their associated watersheds, daily consumption of freshwater and the model of treatment costs based on forest cover (TPL and AWWA 2004), we estimated the annual value of water filtration services in New England at $182/ million gallons. This was derived by estimating the present operational expenditure on water filtration in the region and estimating what that cost would be if there was no forest cover. The TPL and AWWA model estimates the public cost of treating water from a watershed with no forest cover at $140.77/million gallons. Taking this annual value of water filtration and discounting it in perpetuity, this study estimates the net present value of water filtration services in New England is $3.1 billion using a 4.41% discount rate. This discount rate reflects the median yield on 20 year AA rated municipal bonds, which is the approximate cost of capital for New England towns and municipalities (Wall Street Journal 2013).

This method allows the quantification of public water filtration costs as they relate to forest cover without undergoing a time consuming and expensive watershed-specific analysis. While there are numerous variables affecting public treatment costs, the results of the TPL and AWWA study suggest that forest cover is the largest. This method also allows the observer to estimate the value of forest filtration independent of other services. New England's forested watersheds are a vital economic asset to the region. The fact that the water filtration value is worth $3.1 billion alone shows their importance. .

Table 2. Annual forest filtration benefit in New England

	Percent forest	Expected cost of water treatment ($$/Mgal)	Total annual cost of water treatment (water usage * Column 2)	Hypothetical annual cost without forest cover (forecasted water usage * 140.71)	Annual operating cost savings (Column 4 - Column 3)
Column	**1**	**2**	**3**	**4**	**5**
Connecticut	55%	42.24	16,022,953	53,401,250	37,378,297
Maine	86%	32.65	7,383,702	31,838,083	24,454,381
Massachusetts	53%	44.19	23,947,223	76,283,647	52,336,423
New Hampshire	78%	31.88	8,696,209	38,395,846	29,699,637
Rhode Island	51%	45.82	3,129,710	9,616,128	6,486,418
Vermont	76%	32.07	9,403,289	41,274,264	31,870,975
Totals			**68,583,086**	**250,809,217**	**182,226,131**

Table 2. Present value of filtration services

Discount rate	Present	Future	Increase
High – 4.11%	3,317,299,825	4,433,725,814	1,116,425,989
Mid – 4.41%	3,091,633,171	4,132,111,813	1,040,478,642
Low – 5.13%	2,657,719,743	3,552,166,295	894,446,552

There are many potential criticisms of this model. For one it is difficult to imagine a completely deforested watershed in New England. Secondly, there is a great deal of treatment cost variation around the extremes. However, this model allows a cost of replacement estimate for multiple municipalities across several watersheds without a dedicated study or the imprecision of simply using the results from a previous study for another municipality.

Forest conservation for the purpose of protecting water quality is an investment in public infrastructure. When deciding whether to make such an investment, the policy maker should evaluate the future stream of cash flows and discount them based on the cost of capital that can be accessed for such a project. Take for example this hypothetical scenario. The state of Maine can avoid spending $7 million in annual water filtration costs through forest conservation projects and it can access financing at 4%. The present value of the $7 million savings in perpetuity is $175 million. If the project's present cost is less than $175 million, then the return on the investment exceeds the cost of financing it, and economics suggest that the project be undertaken. The rationale is the same as a homeowner taking out a mortgage at 3% to buy an asset, such as another house, because they think it will appreciate at say 6%.

For the purposes of this exercise, we assume that the states and municipalities will be able to issue 20 year bonds at yields reflective of their credit ratings. These discount rates reflect the approximate costs of capital for New England state and local governments, specifically the yields that they currently offer on long term (20 year) municipal bonds. New England's states and towns tend to be very credit worthy. Table 3 shows the rating given to the most recent state municipal bond issue for each New England state. All of which fell within the high "investment grade" rating (Moody's 2013).

Table 3. Most recent credit ratings for New England states

State	Moody's Rating	Date of Rating
Connecticut	Aa3	August, 2013
Maine	Aa2	May, 2012
Massachusetts	Aa1	July, 2013
New Hampshire	Aa1	November, 2012
Rhode Island	Aa3	March, 2013
Vermont	Aa2	July, 2013

Table 4 shows the credit ratings assigned to the six most recent municipal bond offerings in each of the six New England states (Moody's 2013). With the exception of St. Johnsbury Vermont and Central Falls Rhode Island, all these municipalities received investment grade ratings. The largest water user, Boston, holds the much coveted and highest AAA credit rating.

Table 4. New England municipal recent credit ratings

Connecticut		Maine		Massachusetts	
City	**Rating**	**City**	**Rating**	**City**	**Rating**
New Haven	A2	Bar Harbor	AA2	Boston	AAA
Stonington	AA1	Kennebunk	AA2	Easton	AA3
Winchester	A3	Wells	AA2	Medford	AA2
Norwalk	AAA	Brunswick	AA2	Richmond	A1
Canton	AA2	Bangor	AA2	Lanesborough	A1
Westbrook	AA2	Kittery	AA2	Ludlow	AA3
New Hampshire		**Rhode Island**		**Vermont**	
City	**Rating**	**City**	**Rating**	**City**	**Rating**
Durham	AA2	Lincoln	AA2	Burlington	A3
Manchester	AA2	Jamestown	AA2	Arlington	A1
Milford	A1	Cumberland	A1	Woodstock	AA3
Lincoln	A1	Charlestown	AA2	St. Johnsbury	BAA3
Portsmouth	AA1	Central Falls	B1	Housing Finance	AA3
Bedford	AAA	Cranston	A2		

Source: Moody's (2013).

The model only accounts for public operational costs of water filtration. It does not account for the capital expenditure associated with building a new plant. Such outlays cost millions of dollars and are frequently paid for over many years, as waterworks usually need to borrow the funds to pay for the plants. Compounding the financial burden, subsequent decreases in water quality can require plant upgrades. A 30% reduction in the forest cover of New England watersheds would require several plant retrofits over the years. It is impossible to accurately gauge what this would cost without knowing the actual filtration needs of the specific municipal waterworks and without going through a full cost estimation process; however, the case of Portland Maine suggests that the capital cost savings may be as much as twenty five times as high as the annual operating costs.

4. Case Study: Portland Maine

Portland Maine has invested in forest conservation to keep its costs of water filtration low for decades. The city spent approximately three quarters of a million dollars annually during the late 1990s and early 2000s on easements in and around its drinking source, Sebago Lake, and the Presumpscot River basin, which includes the lake. Currently the watershed is approximately 80% forested. The state also enforces a no trespassing area around the southern end of the lake that contains the intake for the city's drinking water (Portland Water District 2013). These investments allowed the city to obtain a filtration waiver from the Environmental Protection Agency and to avoid purchasing a $33.9 million filtration facility (Heal 2000).[1] Using the TPL and AWW model, we estimate that these investments have also allowed the city to avoid a million dollar increase in annual operating costs. Discounted at 4.4% in perpetuity, the net present value of these savings is approximately $25.4 million, which when combined with the cost of a new filtration facility yields a total net present value of these forest filtration services of $59.3 million.

Table 5. Portland Maine value of forest filtration services

Sebago Lake and Presumpscot Watershed	
Watershed percent forest	80%
Watershed area (sq. miles)	1070
Watershed population	80,000
Daily water consumption (millions of gallons)	28
Forest area (acres)	547,840
Cost of water treatment with forest intact ($/Mgal)	$31.88
Total annual cost of water treatment with forest intact	$328,091
Hypothetical annual cost without forest cover	$1,448,634
Annual operating cost savings	**$1,120,543**

Source: TPL and AWWA (2004).

5. Case Study: The Greater Boston Watershed

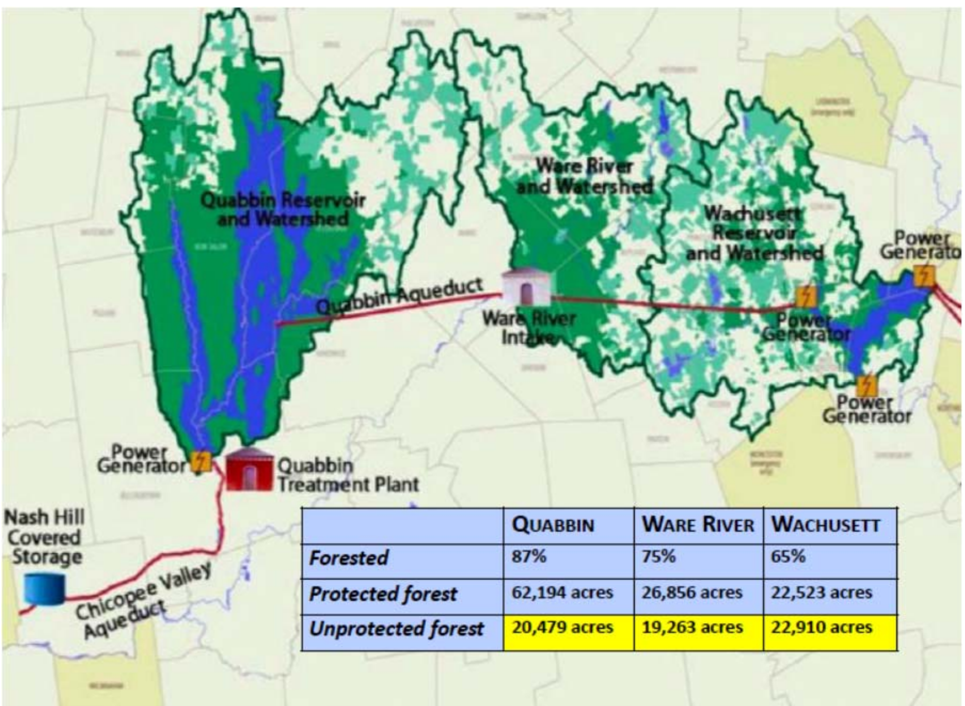
The Quabbin Reservoir, Ware River and Wachusett Reservoirs supply 2.5 million Massachusetts residents, primarily in the Greater Boston area, with approximately 200 million gallons of forest filtered freshwater every day. By maintaining a diverse and multilayered forest ecosystem around the reservoir,

[1] Heal estimate adjusted for inflation

state foresters have allowed the city and commonwealth to keep their EPA filtration waiver, thereby avoiding any major public investments in artificial water treatment. This is achieved by managing over 100,000 acres of forest land for multiple uses. At the same time that watershed values are protected, three to five million board feet of timber are harvested every year. Since 1960 the watershed managers have completed over 1000 timber sales of this nature. These operations help maintain a diverse ecosystem. To augment this diversity, twenty to twenty five percent of these lands are reserved from active management and simply allowed to grow without timber harvesting (Massachusetts DCR 2012).

As is the case for Portland or New York City, the water from these reservoirs does not naturally drain to Boston. Instead a system of gravity fed aqueducts have been built to enable the movement of water from the Quabbin reservoir to the Ware River to the Wachusett reservoirs and finally to the majority of the consumers. Because Boston's water comes from outside its drainage basin, the city and state governments collaborate to protect forest cover throughout the commonwealth. All three watersheds are heavily forested (Figure 5), however only the Quabbin is surrounded by conserved forest lands. The Ware River and Wachusett Reservoir watersheds are between 50 and 60 percent privately owned and unprotected. The Division of Water Supply Protection estimates that if these forest lands were developed the loss of filtration services would necessitate a $400 million investment in artificial water filtration and increase annual operating costs by $10 million, which represents a 50% increase over their current $20 million budget (Massachusetts DCR 2012).

Figure 5: Greater Boston water source



	QUABBIN	WARE RIVER	WACHUSETT
Forested	87%	75%	65%
Protected forest	62,194 acres	26,856 acres	22,523 acres
Unprotected forest	20,479 acres	19,263 acres	22,910 acres

Source: Massachusetts DCR (2012).

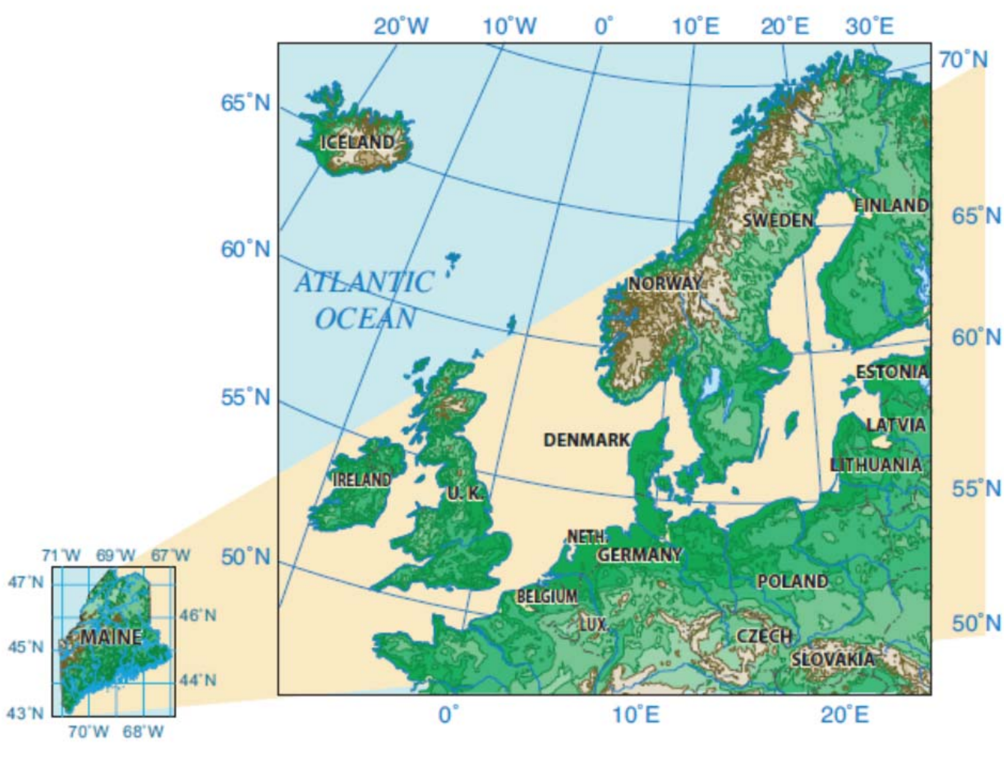
The Division estimates that such capital expenses could be avoided through forest conservation funded by a $16 per user per year water use fee, which equates to $0.0002/gallon of water consumed. Assuming an average price of $5000 per acre, such a program could purchase conservation easements for all the forest land in the three watersheds in just seven years (Massachusetts DCR 2012).

C. Value of Cold Water Fishery

New England's forests and the rivers and streams they feed are a unique ecosystem. Central hardwoods, northern hardwoods, and spruce fir all occupy portions of the New England landscape. This gives the northern forest a set of environmental attributes that make it suitable for both warm and cold water species of fish and other aquatic organisms. Because of this, many species found in New England waters (particularly Maine and New Hampshire) are at the northern or southern extent of their ranges. The combination of converging ecosystem types and abundant freshwater creates both a unique ecological asset and a vibrant angling economy.

New England's geology and position at the confluence of cold and warm air currents gives the region a striking range of climates. The climate gradient that exists across three degrees of latitude in Maine exists across more than 20 degrees of latitude in Europe (Figure 6). This sharp contrast in climates across gives the region more environments than almost any other comparably sized region in the world. This means that the region can support a wide array of freshwater species (Jacobson, et al. 2009).

Figure 6. Maine's climate range



Source: Jacobson, et al. (2009).

1. Ecological Value

New England's forested streams and lakes are internationally renowned. Anglers journey from thousands of miles away to try their luck in the region's waters. They provide habitat to rare and ecologically valuable species. They are one of the last places where landlocked Atlantic salmon, shortnose sturgeon and unstocked, wild brook trout populations still exist. Many of these populations are considered threatened or endangered. Twenty-seven aquatic species and eight Distinct Population Segments of Atlantic salmon are listed as threatened or endangered by the federal government or the State of Maine. An additional 54 aquatic species are considered rare and are tracked by the Maine Department of Inland Fisheries and Wildlife or Maine Natural Areas Program.

Brook trout are the most widely distributed fish in Maine, occurring in 69% of surveyed lakes and an estimated 22,250 miles of streams. Maine possesses the most significant native brook trout resource remaining in the US. This species is one of northern New England's most sought after game fish. An estimated 305 lakes contain wild brook trout populations that have never been stocked. This is very unusual in the US. However, habitat degradation and introduced species have resulted in declining brook trout populations in Maine and elsewhere. Maine also has some of the few remaining sea-run populations of brook trout in the Northeast (TNC 2008).

2. Economic Value

The US Fish and Wildlife service tracks spending on and participation in hunting and fishing recreation in every US state. Approximately $1.7 billion is spent on fishing trips in the region every year (see Table 7).

Table 7. Spending on freshwater recreation in New England

		Direct spending	Users	Population	Per capita spending
Connecticut		436,473,000	342,000	3,510,000	124.35
Maine		371,829,000	341,000	1,320,000	281.69
Massachusetts		455,403,000	532,000	6,400,000	71.16
New Hampshire		208,524,000	228,000	1,310,000	159.18
Rhode Island		130,046,000	175,000	1,080,000	120.41
Vermont		131,317,000	207,000	623,000	210.78
Total spending		1,733,592,000			
Total coldwater spending	*50%*	866,796,000			
Contribution to GDP	*30%*	260,038,800			
Potential	*30%*	338,050,440			

Source: US Fish and Wildlife (2011a-f).

The spending figures include all money spent on gear and equipment and the costs associated with taking fishing trips. These include spending by residents fishing in state and non-residents traveling to the state to fish. The users identified in these statistics can be repeat participants who may spend several days fishing each year. Research shows that anglers do most of their fishing close to home. The vast majority of fishing trips happen on the weekends or for a few hours at a stretch. For this reason, the most populous states also have the highest spending. An exception to this rule is that per capita spending in Maine and Vermont is three to four times that in Massachusetts (US Fish and Wildlife 2011a-f) – likely reflecting the importance of the resource.

Approximately half of all fishing trips are to catch cold water species that require a forested landscape to survive (Connelly and Brown 1991). The shade and filtration provided by trees keeps the water cool and clean enough to support many species such as brook trout and Atlantic salmon. As such, this fishery can be considered a forest ecosystem service and half of spending was therefore attributed to the forest. However, not all recreation spending contributes to state gross domestic product. Most is transferred out of state. For example most money spent on gas does not go to the station owner, it goes to the major oil company that sells them the gas and franchises them. Approximately 70% of recreation and tourism spending is transferred in this way (Maine Developmental Foundation 2004).

D. Global Fresh Water Scarcity

Approximately 60% of the land area of the US, mostly in the Great Plains and Intermountain West, has experienced more than 10% of the last 100 years as extreme drought (GAO 2003). Predictions are that global climate change will cause this figure to increase. Some models show rainfall decreasing by as much as 10 inches in large areas of the US south and south east, leading to more frequent and more severe droughts in those regions. As these areas suffer from water scarcity their productivity will suffer. New England’s abundant water resources will become more valuable in supporting forestry and agriculture (IPCC 2007).

The challenge is more acute internationally. Arnell (1999) estimates that by 2025 five billion people will live in areas suffering from water stress. For example, ground water supplies in the Indian Sub-continent are already diminishing as growing populations and economies increase their usage. As the Himalayan Glacier recedes, these shortages will only become more severe. Large areas including most of Central America, much of South America and much of Europe are forecasted to see similar declines in water availability (Arnell 1999). This has a ripple effect for water supply as snowpack declines, lake levels fall and aquifer recharge slows.

Global climate change is expected to adversely impact water availability throughout the world. New England, by contrast, is expected to remain an island of resilience in a sea of change (IPCC 2007). As water becomes scarcer globally New England’s resource will become more valuable. This increase may manifest itself in many ways. We may export our water. We may become home to more industry. We may see an increase in agriculture.

E. Conclusion

New England's forests protect and provide globally unique freshwater resources. They filter the water we use for drinking, irrigation and electricity generation. The cost of replacing this service with artificial filtration would cost billions of dollars in additional operating costs and capital expenditures. The forests provide habitat for ecologically rare cold water fisheries. There are few places left on the east coast where brook trout populations can survive in significant numbers without stocking. There are even fewer populations of wild Atlantic salmon. In addition to the ecological value of the resource, anglers spend almost $2 billion on fishing trips and gear in New England every year, which translates to approximately $600 million in regional GDP. Approximately half of this amount is associated with the more forest dependent cold water fishery.

With a warming climate and a growing global population, and its associated needs for nutrition, energy and shelter, fresh water will become scarcer. This will make New England's fresh water resource appreciate in real value. It may be exported to drought stricken parts of the country. Agriculture may play a larger role in the region's economy if it becomes prohibitively costly to irrigate in the Southwest or other parts of the country. Immigration may increase as New England's clean water becomes more widely appreciated.

Municipalities in New England have already realized the value of their freshwater resource and the forest's role in protecting it by investing in easements. Portland Maine's work around Sebago Lake and the Massachusetts' investments in land protection around the Quabbin Reservoir, Ware River, and Wachusetts Reservoir are large scale examples of ambitious natural capital investment projects. The City of Ellsworth Maine's investment in a Branch Lake preserve is another example at a smaller scale. The freshwater resource and the forests that preserve it are a major natural capital asset of the citizens and governments of New England with real, monetary benefits that are crucial to recognize. They are also an irreplaceable part of our cultural identity, natural landscape and future wellbeing. These services are worth billions of dollars.

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