ECONOMIC & ENVIRONMENTAL BENEFITS OF BEVERAGE CONTAINER RECYCLING: The Case for Updating Massachusetts' Bottle Bill

Prepared by:
Dr. Jeffrey Morris
Sound Resource Management
1477 Elliott Avenue West
Seattle, Washington 98119

Prepared for:
Massachusetts Public Interest Research Group
29 Temple Place
Boston, Massachusetts 02111-1305

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TABLE OF CONTENTS

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I. Executive Summary

Massachusetts' proposed updated Bottle Bill (UBB) will provide quantifiable economic and environmental benefits with an estimated annual monetary value of <u>$62.3 to $98.7 million</u>. In addition, the proposed UBB will provide substantial, as yet unquantifiable, economic and environmental benefits. These quantifiable and non-quantifiable benefits result from projected total recovery under the UBB of between 160,000 and 164,000 tons of beverage containers for recycling each year, including 86,000 to 94,000 tons collected under the current Bottle Bill, as well as an additional 70,000 to 74,000 tons projected for collection as a result of the proposed update.

A. Quantifiable Benefits

The UBB has many economic and environmental benefits, some of which are quantified in the following report. Quantifiable benefits include:

- $9.4 to $26.8 million from employment opportunities in industries that make new containers and other products from recycled materials;
- $18.8 to $24.8 million in revenues from selling recovered beverage containers to recycling markets;
- $13.5 to $20.2 million from reduced litter and waste management costs;
- $18.1 to $24.0 million in reduced public health costs from pollutants emitted when virgin materials are used in manufacturing beverage containers;
- $1.1 to $1.2 million in reduced public health costs for emergency room visits resulting from cuts on broken glass litter; and
- $1.3 to $1.9 million reduced greenhouse gas emissions from energy used in manufacturing beverage containers from virgin materials.

B. Non-Quantifiable Benefits

Many other positive impacts of the UBB are discussed in the following report, but are not included in monetary estimates for economic and environmental benefits because these impacts have not yet been accurately quantified. Non-quantifiable benefits include:

- Stronger local economies as a result of using recycled materials to manufacture products;
- Reduced emissions of pollutants whose public health costs have not yet been quantified;
- Public health, recreational and aesthetic gains from reduced litter (other than reduced emergency room visits for cuts on broken glass, which are included in quantifiable benefits);
- Slower on-site accumulation of solid and radioactive wastes at resource extraction and processing, energy generation, and manufacturing operations; and
- Reduced ecosystem impacts and resultant productivity improvements in agriculture, fishing and forestry.

C. Materials Captured Under the Proposed UBB

Between 160,000 and 164,000 tons of beverage containers would be recycled under the proposed UBB, 86,000 to 94,000 tons from containers included in the current Bottle Bill and an additional 70,000 to 74,000 tons included in the proposed update. Total collections would include:

- 119,000 to 135,000 tons of glass;
- 15,000 to 21,000 tons of plastic; and
- 14,000 to 20,000 tons of metal (mostly aluminum).

D. Benefits of the Current Bottle Bill and Additional Benefits of the Proposed Update

Massachusetts' Bottle Bill, implemented in 1983, targets beer and carbonated beverage containers with a five cent refundable deposit. The Bottle Bill currently achieves an estimated 85% recycling rate, and recovers between 86,000 and 94,000 tons annually.

Increasing popularity of beverages such as bottled water, juice, iced tea, and sports drinks, which are not covered by the current refundable deposit, motivated the filing of legislation to update the Bottle Bill to cover these beverages as well. ***Inclusion of these drinks would nearly double, by weight, beverage container materials recycled through Massachusetts' bottle deposit system, recovering an additional 70,000 to 74,000 tons.***

Table ES-1 compares quantifiable benefits generated under the current Bottle Bill with those generated by the additional beverage containers targeted by the proposed update. ***We find that updating the Bottle Bill will create $14.9 to $26.5 million in additional quantifiable benefits, a significant supplement to economic and environmental benefits already being generated each year under the current Bottle Bill.***

Table ES-1
Quantifiable Annual Benefits of Beverage Container Recycling

Benefit Type:	Current BB	UBB Additions	UBB Total	Current BB	UBB Additions	UBB Average
	(millions)	(millions)	(millions)	(per ton)	(per ton)	(per ton)
Economic	$30.4 - 49.4	$11.4 - 22.2	$41.8 - 71.6	$321-573	$163-303	$255-$448
Environmental	$17.0 - 22.8	$3.5 - 4.3	$20.5 - 27.1	$183-265	$50-58	$125-170
Total Benefits	$47.4 - 72.2	$14.9 - 26.5	$62.3 - 98.7	$504-836	$213-362	$380-$618

Average per ton benefits are higher for containers included in the current Bottle Bill because of a higher concentration of plastic and aluminum containers. An estimated 35% of containers currently being redeemed are plastic or aluminum, while only about 10% of additional containers recovered under the UBB are expected to be plastic or aluminum. As shown in tables presented in the following report, aluminum and plastic have substantially higher benefits for each ton of material recycled than glass.

E. Proposed Bottle Bill Update: Significant Additional Benefits at Reasonable Cost

Based on the data and analysis contained in the following report, we expect that the proposed update to Massachusetts' Bottle Bill will:

1. Generate additional economic benefits totaling $11.4 to $22.2 million each year from recovery of newly targeted containers. These economic benefits include:

- $2.7 to $10.3 million annually from net new employment opportunities (including about 90 net new manufacturing jobs, after subtracting out job losses in virgin materials manufacturing and at garbage disposal facilities), worth $39 to $140 for each additional ton of container materials recovered;
- $5.5 to $8.2 million each year from reduced garbage and litter management costs, worth $78 to $111 per additional ton recovered; and
- $3.2 to $3.8 million annually in revenues, averaging $46 to $52 per additional ton, from selling recovered containers to businesses that manufacture new products from recycled materials.

2. Generate additional public health and environmental benefits totaling $3.5 to $4.3 million each year from recovery of newly targeted containers, as a result of:

- Substitution of recycled containers for virgin raw materials in manufacturing beverage containers and other products (which reduces releases of chemical pollutants that occur during virgin raw materials drilling, digging, or cutting and refining, smelting, or pulping);
- Reduced disposal of beverage containers (which lessens the release of chemical pollutants during garbage collection and landfill/incinerator disposal);
- Decreased litter (which reduces public health costs because of fewer hospital emergency room visits resulting from cuts on broken glass); and
- Reduced greenhouse gas emissions (because the use of virgin materials in manufacturing beverage containers and other products is very energy intensive).

3. Recover more containers at reasonable cost than other recycling systems:

- Existing recycling systems are estimated to recover only 20% as much of the newly targeted containers by weight as would be captured under the UBB;
- Nationally, existing curbside recycling of UBB-targeted beverage containers is estimated to cost between $175 and $386 per ton recycled, with evidence from one major waste management company indicating that actual costs are close to the top end of this range; and
- Neither augmented curbside recycling nor densely located drop off recycling centers can achieve UBB recovery levels at reasonable cost.

Taking into account all benefits likely to result from additional container recovery in Massachusetts, an update of Massachusetts' Bottle Bill to cover more types of beverage containers appears to be justified. Costs for updating Massachusetts' bottle deposit system are not analyzed in the following report. In its 1997 report for the Massachusetts Department of Environmental Protection, Tellus Institute estimated UBB sorting, handling, and collection costs for retailers, redemption centers, distributors and bottlers at about $380 per ton.* These costs are outweighed by the quantity and quality of benefits to be gained by capturing more beverage containers via the updated Bottle Bill for recycling in the state.

F. Employment As An Economic Benefit Versus A Cost

In discussing economic benefits from increased employment, it is important to distinguish between employment within the bottle redemption system itself and employment generated when the redemption system sells recovered beverage containers to recycling markets. The point of view in this report is that employment and other expenditures incurred by retailers, redemption centers, distributors and bottlers to operate the state's bottle redemption system are economic costs.

On the other hand, the economic benefits of employment discussed in this report are those that occur when the redeemed beverage containers are sold to recycling markets. These benefits include new manufacturing jobs in businesses that purchase recovered containers and manufacture them into new containers or other salable products, as well as "ripple effect" jobs induced by these new manufacturing jobs. Reported benefits include a deduction for any loss of virgin-materials-based manufacturing jobs.

G. Report Structure

The following report details the evidence for the findings reported in this Executive Summary. Section II covers public health and environmental benefits, while Section III discusses economic benefits of the proposed UBB. Section IV discusses the costs of methods other than the UBB that might be used to increase beverage container recycling in Massachusetts. Section V includes a table and discussion summarizing benefits of the proposed UBB.

* Tellus Institute, "An Analysis of the Costs and Benefits of Expanding the Scope of the Bottle Bill in Massachusetts," prepared for Massachusetts Department of Environmental Protection, June 1997, pp. 10-12. Estimate includes sorting and handling costs for retailers and redemption centers, and collection costs for distributors and bottlers.

II. Environmental Benefits of Increased Bottle Recovery

- ♦ Our use of virgin raw materials and fuels in manufacturing products releases harmful pollutants, impairs human health, destroys habitat, diminishes productivity in natural resource industries, impairs ecosystems, and diminishes our enjoyment of previously pristine places.
- ♦ Use of virgin materials and fuels can be substantially reduced by recovering materials from our wastes and using them to replace virgin materials in manufacturing products.
- ♦ Massachusetts' updated Bottle Bill will recover and recycle significant amounts of beverage containers.
- ♦ Public health benefits from reduced use of virgin raw materials and fuels, decreased litter and less waste are worth $50 or more for every ton of UBB containers.
- ♦ Other environmental benefits of UBB recovery almost certainly are worth even more than $50 per ton of beverage containers targeted under the proposed UBB.

The existence, if not the extent, of environmental impacts from virgin material and energy resource acquisition and processing is widely acknowledged. Drilling, digging, or cutting and refining, smelting, or pulping create raw materials to feed our industrial system and, at the same time:

- release chemical substances, carbon dioxide, waste heat and processing refuse into air and water and onto land;
- impair the health of people exposed to polluting chemical releases;
- dislocate and destroy habitat for a wide variety of non-human creatures and organisms;
- diminish productivity in natural resource industries that depend on healthy species and ecosystems;
- impair ecological functions and biological diversity in ecosystems; and
- alter the sights, sound, smells and feelings humans enjoyed in many previously pristine, natural places.

Similarly acknowledged is the existence of environmental impacts resulting from disposal of leftovers from our use and consumption of manufactured products and foodstuffs. Burying these wastes creates a variety of problems, from potential releases into the environment of toxic leachate and landfill gases to noise and traffic impacts on residences and businesses neighboring landfills. Waste incineration creates air and water emissions, as well as potential releases at incinerator ash landfills.

Modern day recycling, e.g., curbside collection from residences, was initiated largely because of a belief that we were running out of landfill space, and because we wanted to reduce the environmental risks associated with waste disposal. Beverage container deposit systems often were put in place largely as a means of reducing litter along our roadways. By now, however, use of recycled materials as substitutes for virgin manufacturing feedstocks is understood as the most significant environmental benefit from curbside recycling and bottle deposits.

Data similar to that shown in Table 1 have been widely cited to indicate the environmental benefits of material recovery. The table shows percentage reductions in various environmental impacts as a result of less use of virgin raw materials in manufacturing products.

Table 1
Environmental Benefits of Recycling

Reduction of:	Aluminum	Steel	Paper	Glass
	(percent)	(percent)	(percent)	(percent)
Energy Use	90-97	47-74	23-74	4-32
Air Pollution	95	85	74	20
Water Pollution	97	76	35	--
Mining Wastes	--	97	--	80
Water Use	--	40	58	50

Source: Shireman, W., "Solid Waste: To Recycle or Bury California," *California's Threatened Environment*, Island Press, 1993, p. 173.

Recently completed and ongoing research that updates the benefit estimates given in Table 1 will be referenced throughout this report.[1] Whether based on recent research or estimates given in Table 1, the conclusion remains the same - - recovery of materials from waste and their use in manufacturing products yields substantial environmental benefits.

In addition, what Table 1 does not show is that most of the environmental benefits of material recovery are associated with reducing the extent of virgin materials production rather than with reduced landfilling or incineration. As explained by Frank Ackerman, one of the authors of Tellus Institute's study on the environmental impacts of packaging materials,

"Air and water emissions from new, state-of-the-art landfills and incinerators, and the emissions from collection trucks, are insignificant in comparison with manufacturing emissions. Often the waste management impacts were 1% or less of the production impacts for packaging materials. That is to say, as unattractive as it is to live next to even the newest landfill, it might be 100 times as bad for your health to live next to a paper mill, oil refinery, or steel mill."[2]

Ackerman and the Tellus study have been criticized for focusing their analysis only on disposal facilities that are in compliance with all current environmental standards. Numerous disposal facilities continue to cause substantial environmental damage for a wide variety of reasons, including exemption from current standards or location in an area where environmental standards are not effectively enforced. In addition, despite control of leachate and gases during a state-of-the-art landfill's operating life and for a proscribed period of time after closure, the threat of environmental releases from landfilled materials and incinerator ash remains forever.[3]

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[1] Because this report is concerned with the benefits of glass, metal and plastic beverage container recovery, recent research on the benefits of paper recycling will not be discussed here. For a comprehensive review and analysis of paper recycling, the interested reader can refer to white papers produced by the Paper Task Force, composed of representatives from industry, government and environmental organizations. These studies are available through the Environmental Defense Fund, New York.

[2] Ackerman, Frank, *Why Do We Recycle?: Markets, Values, and Public Policy*, Island Press: Washington, DC, 1997, p. 89.

[3] See for example, G. Fred Lee, "Municipal Solid Waste Recycling Protects Groundwater: Reply to 'Recycling is Garbage'," *HydroVisions*, 5(3):6, August/September, 1996, or G. Fred Lee and Anne Jones-Lee, "Deficiencies in US EPA Subtitle D Landfills in Protecting Groundwater Quality for as Long as MSW is a Threat," 1997.

100% compliance with regulatory emissions standards also is unlikely for virgin material and energy resource acquisition and processing. Given that emissions from production dwarf emissions from managing wastes when both systems are in regulatory compliance, environmental impacts from actual ongoing exploration, acquisition and processing of virgin materials almost certainly outweigh actual waste disposal system impacts by one or two orders of magnitude. Thus, it is critical to focus on environmental benefits of virgin resource conservation, in addition to reduction in litter and waste disposal, as part of any assessment of benefits from targeting more beverage types for Massachusetts' bottle deposit system.

The remainder of this chapter offers estimates of the economic value for reductions in a variety of environmental impacts as a result of recovering more bottles through Massachusetts' proposed updated Bottle Bill (UBB). The economic value of direct human health benefits from reduced disposal, less litter and more use of recovered materials in manufacturing are all discussed in the first section of this chapter, while the second section addresses the economic value of more general environmental benefits, such as reduced energy use and habitat or ecosystem impairment or loss.

A. What Are Public Health Benefits of Increased Bottle Recovery Worth?

Much research has been devoted to calculating public health effects from chemical substance releases and other environmental changes resulting from human activities. A less substantial, but still significant body of research has accumulated on how to estimate the economic costs of these impacts. This section reports on estimated human health costs from toxic substances released as a result of beverage container production and their disposal after beverages have been consumed. This section also discusses human health costs from illegal disposal of beverage containers.

1. Direct Public Health Benefits of Replacing Virgin Raw Materials

- Recycling beverage containers into new products reduces hazards otherwise released from virgin materials acquisition, processing and product manufacturing, saving $39 - 46 in public health costs per ton of containers recovered.

In their four-year study of the social costs of packaging materials, recycling and packaging alternatives, Tellus Institute conducted a lifecycle inventory of the emissions of nearly 200 chemical substances associated with the production and disposal of packaging materials, including emissions from acquisition and processing of raw materials used to manufacture packaging.[4] The hazards chosen for inclusion in Tellus' inventory included the US EPA's criteria air pollutants[5], methane (a greenhouse gas[6]),

[4] Tellus Institute, *CSG/Tellus Packaging Study*, prepared for The Council of State Governments, US Environmental protection Agency, and New Jersey Department of Environmental protection and Energy, May 1992. Estimates of the economic cost of production system impacts reported herein are based on "The 1994 Update of the Tellus Institute *Packaging Study* Impact Assessment Method," prepared by Brian Zuckerman and Dr. Frank Ackerman. Economic costs in the latter report reflect updated information for valuing impacts of criteria air pollutants and toxics.

[5] Particulates, nitrogen oxides, sulfur oxides, volatile organic chemicals, and carbon monoxide.

[6] Carbon dioxide, nitrous oxide and perfluorocarbons are also greenhouse gases but were not included in the Tellus assessment. Carbon monoxide's greenhouse potential was included in Tellus' valuation of CO as a criteria air pollutant. Nitrogen oxides were also evaluated because they are criteria air pollutants, as well as being greenhouse gases.

carcinogens, and toxic noncarcinogens.[7] Economic valuation of these hazards was restricted to their direct impacts on human health.

Valuation of the public health costs for releases of criteria air pollutants and methane were based on expenditures required to achieve regulatory limits for emissions of these gases. Valuation for carcinogens and noncarcinogens involved three steps.

First, carcinogens were ranked on the basis of laboratory analyses of each pollutant's oral cancer potency factor, while noncarcinogens were ranked according to the inverse of laboratory estimates of the maximum daily exposure that would not cause harm, the so-called oral reference dose. Second, carcinogens were compared with noncarcinogens according to US Occupational Safety and Health Administration (OSHA) permissible exposure levels for the lowest ranked carcinogen, isophorone, and the lowest ranked noncarcinogen, xylene. Third, rankings were converted to monetary values ($/lb) based on estimated emissions control costs for lead, one of the toxic noncarcinogens.

Table 2 reports Tellus' estimate of the human health costs for emissions of hazards related to beverage container production that occur even when all operations and facilities are in regulatory compliance - i.e., for "controlled" emissions levels. The table shows costs for both virgin- and recycled-content production.

Glass and aluminum container emissions cost estimates are for production involving 100% virgin or 100% recycled raw materials. The latter is what is customarily meant by closed-loop recycling-- each new container is produced from a feedstock composed only of recycled containers and the new containers are said to have 100% recycled content.

Table 2
Estimated Public Health Costs from Releases of Hazards During Container Production

Container Material	Virgin Feedstocks	Recycled Feedstocks
	($/ton)	($/ton)
Glass	$70	$48
PET	331	NA
HDPE	128	NA
Aluminum	928	76
Steel	80	78
Weighted Average[8]	$88-95	$49[9]

Source: Zuckerman, Brian, and Ackerman, Frank, "The 1994 Update of the Tellus *Packaging Study* Impact Assessment Method," Tellus Institute, Table 2.

[7] Carcinogenic and toxic noncarcinogenics were categorized using US EPA's classification system.
[8] Weighted averages calculated on basis of both Tellus and Northbridge projections for types of containers recovered by the Updated Bottle Bill, as reported in Table 11 below. The Tellus and Northbridge projections assume different distribution of recovered container types, so both projections were used, resulting in weighted average ranges given in Table 2.
[9] Calculation of weighted average for recycled-content containers assumes that 100% recycled-content plastics products would have percentage reductions in emissions equivalent to percentage savings in energy use that are shown in Table 4.

The public health hazard cost estimates for emissions caused by steel container production are for 72% virgin, 28% recycled material feedstocks on the virgin side, versus 60% virgin, 40% recycled for the maximum recycled-content steel can. The limitation on virgin content is due to 20%-35% recycled steel being a technical requirement for steel making in the basic oxygen furnace. The limitation on recycled content to a 40% maximum is also a constraint of steel making in the basic oxygen furnace. The electric arc furnace can use 100% steel scrap feedstock, but cannot make steel with the properties required to make can sheet.[10] Thus, the environmental benefits from using recycled feedstocks in making steel products other than can sheet are substantially underestimated by the figures given in Table 2.

Tellus was unable to estimate emissions levels from recycled-content plastic container production because plastics recycling was a very new, infant industry at the time of their study. Publicly available data on energy and material requirements, and on environmental impacts of plastics recycling operations were virtually non-existent.[11]

The estimates in Table 2 indicate that each ton of containers captured by the UBB and used in manufacturing new products will yield a human health benefit of $39 to $46, given the distribution of container material types projected by Tellus and Northbridge in their UBB analyses.[12] This benefit, amounting to $0.01 per container targeted, provides one significant offset to projected costs for the UBB.

2. Direct Public Health Benefits of Reducing Disposal of Used Containers

- Recovering beverage containers through Massachusetts' Bottle Bill reduces hazards released during garbage collection and landfilling or incineration disposal, saving $1 - 2 in public health costs per ton recovered.

Tellus' Packaging Study also developed economic cost estimates for human health impacts resulting from environmental hazards released during collection and disposal of solid waste. Hazards included and their valuation methods were the same as applied to assess the environmental impacts of packaging material production. As shown in Table 3, each ton of beverage containers recovered under the UBB will yield a $1 to $2 benefit in reduced human health costs as a result of lower garbage collection quantities and less landfilling or incineration.

[10] Tellus, *op. cit.*, Volume II, "Inventory of Material and Energy Use and Air and Water Emissions from the Production of Packaging Materials," p. 5-10.
[11] *Ibid*, p. 13-1.
[12] See Table 11 in Chapter IV.

Table 3
Estimated Public Health Costs from Hazards Released During Used Containers Collection and Disposal

Container Material	Collection & Landfill Disposal	Collection & Incineration
	($/ton)	($/ton)
Glass	$< 0.50	$1
PET	3	4
HDPE	3	4
Aluminum	3	4
Steel	1	2
Weighted Average[13]	$1	$2

Source: Tellus *Packaging Study*, Report #4, "Impacts of Production and Disposal of Packaging Materials - Methods and Case Studies," Table 2.15, p. 2-27.

3. Direct Public Health Benefits of Reducing Litter

- ♦ Recovering beverage containers through Massachusetts' Bottle Bill reduces hospital emergency room visits resulting from cuts on broken glass bottle litter, saving $7 in public health costs per ton recovered.
- ♦ Other benefits from reduced litter likely are worth even more.

Increased recovery of used containers through the UBB will not only reduce landfilling and incineration, but also decrease the amount of litter and other illegal dumping that occurs in Massachusetts. According to the Massachusetts Department of Environmental Protection,

"The current Bottle Bill has effectively decreased litter along roadways and in public places and achieved an 85% recycling rate for the containers to which it applies. The proposed expanded Bottle Bill would achieve similar success for the additional containers it would cover....."[14]

Because so many of the containers targeted by the UBB are glass, the beneficial impact on public health from reduced litter has been estimated to amount to $400,000 annually just as a result of fewer hospital emergency room visits to deal with cuts from littered glass.[15] This benefit is worth $7 per net additional ton recovered by the UBB -- that is, after adjusting for containers recovered under the UBB that are already being collected by municipal recycling programs in Massachusetts.[16]

Other benefits from reducing litter have not been quantified in a way that is amenable to calculating a per ton value. However, they are probably of even greater importance given the popularity of Bottle Bills in many parts of the country. These

[13] Weighted averages calculated on basis of Tellus and Northbridge projections for types of containers recovered by the Updated Bottle Bill, as reported in Table 11.
[14] June 23, 1997 letter from Carl F. Dierker, Assistant Commissioner, Department of Environmental Protection. p. 2.
[15] Tellus Institute, "An Analysis of the Costs and Benefits of Expanding the Scope of the Bottle Bill in Massachusetts," prepared for Massachusetts Department of Environmental Protection, June 1997, p. 9.
[16] An estimated 20% of containers collected under the UBB are currently being recycled in Massachusetts.

include less litter on public beaches[17], fewer bicycle and other vehicle tire punctures from broken glass bottles on the roadways, less equipment and livestock damage and crop contamination from bottles thrown onto farmlands from passing vehicles[18], and improved aesthetics along our nation's highways.

B. What Are Other Environmental Benefits of Increased Bottle Recovery Worth?

Improved public health is not the only environmental benefit from recovering more used containers through the proposed UBB. Reduced use of virgin raw materials and decreased disposal and littering also reduce numerous other environmental impacts. This section covers those which have been sufficiently studied to provide quantitative estimates for their benefits as a result of reducing virgin materials use.

1. Benefits from Reducing Energy Use

- Recycling beverage containers into new products reduces energy otherwise used for virgin materials acquisition, processing, and product manufacturing by 40 - 50% on average for containers targeted by the UBB.

Acquiring raw materials from nature and transforming them into materials suitable for use in manufacturing containers requires intensive applications of energy. Substantially less energy is required to transform recycled containers into materials that can be used in manufacturing new containers, as well as other products.

Table 4 exhibits estimated energy requirements for containers produced from virgin versus recycled feedstocks. In the case of glass and aluminum, the estimates represent closed loop recycling. In the case of plastics and steel, recycled-content energy estimates are for non-container products manufactured from recycled plastic and steel containers, respectively. The latter comparison is given in the table because energy usage for closed loop recycling of plastic and steel containers is not available, mainly because few, if any, closed loop commercial operations exist.

At electricity prices of $0.02 to $0.04 per kilowatt hour, each ton of containers recovered through the UBB provides energy savings worth $16 to $45 in electricity purchases. This represents an energy savings of about $0.01 per container recovered and used as a manufacturing feedstock.

These energy savings are reflected in part in market prices for recycled materials, one of the economic benefits of increased container recovery that is discussed in the following chapter. That chapter also points out some of the subsidies that reduce energy prices and cause some of the energy benefits of recycling to be unrecovered through sales of recycled materials.

Table 4

[17] According to the Center for Marine Conservation's 1995 International Coastal Cleanup, beach cleanup in Texas, a non-bottle bill state, yielded 2,461 pounds of litter per mile of beach, while cleanup efforts in two bottle bill states, Maine and Michigan, yielded, respectively, just 152 and 35 pounds of litter per mile of beach.

[18] For a personal account see Ed Fielder' testimony before US Senate Committee on Commerce, Science, and Transportation, hearing to consider *Beverage Container and Recycling Act*, 5 Nov. 1981 (Y4.C73/7.97-83). For a quantified assessment see Daniel B. Taylor and John B. Hodges, "Impacts of Beverage Container Litter on Virginia Farms," *Virginia Agricultural Economics*, September-October 1985. These sources are cited and discussed in Ackerman, *Why Do We Recycle, op. cit.*

Estimated Energy Use in Container Production

Container Material	Virgin Feedstocks	Recycled Feedstocks
	(thousand Btu/ton)	(thousand Btu/ton)
Glass	13,500	10,700
PET	97,400	23,600
HDPE	73,000	9,100
Aluminum	229,000	8,300
Steel	21,700	2,700
Weighted Average[19]	20,000-23,500	11,400-11,900

Sources: Jeffrey Morris - Sound Resource Management, "Recycling versus incineration: an energy conservation analysis," *Journal of Hazardous Materials*, 47 (1996), Table 1, and Franklin Associates, Ltd., *The Role of Recycling in Integrated Solid Waste Management to the Year 2000*, prepared for Keep America Beautiful, Inc., September 1994, Table 6-8, p. 6-22.

However, given that the economic value of energy savings should be reflected in market prices and costs, energy use, strictly speaking, does not belong in this chapter's discussion of public health and environmental impacts that are external to market costs paid by virgin materials producers and manufacturing users. However, energy use is included in the widely cited environmental benefits of recycling given in Table 1 and is routinely included in environmental impact assessments. For these reasons energy use is discussed here, but its economic value is not added into any summary totals for the environmental benefits of increased beverage container recovery.

2. Benefits from Reducing Greenhouse Gas Emissions

- ♦ Recycling beverage containers into new products reduces greenhouse gases otherwise released from virgin materials acquisition, processing and product manufacturing, saving at least $3 in potential costs from global warming per ton of containers recovered.
- ♦ This $3 per ton cost estimate is based on using reforestation to sequester carbon. To the extent that greenhouse gas emissions are not controlled in some manner, actual public health and environmental cost from rising sea levels, diminished water resources, spread of infectious diseases and increased heat-related mortality could be substantially higher.

Reducing the amount of containers landfilled or incinerated in Massachusetts will provide a substantial environmental benefit by decreasing emissions of gases -- carbon dioxide, methane, carbon monoxide, nitrous oxide, nitrogen oxides and perfluorocarbons -- that contribute to global warming. Once again it is savings in the use of virgin raw materials in production that provide most of this benefit.

Table 5 reports emissions of greenhouse gases in pounds of carbon dioxide equivalents per ton for each type of container material for virgin- and recycled-content production, and for container disposal in landfills or waste-to-energy incinerators.

[19] Weighted averages calculated on basis of both Tellus and Northbridge projections for types of containers recovered by the Updated Bottle Bill, as reported in Table 11 below. The Tellus and Northbridge projections assume different distribution of recovered container types, so both projections were used, resulting in weighted average ranges given in Table 4.

Because it is so energy intensive, virgin aluminum production has the highest greenhouse gas releases for virgin production, followed by steel and plastics. Virgin glass is last with greenhouse gas emissions levels less than 10% of levels for virgin aluminum.

Table 5
Greenhouse Gas Emissions from Container Production and Disposal[20]

Container Material	Virgin Feedstocks	Recycled Feedstocks	Landfill Disposal	Incineration Disposal[21]
	(lbs CO_2/ton)	(lbs CO_2/ton)	(lbs CO_2/ton)	(lbs CO_2/ton)
Glass	2,112	1,838	6	33-52
PET	4,769	1,859	6	1,776
HDPE	2,910	1,172	6	1,776
Aluminum	22,270	2,910	6	33-52
Steel	4,526	2,142	6	33-52
Weighted Average[22]	2,406-2,459	1,813-1,831	6	150-261

Source: Emissions during production of glass containers from Proctor & Redfern Ltd and ORTECH International, *Estimation of the Effects of Various Municipal Waste Management Strategies on Greenhouse Gas Emissions*, prepared for Environment Canada, February 1994, Part II, Table 3.1, pp. 18-19; PET, HDPE aluminum and steel production emissions from US EPA, *Greenhouse Gas Emissions from Municipal Waste Management*, Draft Working Paper, prepared by ICF Incorporated, EPA Contract No. 68-W6-0029, March 1997, Exhibit 2-2, p. 33; and landfill and incineration emissions from Proctor & Redfern Ltd and ORTECH International, *op. cit*., Part II, Table 4.2, pp. 78-79.

Energy use is the major source of greenhouse gas emissions for container production. Thus, emissions from recycled content production are less than for virgin production, as one would anticipate based on energy consumption estimates given in Table 4. Emissions from disposal are smaller still. In terms of emissions from incineration, the amount of plastics projected for recovery under the UBB accounts for only between 6% and 12% of anticipated total recovery by weight. If plastic bottles continue to erode glass' market share in beverage bottling, then emissions savings from incineration avoidance under the UBB will become more significant.

Valuation of environmental costs for carbon dioxide emissions vary widely. The Cal-ifornia Energy Commission's control cost estimate of $8 per ton is one of the lower estimates.[23] It is used in this report to cost greenhouse gas emissions reported in Table 5. The Commission developed their estimate from reforestation costs incurred to grow enough trees to absorb a ton of carbon dioxide each year. Reforestation is one means of offsetting the global warming caused by greenhouse gas releases during production and disposal of beverage containers.[24]

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[20] Emissions of all greenhouse gases have been converted to carbon dioxide equivalents.
[21] Includes offsetting credit for electrical energy generated from incineration.
[22] Weighted averages calculated on basis of both Tellus and Northbridge projections for types of containers recovered by the Updated Bottle Bill, as reported in Table 11. The Tellus and Northbridge projections assume different distribution of recovered container types, so both projections were used, resulting in weighted average ranges given in Table 5.
[23] See Pearce, D., "An economic approach to saving the tropical forests," in D. Helm (ed.), *Economic policy toward the environment*, Blackwell, Oxford, 1991, pp. 239-262, for an argument that a value of $13 per ton for sequestering carbon is a conservative estimate based only on its value in reducing coastal damage from sea level rise.
[24] California Energy Commission, Committee Order for Final Policy Analysis, Docket No. 88-ER-8, March 27, 1990, as reported in the Tellus *Packaging Study*, Report #4, "Impacts of Production and Disposal of Packaging Materials - Methods and Case Studies," p. 1-5.

Using $8 per ton as the control cost for carbon dioxide emissions, the UBB will accrue an environmental benefit in reduced greenhouse gas releases of about $3 per ton for each additional ton recovered. To the extent that greenhouse gas emissions are not controlled in some manner, actual public health and environmental costs from rising sea levels, diminished water resources, spread of infectious diseases and increased heat-related mortality could be substantially higher. Also, if plastic or metal containers eventually account for a larger portion of bottles and cans recovered under the UBB than estimated by Tellus and Northbridge, the greenhouse gas reduction benefit of the Updated Bottle Bill could be greater. Glass bottles are projected to make up 85 to 90% by weight, and 40 to 50% by number, of recovered containers. Unlike metals and plastics, recycling glass into new containers requires almost as much energy to remelt recycled glass as is required to melt sand and other virgin raw materials into glass in the first place.

3. Benefits from Reducing Ecosystem Impacts

- Ecosystems provide support for human welfare that are mostly not counted in current prices for materials and services. These ecosystem benefits are estimated to be worth about twice as much as all goods and services produced each year. Virgin materials used in container production often cause substantial impairments to ecosystems. As a result, recycling more containers likely provides substantial benefits that have not as yet been traced to specific virgin container feedstocks.

Earlier this year the results of a major study on the value of the world's ecosystems were published in Nature magazine.[25] This study represents one of the very few systematic attempts to estimate an economic value for all the goods (such as food and raw materials) and services (such as waste assimilation, gas regulation, habitat and recreation) provided by Earth's biomes -- i.e., Earth's major ecological community types (such as coastal estuaries, wetlands, grasslands, and deserts).

The conclusion of the work, as summarized by the authors, is,

"The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range US$ 16 - 54 trillion (10^{12}) per year, with an average of US$33 trillion per year. Because of the nature of the uncertainties, this must be considered a minimum estimate. Global gross national product total is around US$18 trillion per year."[26]

This $33 trillion value for nature is not easily applied to estimating the value of environmental benefits from Massachusetts' proposed UBB. However, to the extent that virgin material and energy resource exploration, extraction, and processing impair or

[25] Costanza, *et al*, "The value of the world's ecosystems services and natural capital," *Nature*, Vol. 387, May 15, 1997, pp. 253-260.
[26] *Ibid*, p. 253.

destroy the functions of ecosystems, $33 trillion is indicative of how high the real costs of virgin materials use may be.

The estimates given in Section A for the value of environmental benefits from the UBB were all calculated from studies of human health impacts. The Costanza study reveals that these sorts of direct human health costs, which are reflected in expenditures on health care, are likely to be dwarfed by impacts on ecosystem functions as a result of the use of virgin materials and fuels in beverage container production and disposal. Cost of these ecosystem impacts, the Costanza study authors argue, are hardly captured at all in current product and service prices.

Expenditures for clean up at abandoned mine sites[27], remediation of old dumps, containment and clean up of oil spills, and other attempts to mitigate or repair ecosystems damage caused by our use of virgin material and energy resources provide concrete examples of the value of ecosystems and what we have to pay to maintain them. Until they are damaged, the role of ecosystems in supporting human activities often goes unnoticed.

Furthermore, when ecosystems are damaged, clean up and mitigation costs often are borne by taxpayers and, thus, not directly included in prices we pay for materials, fuels and electrical power. As will be discussed in Chapter III, virgin materials prices set an upper bound on prices for recovered materials. Anytime that an environmental cost of virgin materials acquisition and processing is not charged directly to virgin material producers, the probable result is that a virgin material's price is lower than it would otherwise be. In turn this means lower prices paid by manufacturers to buy recovered materials for use in making recycled-content products. Thus, ecosystem services that the virgin producer uses free of charge and clean up costs that are funded by government programs impair the financial viability of waste material recovery, whether through curbside recycling or bottle deposit systems.

Finally, the Costanza study did not include non-renewable fuels and minerals and the atmosphere in calculating nature's value. Because future generations' needs and wants are not reflected in current market prices for non-renewables, one can plausibly argue that current prices for such commodities as petroleum, bauxite, and iron ore are too low because current markets are not available to all those who want to use those resources, whether now or at some future time. As a result, current use of non-renewables would be too high, and they might be used up too soon from the point of view of those generations having to live with the consequences of non-renewables exhaustion.

On the other hand, one can also posit a future which no longer needs certain non-renewable resources. For example, a solar energy based society that produces plastics from carbohydrates instead of oil and natural gas. Or a future which has discovered a synthetic substitute for some other non-renewable. In that case the non-renewable's current price might be judged to be too low if the associated rate of use results in some of the resource being conserved even after it is no longer necessary for society's well being.[28]

[27] Estimated by Mineral Policy Center in its recent publication *Golden Dreams, Poisoned Streams* to total $32 - $72 billion in taxpayer absorbed costs for 557,000 abandoned mine sites in just the US alone.

[28] See P.S. Dasgupta and G.M. Heal, *Economic Theory and Exhaustible Resources*, London: Cambridge University Press, 1979, for an economist's perspective on the complexity of this issue.

Because of the negative impacts on habitats and ecosystems from exploration and extraction of non-renewable virgin fuels and metal minerals, one can make a strong case for virgin prices being too low regardless of whether current prices eventually result in depletion that is too early or too late from the point of view of future generations. In addition, higher virgin materials prices would reduce current consumption of virgin resources, and intensify the search for, and use of, alternative energy sources and synthetic substitutes. As a result, environmental impacts of virgin fuels and materials use would be reduced for generations currently alive, and additional future generations would get more choice in whether they do or don't need the non-renewables that might otherwise have been exhausted.

C. Not-Yet-Quantified Environmental Benefits of Increased Bottle Recovery

Data presented thus far cover several of the environmental benefits from expanded beverage container recovery. However, numerous potential benefits have not been addressed because they have as yet not been adequately studied and quantified. Omissions include:

- Direct human health impacts from releases of currently unregulated substances or substances that have been overlooked in available studies[29];
- Human health and other environmental impacts from currently unregulated on-site disposal or impoundment of a wide variety of processing and manufacturing wastes; and
- Valuation of the ecosystem impairment directly caused by virgin beverage container materials exploration and harvesting

A few examples are provided to indicate the probable enormity of these potential benefits from increased beverage container recovery.[30]

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[29] For example, Frank Ackerman has pointed out to me that the Tellus *Packaging Study* did not address emissions of the carcinogen friable asbestos in their study. In his review of a draft of this report, Dr. Ackerman reported to me that Chem Systems, Inc. prepared a report in March 1992 for the Vinyl Institute, "Vinyl Products Lifecycle Assessment," that shows in Figure VI.A.1 significant levels of asbestos emissions for PVC container production.

[30] As an indication of how unaware we may be of the threats posed by chemical substances in common use, the interested reader is urged to review the Flashback photograph and explanation in *National Geographic*, Vol. 189, No. 2, February 1996, p. 132. The picture shows DDT being sprayed indiscriminately over beach and beachgoers in 1945 as part of a mosquito-control program at New York's Jones Beach State Park. DDT once was hailed as a miracle product and the picture first published in the October 1945 *Geographic* article "Your New World of Tomorrow."

1. Chemical Substances Used in the US

- About 70,000 chemical substances are used in commerce.
- Far less than 10% of all chemical substances used in commerce have been tested to determine whether they pose a public health or other environmental hazard when released into air or water or onto land.
- Cost estimates reported in Tables 2 and 3 for public health impacts from virgin container production and disposal are based on evaluation of releases of less than 200 chemical substances.

A 1987 review by the Conservation Foundation[31] revealed that the Toxic Substances Control Act (TSCA) inventory listed over 63,000 chemical substances used commercially since 1975, with nearly 1,500 additions to the inventory occurring each year. Some of these substances are not toxic under normal usage - e.g., that inventory even included water because people can drown in it.

In 1992 the National Research Council reported that,

"About 70,000 chemicals are used in commerce, of which several hundred are known to be neurotoxicants. However, except for pharmaceuticals, less than 10% of all chemicals in commerce have been tested at all for neurotoxicity, and only a handful have been evaluated thoroughly."[32]

The Toxics Release Inventory provisions of the Emergency Planning and Community Right to Know Act of 1986 require certain industrial facilities to annually disclose large releases to air, land and water for a list of some 654 chemicals. In 1995 EPA added 280 more chemical substances to the required reporting list. In addition, seven non-manufacturing industries --metal mines, coal processors, waste disposal, solvent recyclers, oil- and coal-fired utilities, chemical wholesalers and petroleum bulk storage -- are required to report annual releases starting with 1998.

The estimates for human health impacts from virgin container production that have been discussed in this report cover less than 200 chemical substances. These relatively few chemical substances may be the only ones that cause significant impacts during the production of beverage containers, but this supposition remains unproven until releases from all chemicals are measured and evaluated.[33]

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[31] The Conservation Foundation, *State of the Environment: A View toward the Nineties*, Washington, DC, 1987.
[32] National Research Council, *Environmental Neurotoxicology*, National Academy Press, 1992, p. 2.
[33] See footnote 29 for an example of an important carcinogen that was not included in the list of almost 200 chemical substances covered in the Tellus *Packaging Study*.

2. On-site Storage and Disposal of Industrial Wastes

- Solid waste disposed or stored on-site at industrial facilities is many times greater than all the municipal solid waste disposed in regulated landfills and incinerators.
- Cost estimates reported in Table 2 for public health impacts from virgin container production do not include any evaluation of the hazards from releases of solid wastes.
- Low- and high-level radioactive wastes stored at nuclear energy facilities are included in the list of solid (as well as liquid) wastes whose cost impacts have not been addressed by studies on the hazards posed by energy-intensive virgin materials production.

Sound Resource Management participated on the consultant team that conducted Washington State's Future of Recycling Study in 1996.[34] One of the topics addressed in that study was the current status of recycling and disposal of industrial wastes that are not managed within the municipal solid waste (MSW) system. The study determined that an estimated 2.5 million tons of non-MSW material was disposed in off-site landfills in 1994, including demolition debris, industrial wastes, inert materials, petroleum contaminated soils, wood, sludge, and asbestos. No reliable data could be found on the status of recycling for these materials.[35]

On-site storage and disposal of industrial waste probably far exceeds the amount of waste disposed off-site. One source indicates that a 1987 US EPA screening survey found significant on-site disposal quantities in the state of Washington totaling an estimated 43.7 million tons, including 6.8 at primary iron and steel manufacturers, 6.1 million tons at petroleum refineries, 0.4 at stone, clay, glass and concrete manufacturers, and 0.3 million tons at primary nonferrous metals manufacturers.[36] If this estimate is accurate, solid waste managed on-site at industrial facilities is ten times greater than all of Washington state municipal solid waste disposed at landfills and incinerators.

EPA's assessment of relative levels of heavy metals or organics by major industry grouping indicated high potential risk from on-site disposal in primary ferrous and nonferrous metals (heavy metals in wastes), organic chemicals (many waste streams contain high levels of toxic organic chemicals, and small quantity generators may dispose of hazardous wastes on-site), plastics and resins manufacturing (many wastes contain organic solvents and unreacted monomers which are frequently toxic), and rubber and miscellaneous products (possibly significant levels of elastomers, carbon black, plastic resins, plasticizers, and pigments) industries. Stone, clay, glass and concrete manufacturing was assessed to have low risk because most wastes are inert, earth type materials. The stated exception for this industry was that significant quantities of pollution control sludges are generated, possibly containing heavy metals.[37]

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[34] The Future of Recycling Task Force (chaired by William Ruckelshaus, Chairman, Browning-Ferris Industries), with staff support by Cascadia Consulting Group, Gulick Environmental Consulting, Sound Resource Management Group, and Cedar River Associates, *Washington State "Future of Recycling" Study: Final Report to the Governor of the State of Washington*, November 1996.
[35] Ibid, Volume I, p. 23 and Figure IV-5.
[36] Synergic Resources Corporation, GBB, and Booz-Allen & Hamilton, Inc., *Industrial Solid Waste Survey, Task 2: Industrial Wastes of Concern in Washington*, February 25, 1993, Table 4 on p. IV-8.
[37] US Congress Office of Technology Assessment, "Managing Industrial Solid Wastes," February 1992, as cited in Synergic Resources Corporation, *et al*, *op. cit*., Table 5 on p. !V-10.

The lack of information on industrial solid wastes caused Tellus Institute to exclude an assessment of solid waste emissions from their *Packaging Study*. Yet the EPA risk rankings indicate that virgin container manufacture may result in significant public health hazards from solid wastes managed on-site.

Furthermore, virgin beverage container production is energy intensive. Any comprehensive assessment of the environmental costs of container production should include impacts from low- and high-level radioactive wastes stored on-site at nuclear power plants, as well as public health and environmental costs associated with their eventual storage and/or disposal.

D. Summary of Quantified Environmental Benefits of Increased Bottle Recovery

- ♦ Our use of virgin raw materials and fuels releases harmful pollutants, impairs human health, destroys habitat, diminishes productivity in natural resource industries, impairs ecosystems, and diminishes our enjoyment of previously pristine places.
- ♦ Use of virgin materials and fuels can be substantially reduced by recovering materials from our wastes and using them to replace virgin materials in manufacturing products.
- ♦ Massachusetts' updated Bottle Bill (UBB) will recover and recycle significant amounts of beverage containers.
- ♦ Public health benefits from reduced use of virgin raw materials and fuels, decreased litter and less waste are worth $50 or more for every ton of UBB containers.
- ♦ Other environmental benefits of UBB recovery almost certainly are worth even more than $50 per ton on recovered beverage containers.

Table 6 summarizes the economic value of environmental benefits from increased bottle recovery -- the result of decreased use of virgin materials in production, as well decreased littering and disposal of used containers. Table 6 does not show the value of energy saved through less use of virgin materials. This value is, in part, reflected in market prices for recovered materials, and is included in economic benefits of the UBB which are enumerated in the following chapter.

Because many environmental impacts of virgin materials exploration, acquisition and processing are not reflected in UBB benefits shown in Table 6, these figures almost certainly underestimate full environmental value from increased bottle recovery. That is, Massachusetts' proposed UBB will yield environmental benefits worth at least between $50 and $60 per additional ton of bottles and cans returned for deposit.

Table 6
Summary of Quantified Environmental Benefits from Increased Bottle Recovery

Container Material	Lower Hazards Emissions	Lower Green-house Emissions[38]	Less Litter	Total Benefit
	($/ton)	($/ton)	($/ton)	($/ton)
Glass	$23	$1	$8	$32
PET	255	15	-	270
HDPE	116	11	-	127
Aluminum	855	78	-	933
Steel	3	10	-	13
Weighted Average[39]	$40-48	$3	$7	$50-58

[38] Costs for greenhouse gas emissions reflect 47% landfill and 53% incineration disposal of used containers. This estimate for relative disposal quantities is reported for Massachusetts facilities in Chartwell Information Publishers, Inc., *Solid Waste Digest*, September 1997, Solid Waste Price Index Table, pp. v-vi.

[39] Weighted averages calculated on basis of both Tellus and Northbridge projections for types of containers recovered by the Updated Bottle Bill, as reported in Table 11 below. The Tellus and Northbridge projections assume different distribution of recovered container types, so both projections were used, resulting in weighted average ranges given in Table 6.

III. Economic Benefits of Increased Bottle Recovery

Direct economics benefits from increased bottle recovery include revenues earned from selling recovered containers on recycled commodity markets, savings in garbage collection and disposal expenditures, savings in litter control costs, and new jobs processing and marketing recovered containers, as well as new manufacturing jobs in businesses that make recycled-content products. Offsetting these direct benefits would be job and income losses in garbage collection and disposal, as well as in virgin materials manufacturing.

Indirect benefits include additional income and jobs created via the multiplier or ripple effects from recovered container sales revenue and net job and income creation.

A. Direct Economic Benefits

1. Recovered Materials Sales Revenue

- Recovering beverage containers through the proposed UBB will yield almost $50 of revenue from selling each ton recycled.
- Subsidies to virgin materials and fuels producers and users cause recycling revenues to be lower than they would be in the absence of virgin subsidies.

Revenues from selling materials collected through Massachusetts' proposed UBB will provide significant direct economic benefit. Table 7 shows average prices per ton during 1992 through 1996 for recovered container materials processed and sold by the Springfield material recovery facility (MRF). Recycled containers processed at the Springfield MRF are collected primarily through residential curbside programs. The table also shows price projections for the five years through 2001.

Because Bottle Bill commodities typically are better sorted and less contaminated with refuse material, they often command a price premium over curbside recyclables. As a result, the prices shown in Table 7 probably underestimate revenue from UBB materials. UBB revenues will likely average more than $50 per ton, based on Springfield MRF prices during the past five years, projected prices for the next five years, and the estimated mix of containers types that will be recovered under the proposed UBB.[40]

Projected recycled container prices shown in Table 7 are based on Sound Resource Management's analysis of market trends. As indicated, the weighted average price for recycled cans and bottles over the next five years is not expected to be significantly different than it was in the last five. There are many reasons for this forecast, some of which are related to the fact that prices for virgin materials set an upper bound on prices for recovered materials.

[40] Also worthy of note with reference to the prices in Table 7 is that collection and processing of glass for the typical three-bin curbside program result in as much as 50% of collected glass bottles being broken and not separable by color. The glass price shown in Table 7 is a weighted average price for color separated glass, based on a distribution of 50% clear, 30% brown and 20% green. Clear glass usually sells for more than brown, with green glass having a much lower price than either clear or brown. Mixed color glass has little or no market value. Because of breakage and color mixing of glass in curbside collection, the glass price shown in Table 7 would be a substantial overestimate for curbside collection, unless additional on-route time is spent color sorting glass containers at the curb and loading the sorted material into separate compartments on the collection truck.

Table 7
Historical and Projected Material Sales Revenues

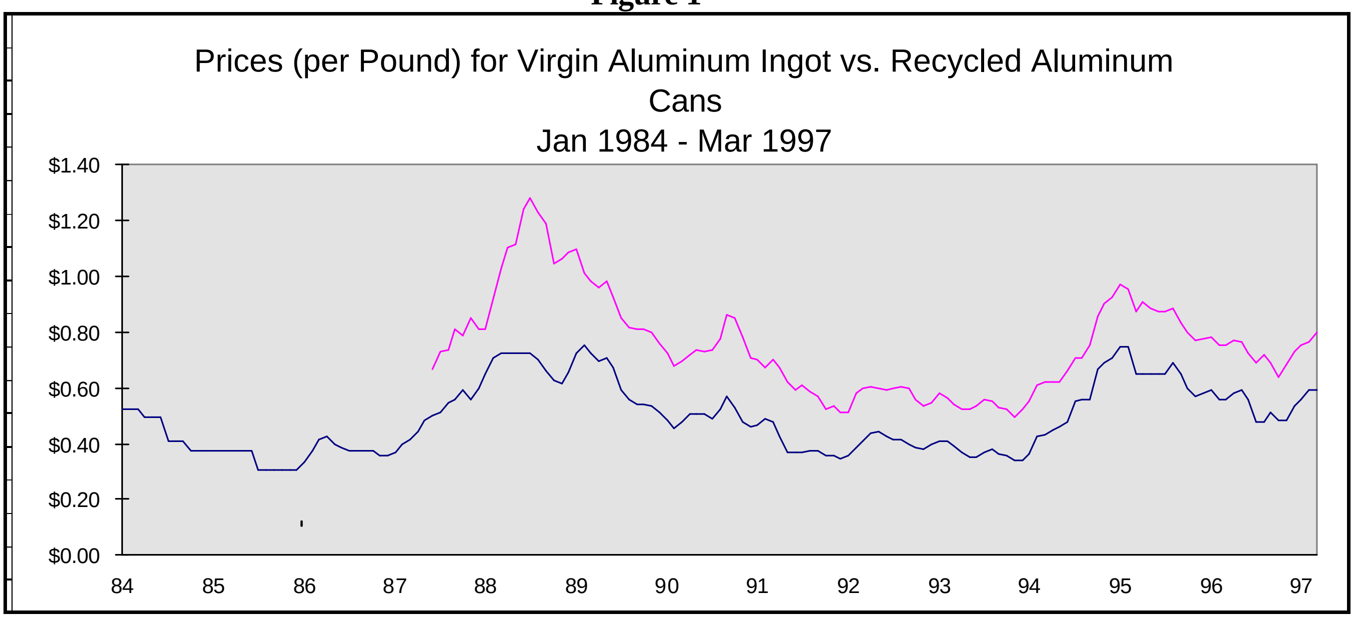
Container Material	1992-96 Average	1997-2001 Projected
	($/ton)	($/ton)
Glass	$30	$30
PET	208	149
HDPE	188	205
Aluminum	864	926
Steel	40	55
Weighted Average[41]	$47-55	$46-52

Source: Massachusetts Department of Environmental Protection Springfield MRF Commodity Prices, Monthly Data for January 1992 through December 1996. 1997 -2001 price projections from Sound Resource Management.

Figure 1 shows the relationship between virgin and recycled aluminum prices in the US over the past ten years. Except for a period during 1988-89 when virgin aluminum was in very short supply and can sheet producers wanted to keep recycled can prices from rising, recycled aluminum prices have followed fluctuations in virgin prices. The price differential between virgin and recycled tends to remain within a relatively narrow band that reflects the cost of converting recycled cans into a feedstock that competes with virgin in new can manufacture.

Similar relationships hold between virgin and recycled plastic pellets prices, and between recycled glass and tin cans and the basic virgin ores used to manufacture, respectively, glass and steel. For example, glassmaking sand prices exert a significant influence on prices for recycled container glass.

Figure 1



Source: *American Metal Market*, various daily issues for the period covered in Figure 1.

[41] Weighted averages calculated on basis of both Tellus and Northbridge projections for types of containers recovered by the Updated Bottle Bill, as reported in Table 11 below. The Tellus and Northbridge projections assume different distribution of recovered container types, so both projections were used, resulting in weighted average ranges given in Table 7.

It is not the purpose of this report to provide an analysis of price movements for virgin versus recycled feedstocks. However, Chapter II discussed, and to a limited extent quantified, some of the public health and environmental costs incurred in exploration, extraction and processing of virgin materials. That discussion noted that many of these public health and environmental costs are not directly charged to producers and users of virgin materials. For this reason virgin material prices likely are lower than they would be if all public health and environmental costs related to virgin materials use were charged to virgin material producers and users.

In addition, in the past and to a somewhat reduced extent in the present, federal regulations and tax policies have provided exemptions and subsidies that offset costs for virgin materials.[42] For example, the 1872 Mining Law provides below market sales and leases of federal lands for mining. According to the Mineral Policy Center, mining companies have purchased lands containing $15 billion worth of minerals for only $23,601 since 1994.

Mining wastes, as well as oil and gas extraction wastes, also are exempt from federal hazardous waste regulations, making it possible to dispose of these materials on site at little or no cost.[43] As indicated in Chapter II, wastes disposed on site at abandoned mines are estimated to require a multi-billion dollar clean up effort that will be paid by taxpayers, not virgin metals producers and users.[44]

Continuing federal energy subsidies also contribute to lower prices for virgin materials and fuels. One study of federal energy subsidies to virgin aluminum producers estimated that these subsidies amounted to between 5 and 13% of primary aluminum prices in 1989.[45] If virgin ingot prices were to be increased to cover this subsidy and recycled aluminum prices followed, prices for recycled aluminum cans would be $80 to $210 higher than the averages shown in Table 7.

The quantitative impact on virgin prices from the sum total of federal subsidies has not been examined to any very great extent. Studies that have been done tend to measure potential price impacts as a function of the percent of total costs represented by subsidies. This methodology overlooks the equally important impact of subsidies on profits and resultant industry growth.[46] In addition, the nature and extent of state and local or foreign government subsidies has not been investigated at all. Since most virgin commodities trade on international markets, foreign subsidies also are an important factor in low virgin material prices.

Suffice it to note for this report that governmental subsidies and regulatory exemptions of all kinds, as well as externalized public health and environmental costs, contribute significant unearned benefits to virgin materials producers and users, and uncompensated costs to the public and the environment. A corollary result is prices for

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[42] See, for example, US Environmental Protection Agency, *Federal Disincentives: A Study of Federal Tax Subsidies and Other programs Affecting Virgin Industries and Recycling*, EPA 230-R-94-005, August 1994; or, Roland Hwang, “Money Down the Pipeline: Uncovering the Hidden Subsidies to the Oil Industry,” prepared for the Union of Concerned Scientists, September 12, 1995.

[43] See 40 CFR 261.4(b)(5) and (7).

[44] See footnote 27.

[45] Douglas Koplow, “Federal energy subsidies and recycling: A case study,” Resource Recycling, November 1994, Table 1, p. 30.

[46] See US EPA, *Federal Disincentives....., op. cit.* Profits often amount to less than 10% of costs or revenues. Therefore, a “small” impact on costs would have at least a ten times greater impact on profits.

virgin materials that most likely are substantially lower than they would be in the absence of these unearned benefits.

This is significant for evaluating waste material recovery programs such as the proposed UBB, because it means that revenues from selling recovered materials will be much lower than they would be in the absence of subsidies. Net costs of the recovery program, thus, will appear higher than they should, which may lead to unwarranted rejection of a program that is beneficial from a society-wide point of view.

2. Decreased Litter Control and Garbage Collection & Disposal Costs

- Recovering beverage containers through the proposed UBB will yield a $78 to $111 reduction in garbage and litter management costs for each ton recycled.

A second major dollar benefit from increased recovery of otherwise wasted materials arises from decreased garbage collection, transfer and disposal costs. When increased recovery is the result of bottle deposit laws, expenditures on litter control also go down. Table 8 provides estimates of these savings for each additional ton recovered from Massachusetts' wastes if the proposed UBB is enacted into law.

Garbage disposal cost savings of $59 per ton represent fees avoided on average at landfills and incinerators. Litter control cost savings are estimated to be $6 per additional ton of bottles captured under the UBB. Garbage collection costs will decrease between $13 and $46 per ton, depending on the responsiveness of garbage collection systems to the decreased tonnage.

If there is little change in garbage collection routes, trucks and collection frequency, then savings will be only about $13 per ton. On the other hand, garbage collection routes can be redesigned and trips to the transfer station or disposal facility decreased as a result of hauling around fewer containers and reducing the significant truck space occupied by air inside of those bottles and cans collected in household and business refuse. In that case, after a sufficient amount of time has passed to allow new routes, and perhaps new trucks, to be put in place, collection cost savings could amount to as much as $46 per ton.

In total, waste management costs are estimated to decrease between $78 and $111 for every additional ton recovered under the UBB. This estimate does not include reduced transfer station costs. We did not have sufficient research time and resources to investigate the percent of trash in Massachusetts that flows through a transfer station first before being sent to an in-state disposal facility. This omission means that Table 8 probably underestimates waste management cost savings.

The calculation of savings given in Table 8 also does not address containers already being recycled through curbside collection. As will be discussed later in this report, to the extent that curbside collection of containers has costs that are similar to recovery costs under the UBB, transfer of material from curbside to UBB would have little impact on overall waste handling costs.

Table 8
Decreased Waste Management Costs from Increased Bottle Recovery

Container Material	Garbage Collection Cost Savings[47]	Garbage Disposal Cost Savings	Litter Control Cost Savings	Overall Waste Management Cost Savings
	($/ton)	($/ton)	($/ton)	($/ton)
Glass	$10-30	$59	$6	$75-95
PET	52-155	59	6	117-220
HDPE	49-148	59	6	114-213
Aluminum	50-151	59	6	115-216
Steel	34-103	59	6	99-168
Weighted Average[48]	$13-46	$59	$6	$78-111

Sources: *Solid Waste Digest*, *op. cit.*, for disposal cost savings, and Tellus UBB Analysis, *op. cit.*, p. 12 for litter control cost savings. Garbage collection cost savings are based on survey costs for garbage collection in Barbara Stevens, "Recycling collection costs by the numbers: a national survey," *Resource Recycling*, September 1994, Table 4, P.60; and, Sound Resource Management Group, *The Economics of Recycling and Recycled Materials*, prepared for the Clean Washington Center, June 30, 1993, Tables A-5 and A-6, pp. 29-30. The latter source also provided weight to volume conversion factors.

3. Increased Jobs

♦ Recovering beverage containers through the proposed UBB will result in between 88 and 92 new recycled-content manufacturing jobs in Massachusetts, after accounting for job losses in virgin materials based glass manufacturing as well as garbage disposal facilities.

According to a 1994 study by the engineering firm Roy F. Weston, Inc., Massachusetts had over 8,000 jobs in recycling processing and manufacturing industries, including 285 in glass and 1,118 in plastic manufacturing, as well as 785 jobs processing recovered plastics and metals.[49] Recovery of waste materials, thus, has already created a substantial employment base in the state. With estimated net new recovery of 59,000 tons if the proposed UBB is implemented, one would expect recycling-related employment opportunities to expand.

[47] Overall costs per ton for garbage collection from Dr. Steven's study were converted to material specific costs based on relative densities for the various container materials. The amount of garbage truck space occupied by each ton of a material was assumed to correlate with each material's relative collection cost. The collection cost savings range shown for each material reflect short-run versus long-run cost savings. The lower figure is short run savings based on the conservative assumption that 33% of collection costs varying directly with number of tons collected. (The City of Seattle's residential refuse collection contracts provide for 50% of cost varying directly with tons collected.) The higher figure is average cost and includes relatively fixed overhead and equipment amortization costs. In the long run, garbage cost savings per ton diverted should approach average cost as routes are optimized and trucks reconfigured as a result of reduced garbage volumes.

[48] Weighted averages calculated on basis of both Tellus and Northbridge projections for types of containers recovered by the Updated Bottle Bill, as reported in Table 11 below. The Tellus and Northbridge projections assume different distribution of recovered container types, so both projections were used, resulting in weighted average ranges given in Table 8.

[49] Roy F. Weston, Inc., "Value Added to Recyclable Materials in the Northeast," prepared for the Northeast Recycling Council of the Council of State Governments, May 8, 1994, Table 1-1, p. 4.

The first column in Table 9 shows 235 projected new jobs as a result of the recovery of additional containers through the UBB, with most of those occurring in glass manufacturing because 85% to 90% of the newly targeted materials are glass bottles. In addition, one would expect significant new jobs in processing and manufacturing recovered plastic bottles into a wide variety of plastic products. These material specific job estimates are based on survey research by the Institute for Local Self-Reliance covering about 80 processors and recycled-content manufacturers of paper, plastic, metal and glass products.

Interestingly, a corroborating estimate for jobs impact is provided in a report by R.W. Beck for the Arizona Department of Commerce. That report estimates creation of 4.1 new jobs in recyclables processing and recycled-content manufacturing for every 1,000 additional tons recovered, without regard to type of recycled waste material.[50] The UBB is expected to recover an additional 59,000 tons, after adjusting for containers already being recycled. This would yield 242 new jobs.

Table 9
Potential Employment Impacts from Increased Bottle Recovery (Net of Recycling Decrease)

Container Material	Job Gains in Processing & Recycled-Content Manufacturing	Job Losses in Virgin Materials Mining & Virgin-Content Manufacturing[51]	Job Losses in Garbage Transfer and Disposal Operations	Net Employment Gain or (Loss)
Glass	146	134-138	8	0-4
PET	50	0	<1	50
HDPE	37	0	<1	37
Aluminum	1	0	<1	0-1
Steel	1	0	<1	0-1
Total	235	134-138	9	88-92

Sources: Brenda Platt, Institute for Local Self Reliance, Washington, DC, 1997 for estimated job gains in processing and manufacturing, and job losses in garbage transfer and disposal; Michael James Shore, "The Impact of Recycling on Jobs in North Carolina," Masters Thesis for MS in Environmental Science and Engineering, 1994, p. 45, for possible job losses in glass sand mining.

Reductions in employment in virgin materials acquisition, virgin-content manufacturing, and garbage are also a likely result of increased container recovery. Job losses in garbage collection, as well as losses due to transfer of some recovery from current curbside programs to the UBB collection network, will be offset by increased employment in handling the new deposit material. The data in Table 9, thus, only show estimated job losses in virgin materials acquisition and manufacturing, and decreased jobs in garbage transfer and disposal. This is consistent with this report's purpose of outlining environmental and economic benefits from increased container recovery through the proposed UBB. One of the costs to be weighed against these benefits is the cost of additional jobs created to handle increased container redemptions.

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[50] Arizona Department of Commerce, "Arizona Recycling Market Development Study: Economic Impact of Recycling in Arizona," prepared by R.W. Beck, December 1996, p. 5.

[51] Lower estimates for virgin job losses correspond to case in which glass sand mining occurs outside of Massachusetts. According to Roy F. Weston, *op. cit.*, Table 1-1, p. 4, Massachusetts in 1994 had substantial employment in both glass and plastic recycled-content production.

We did not have the resources to investigate current employment in virgin materials handling and manufacturing in Massachusetts. For this reason, estimates of virgin job losses shown in Table 9 should be considered very preliminary. However, in the case of glass manufacturing which already occurs in Massachusetts we can be reasonably sure that recycling will substitute almost on a 1 to 1 basis for virgin, because recycled glass and glass-making sand are very close substitutes.

As can be seen from the data in Table 9, the UBB could result in the creation of about 90 new jobs in Massachusetts. This is mainly due to the fact the recycled plastics processing and manufacturing is quite labor intensive, whereas virgin plastic container production is much less labor intensive. Massachusetts already has an extensive network of recycled plastic processors and end users. For this reason, plastic containers recovered through the UBB should generate new jobs for the state, even if virgin plastic bottle manufacturing is occurring in Massachusetts.

B. Indirect Economic Benefits

- ♦ Recovering beverage containers through the proposed UBB will result in net new employment opportunities worth between $39 and $140 for each ton recycled.

A recent study for the ReCycle Iowa Program (a joint venture of the Iowa Department of Natural resources and the Iowa Department of Economic Development) attempted to measure the jobs and income impact of recycling activities in Iowa.[52] Although that study did not estimate job losses in virgin material acquisition and manufacturing, it did estimate a jobs multiplier -- the indirect effect on jobs in other intermediate commodities industries and the induced effect on jobs in consumption products industries from increased jobs in recycling industries. The study found that for every job created as a result of recovering additional previously-wasted materials, another job is created in the non-recycling-related portion of Iowa’s economy. A similar multiplier effect was estimated for income flows.

Applying the multiplier to jobs created as a result of UBB material recovery indicates that as many as 184 new jobs could result from the UBB. Again the reader is cautioned to bear in mind that concrete information on current virgin material jobs in Massachusetts should be gathered before reaching any final conclusions. However, it is fair to say that the UBB will undoubtedly produce new jobs in Massachusetts beyond those needed to handle more containers through the redemption system.

[52] R.W.Beck, Ames Economic Associates, and Andrew Reamer and Associates, *Economic Impacts of Recycling Study, prepared for ReCycle Iowa Program*, 1997.

Assuming that these new jobs provide annual incomes between $20,000 and $30,000, Table 10 shows additional income for each ton of material recovered under the proposed UBB. Separate estimates are shown for net new processing / manufacturing jobs directly related to recovering additional containers and for jobs indirectly created in non-recycling-related industries. As indicated in Table 10, recovering more containers will create net new employment opportunities worth Between $39 and $140 for each ton recycled.

Table 10
Value of Additional Employment from Increased Bottle Recovery

Container Material	Direct Jobs Income	Induced Jobs Income[53]
	($/ton)	($/ton)
Glass	$0-2	$0-2
PET	375-562	188-562
HDPE	370-555	185-555
Aluminum	52-78	26-78
Steel	31-47	16-47
Weighted Average[54]	$26-70	$13-70

[53] The lower numbers represent indirect jobs induced at only half the rate estimated in the Recycle Iowa study, i.e., one induced job for every two net new recycling-related jobs instead of one for one. This is to account for the possibility that a larger state like Iowa might capture a larger percentage of its own indirect employment effects than would a small state like Massachusetts that is more integrated into the economies of surrounding states.

[54] Weighted averages calculated on basis of both Tellus and Northbridge projections for types of containers recovered by the Updated Bottle Bill, as reported in Table 11 below. The Tellus and Northbridge projections assume different distribution of recovered container types, so both projections were used, resulting in weighted average ranges given in Table 7.

IV. Costs of Alternative Methods for Increased Bottle Recovery

- ♦ Recovering beverage containers through the proposed UBB will increase Massachusetts' recycling rate by almost one percentage point.
- ♦ Existing recycling systems are estimated to recover only 20% as much as would be captured under the UBB.
- ♦ Nationally, existing curbside recycling of UBB targeted beverage containers is estimated to cost between $175 and $386 per ton recycled, with evidence from one major waste management company indicating that actual costs are close to the top end of this range.
- ♦ Costs per ton for the UBB are estimated at $430 to $438 per ton, compared with $320 for the current system. These UBB cost estimates may have ignored innovations and economies of scale that could be implemented when Massachusetts' bottle deposit system doubles in size.
- ♦ Neither augmented curbside nor densely located drop off recycling centers can achieve UBB recovery levels at reasonable cost.

Bottle bill opponents often claim that deposit laws are substantially more expensive than other recovery methods such as curbside recycling. Opponents also claim that bottle bills reduce the cost-effectiveness of recycling programs by taking away materials such as aluminum cans that generate a significant portion of the revenue from recycling.[55]

Yet it is difficult to beat the recovery rates achieved by deposit systems. Using data from EPA's 1996 waste characterization[56], the Container Recycling Institute (CRI) calculated that beer and soda cans and bottles had a 1996 recovery rate of 75% in deposit states versus 26% in non-deposit states.[57] Another source puts redemption rates between 85% and 90% for deposit systems, compared with 40% to 60% recovery in well-run recycling programs.[58] As reported in Chapter II, Massachusetts' recovery rate for containers targeted by the current Bottle Bill is estimated at 85%.

Estimates for deposit redemption rates may not adjust for bottles and cans brought into deposit states from neighboring non-deposit states. But the difference between redemption rates and, say, recycling rates for curbside collection is too great to be explained by illegal redemptions.

[55] This latter claim is not so easy to prove. See Lisa A. Skumatz, *Nationwide Diversion Rate Study - Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies*, Seattle: SERA, July, 1996, for one of the few systematic, statistical studies of factors influencing recycling rates. Skumatz could find no significant impact on recycling rates for community curbside or dropoff programs in non-deposit versus deposit states (See Skumatz, p. 24). Deposit cans and bottles may represent too small a portion of a community program's overall recovery rate (which includes recovery of paper, glass, plastics and metals) for the loss in recycling program tonnage in bottle bill states to be significant. In addition, valuable recyclables such as aluminum cans also are diverted from recycling programs in non-deposit states due to their high market value. Furthermore, some curbside programs only collect clear glass bottles or don't collect glass at all. Finally, in a conversation with this report's author, Dr. Skumatz indicated that the SERA study did not adjust for differences in deposit systems among the various bottle bill states, which may have further confounded identification of any bottle bill impact on community recycling program diversion rates.

[56] US EPA, "Characterization of Municipal Solid Waste in the United States, 1996 Update," May 1997.

[57] CRI, *Container and Packaging Recycling Update*, Vol. VII, No 2, Summer 1997, p.1.

[58] Ackerman, *op. cit*., p. 129.

This chapter explores the costs of recycling systems that might compete with deposit laws as a means of recovering bottles and cans.

A. Cost for Container Recovery Through Curbside Recycling

Table 11 shows projected recovery levels for containers newly targeted by the UBB. According to estimates developed by Tellus and Northbridge the UBB is expected to increase Massachusetts' recycling rate by more than one percentage point.

Table 11 also shows costs, by container material and for the average mix of containers, to collect and process bottles and cans via residential curbside programs that also collect newspapers, cardboard and in many cases mixed scrap paper (e.g., junk mail, cereal boxes, magazines, and other types of recyclable paper found in household waste). The cost estimates are from detailed studies directed by the National Solid Wastes Management Association and the Waste Recyclers Council, and represent typical costs incurred for well-run curbside recycling systems.

As indicated in Table 11, curbside collection and MRF processing costs per ton are quite different for the various container materials. Collection costs for a particular material are mostly a function of the amount of space that material occupies in the collection truck, while processing costs depend on the difficulty of separating the material from other can and bottle materials at the processing facility. Estimated curbside recovery costs for glass bottles are between $105 and $201 per ton, whereas costs for plastic bottles are estimated at $1,051 to $1,696 per ton. Curbside recycling costs for metal cans fall in between the glass and plastics extremes.

On average, curbside recycling of bottles and cans in proportions projected by Tellus and Northbridge for the UBB would cost between $175 and $386 per ton, as indicated in Table 11. This amounts to a cost of $0.04 to $0.09 for each container collected curbside. According to internal calculations a few years ago of national average costs for their curbside recycling programs, WMI personnel at that time believed that their recycling costs were in the upper end of this range.[59]

Based on this information, per ton costs for curbside collection of bottles and cans in Massachusetts probably are similar to costs for the state's current bottle deposit system.[60] This is especially the case if one were to add in costs for publicity and education, as well as for enforcement of new mandatory recycling laws, all of which would be necessary to attain levels of diversion under curbside that would be equivalent to recovery rates under the Massachusetts Bottle Bill.

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[59] Personal communication with the author.

[60] Northbridge, op. cit., Executive Summary, Exhibit 1, estimates that the current system costs $320 per ton recovered.

Table 11
Cost of UBB Container Recovery through Curbside Recycling

	Projected Number (Mils) of UBB Containers Captured Via Deposit System		Projected Weight (Tons) of UBB Containers Captured Via Deposit System		Estimated Range for Curbside Recycling Costs Per Ton						Estimated Total Costs to Capture EBB Deposit System Material Through Curbside Recycling			
					Collection		Processing		Total		Tellus Capture		Nrthbrdg Capture	
Material	**Tellus**	**Nrthbrdge**	**Tellus**	**Nrthbrdge**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low** (000)	**High** (000)	**Low** (000)	**High** (000)
Glass	187.1	133.3	63,601	64,000	$54	$77	$51	$124	$105	$201	$6,678	$12,784	$6,720	$12,864
Plastic	117.1		8,839											
- PET		50.0		2,667	$987	$1,401	$64	$295	$1,051	$1,696	$5,309	$8,567	$2,803	$4,523
- HDPE		47.3		2,000	$987	$1,401	$122	$256	$1,109	$1,657	$4,201	$6,277	$2,218	$3,314
Other		48.0		1,333										
- Alum.	6.3		384		$526	$748	$73	$363	$599	$1,111	$230	$427	$299	$555
- Steel	17.1		641		$217	$309	$30	$126	$247	$435	$158	$279	$206	$363
Totals	327.6	278.6	73,465	70,000							$16,576	$28,332	$12,246	$21,619

Average Costs for Recovery of UBB Material Through Curbside Collection and Processing:				
- Per Ton Captured	**$226**	**$386**	**$175**	**$309**
- Per Container Captured	**$0.05**	**$0.09**	**$0.04**	**$0.08**

Notes: 1. To compute total cost, PET/HDPE split for Tellus based on PET/HDPE distribution in Northbridge weight estimates; aluminum/steel split for Northbridge based on aluminum/steel distribution in Tellus weight estimates.

Sources:
1. Tellus Institute, "An Analysis of the Costs and Benefits of Expanding the Scope of the Bottle Bill in Massachusetts," prepared for Massachusetts Department of Environmental Protection, June 1997.
2. Northbridge Environmental Management Consultants, "Scope and Economic Impact of Massachusetts Beverage Container Deposit Legislation," prepared for The Solid Waste Project of the Massachusetts Food Association, May 1997.
3. Killam Associates in association with Ecodata, "Collection Costs for Residential Commingled Recyclables," prepared for National Solid Wastes Management Association and Waste Recyclers Council, Washington, D.C., September 1993.
4. Roy F. Weston and McMillen Environmental, Processing Costs for Residential Recyclables at Materials Recovery Facilities, prepared for National Solid Wastes Management Association and Waste Recyclers Council, Washington, D.C., August 1992.

Tellus and Northbridge studies on the UBB have estimated that its cost per ton would be $438 and $430, respectively, or about $115 per ton more than Northbridge's $320 estimate of costs for the current system.[61] Apparently this increase is due to bottle and can handling fee increases contained in the proposed legislation.

Developing an estimate of expected cost for the UBB is not one of the purposes of this study. But we would be remiss if we failed to note that costs for new environmental regulations or environmentally beneficial programs are typically overestimated because academic and governmental economists, as well as industry-funded experts, routinely ignore the innovations that often occur as a newly mandated program is being implemented.[62] In the case of the proposed UBB, economies of scale, backhaul arrangements not previously implemented, technological advances such as reverse vending machines, or any one of a number of currently unforeseen innovations could reduce actual costs of handling an additional 73,500 tons through the state's deposit system which is already recovering over 86,000 tons.

In any event, whether actual costs for the UBB turn out to be $400 or $300 per ton or less, the two most important questions are:

1. Is additional diversion worth spending as much as $400 per ton?
2. Can another system of recycling achieve the same bottle and can diversion levels at less cost?

The first question will be addressed in the final chapter's summary of benefits from recovering more containers in Massachusetts. The latter question, at least in the case of residential curbside recycling or, as indicated in the section below, a hybrid curbside-staffed dropoff system, almost certainly must be answered in the negative.

B. Costs for Container Recovery Through Other Types of Recycling Programs

A substantial portion of the beverages targeted by the proposed UBB may be consumed away from home. This is an important reason, in addition to the low capture rate in current recycling systems for UBB targeted containers, for believing that curbside recycling alone can not cost effectively capture the number of containers that will be recovered under the UBB.

Dropoff depots conveniently located at convenience stores, gas stations, shopping centers, highway rest stops and other public places might be a way to recover containers from beverages consumed on the go. Residential dropoff programs typically achieve much lower recovery rates than curbside.[63] However, if enough drop sites were located conveniently throughout the state, dropoff recycling might, in combination with mandatory curbside recycling, attain high diversion rates in some communities.

One significant problem with numerous, densely located dropoff recycling sites is that it would be quite expensive to staff all the locations whenever they were open

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[61] Tellus UBB study, *op. cit*., Table 3, p. 9; and Northbridge UBB study, *op. cit*., Executive Summary, Exhibit 1.

[62] See Eban Goodstein and Hart Hodges, "Polluted Data: Overestimating Environmental Costs," *The American Prospect*, November-December 1997, pp. 64-69. Goodstein and Hodges found that for every one of a dozen examples where researchers calculated expected costs of some regulatory program, projected costs exceeded actual costs once the program had been fully implemented.

[63] For example, see Skumatz, *op. cit*., p. 19.

to accept used containers. Unstaffed drop sites often face substantial costs for handling and disposal of contaminants and garbage thrown into recycling receptacles, and even for dealing with large items such as old appliances dropped off in the middle of the night.

Existing staffed dropoff/buyback recycling operations are cost-effective because only a few are located in any given community, and they take in mostly high value materials such as non-ferrous metals and cardboard, or lower value materials that are easy to handle and store such as ferrous scrap. They are not effective at recovering low value materials such as glass. Nor are they cost efficient at diverting wastes such as bottles and cans which are generated primarily at home and, to a lesser extent, at work, or while people are in motor vehicles or using other forms of transit.

That is, dropoff recycling for bottles and cans would depend for its success more on good intentions than on direct financial rewards, especially for beverages consumed away from home. Free disposal of car trash is a necessity to prevent littering. Thus, no matter how many dropoff recycling bins are sited across Massachusetts, there will always be more garbage cans waiting in public places to suck up used beverage containers.

By contrast, bottles and cans that can be returned for a deposit refund are virtually self-diverting. The redemption fee motivates most people to return their own used cans and bottles. Even if a few don't want to take the trouble, somebody else will pick up containers tossed aside by those for whom the bottle refund does not provide sufficient incentive.

These considerations strongly suggest that achieving recovery rates comparable to the 80% or 90% levels attainable by the UBB would require:

- An extraordinarily committed citizenry;
- Mandatory bottle and can recycling through curbside collection from every single- and multi-family residence;
- Mandatory bottle and can recycling at drop sites located at virtually every place a car, truck or public transit carrier might stop;
- Substantial ongoing promotional and educational expenditures; and
- Substantial ongoing expenditures to enforce mandatory recycling laws.

In total, these efforts to achieve 80% to 90% recovery without an Updated Bottle Bill would likely cost more than the UBB.

V. Summation of Environmental & Economic Benefits of the UBB

- Recovering beverage containers through the proposed UBB will yield quantifiable public health, environmental and economic benefits totaling between $200 and $400 per ton recycled.
- As yet unquantified public health, environmental and economic benefits may be worth even more per ton of additional container recovery.

Table 12 summarizes the environmental and economic benefits from increased bottle and can recovery that have been quantified in this report. Total benefits average between $213 and $361 for each ton recovered under the proposed UBB. Glass bottles and steel cans have the lowest benefits per ton recovered. Plastic bottles have per ton environmental and economic benefits in the $1,001 to $1,763 range. Recovery of aluminum cans provides the highest per ton benefits, at least $2,052 for each ton diverted.

Table 12
Environmental and Economic Benefits from Increased Bottle Recovery

Container Material	Public Health Benefit from Reduced Emissions of Hazards & Less Litter	Environmental Benefit from Lower Greenhouse Gas Emissions	Recovered Material Sales Revenue (projected)	Decreased Waste Management Costs	Net Direct and Induced Employment	Total Quantifiable Benefits
	($/ton)	($/ton)	($/ton)	($/ton)	($/ton)	($/ton)
Glass	$31	$1	$30	$75-95	$0-4	$137-161
PET	255	15	149	117-220	563-1,124	1,099-1,763
HDPE	116	11	205	114-213	555-1,110	1,001-1,655
Aluminum	855	78	926	115-216	78-156	2,052-2,231
Steel	3	10	55	99-168	47-94	214-330
Weighted Avg.	$47-55	$3	$46-52	$78-111	$39-140	$213-361

Sources: Tables 6, 7, 8 and 10.

Unfortunately, the estimates listed in Table 12 don't tell the whole story about benefits from increased recovery of beverage containers. Quantified benefits do include about $50 per ton for public health improvements resulting from reduced emissions of certain pollutants into air and water as a result of reduced usage of virgin raw materials, and health benefits from fewer hospital emergency room visits caused by broken glass litter. They include economic benefits of about $50 per ton from the sale of recovered materials, and another approximately $75 to $110 in waste management cost savings for each ton of containers recovered. Benefits listed in Table 12 also include between $40 and $140 in employment opportunities arising from each additional ton of increased container recovery. Finally, Table 12 includes less than $5 in benefits arising from reduced emissions of greenhouse gases.

What the table does not quantify are at least four additional major benefits from increased recovery of beverage containers:

- ♦ Public health gains from reduced emissions of many other polluting substances such as friable asbestos that are released as a result of using virgin raw materials and fuels to manufacture beverage containers;
- ♦ Public health (other than emergency room visits for glass cuts), recreational and aesthetic gains from reduced litter;
- ♦ Reduced ecosystem impacts, including reduced habitat impairment or destruction and species extinctions, and resultant productivity improvements in agriculture, fishing and forestry; and
- ♦ Reduced on-site accumulation of solid and radioactive wastes at resource extraction and processing, energy generation, and manufacturing operations.

Chapter II discussed the importance of including these as yet unquantified benefits in any assessment of Massachusetts' proposed UBB. However, the potential value of ecosystem benefits warrants further consideration here.

Only about 1% of the dollar value for environmental and economic benefits shown in Table 12 is related to general environmental costs as opposed to human health or waste management costs and employment opportunities. Yet, as briefly discussed in Chapter II, Costanza's study on the value of nature suggested that goods and services provided mostly free of charge by Earth's ecosystems likely are worth much more than all the goods and services produced by the world's economic systems.

Mining metal ores and glass-making materials, drilling for fuels and plastics feedstocks, and then processing those materials and fuels into marketable commodities used to produce glass, plastic and metal containers, results in substantial releases of harmful chemical wastes into air and water and onto land, on-site accumulations or disposal of solid wastes, and consumption of energy. Earth's ecosystems are called upon to manage these wastes. In the process their ability to perform other vital functions may be impaired.

According to the Costanza study estimates, every dollar of economic activity entails, on average, use of two dollars worth of services from Earth's ecosystems. Given the extent of environmental intrusion associated with virgin materials production, this economic activity is likely to have significantly greater ecosystem impacts than the "average" economic activity. On this basis every dollar paid for virgin materials used in producing containers is associated with consumption of at least another two dollars worth of Earth's ecosystem services.

Recall that virgin prices typically set the upper limit on prices for recycled materials. Prices paid for the virgin materials used in container production, thus, would average substantially more than the approximately $50 per ton that Table 12 shows for recycled container material sales revenues. Assuming that at least two dollars in ecosystem costs are saved for every dollar not spent on virgin feedstocks, then increased container recovery would yield ecosystems benefits totaling at least $100 (i.e., twice the average market value for recycled containers) for each ton of containers recovered under Massachusetts' proposed UBB.

Conclusion

In summary, quantifiable public health, environmental and economic benefits totaling between $213 and $361 for each ton recovered under Massachusetts' proposed UBB were discussed in this report. Many other benefits could not be directly quantified. For example, impacts on human health from releases of many chemical substances were not included, nor were the public health effects of solid waste releases. The potential for increased local economic self-reliance resulting from additional recycling was not directly addressed, although the value of increased employment opportunities was quantified. As a last example, the value of Earth's ecosystems services used and affected in all the processes required to manufacture a container from virgin raw materials was also omitted from estimated monetary benefits for increased recovery of bottles and cans through the UBB.

Taking into account all benefits, both monetarily quantified and as yet unquantified, that will result from additional container recovery in Massachusetts, the costs of recovering additional beverage containers through an update of the state's Bottle Bill appear to be justified. These costs are outweighed by the quantity and quality of benefits to be gained by capturing more beverage containers for recycling in the state.