Regional Economic Effects of Recycling in Ontario

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Waste management policies are an important element of sustainable development strategies. The popular 4R's - Reducing, Reusing, Recycling and Recovering - not only reduce the volume of waste flowing into landfill sites but also conserve renewable and non-renewable natural resources. These policies are introduced in response to increased public concern over environmental problems and have environmental objectives; however, because these policies significantly alter the pattern of resource use, they have important effects on both the regional and sectoral distribution of economic activity. Depending on their magnitude and direction, these effects may suggest different choices of waste management initiatives or a need for complementary policies. This paper presents estimates of the economic effects of several packages of waste management policies at the regional and sectoral levels in Ontario. These effects are expressed in terms of employment differences compared to a reference scenario for the years 1992 and 2000. The scenario calculations use a regional input-output model of the Ontario economy which explicitly incorporates increased recycling and other changes in economic structure which are predicted to result from increased recycling. The input-output model provides a convenient framework for the inclusion of increased recycling activities,

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which imply changes in the pattern of input use and in the location of production. The recycling activities which are examined are largely related to paper products, which are major components of the recycled waste stream in Ontario. The results indicate shifts of employment away from the forestry-based regions of Northern Ontario and toward regions in Central Ontario which are closer to major sources of recyclable waste. In what follows the expanded input-output framework is presented first. The recycling scenarios are then described, the results discussed and conclusions presented.

Recycling in an Input-Output Framework

The expansion of the input-output framework to explicitly incorporate recycling and other waste management activities can be broken down into two stages. The first involves elaborating the input-output accounting framework so that it explicitly shows the recycling activities. The second involves modelling the recycling-related flows of product in an expanded input-output model. These stages are presented below.

The Expanded Input-Output Accounts

The input-output accounting framework is based on the commodity by industry system used by Statistics Canada (see Statistics Canada 1987: 13-62, for a full description of this system). This system is illustrated in Figure 1. The data are organized into 5 basic matrices, an output (make) matrix, V; an input (use) matrix, U; a final demand matrix, F; and two primary input matrices, Y and YF, which are associated with the input and final demand matrices, respectively. The typical element of the output matrix, V_{ji}, represents the value of commodity i produced by industry j. Thus the row totals of the output matrix, g_j, represent the total value of output produced by industry j; and the column totals, q_i, represent the total value of domestic output of commodity i. The typical element of the input matrix, U_{ij}, represents the value of the input of commodity i used in production by industry j; and the typical element of the final demand matrix, F_{is}, shows the value of the deliveries of commodity i to final demand sector s. The typical element of the primary input matrix associated with the input matrix, Y_{kj}, shows the value of primary input k used in production by industry j; and the typical element of the primary input matrix associated with the final demand matrix, YF_{ks}, is the value of primary input k used in final demand sector s.

The last primary input category of the primary input matrix, Y, operating surplus, is defined as a residual so that the column totals of the input matrix, U, and the associated primary input matrix, Y, equal the values of industry outputs, g_j. It is this feature of the accounts which forces the column totals, f_s,

	Commodities	Industries	Final Demand	Row Totals
Commodities		U	F	q + m
Industries	V			g
Primary Inputs		Y	YF	y
Column Totals	$q^{/}$	$g^{/}$	$f^{/}$	

FIGURE 1 The Statistics Canada Input-Output Accounting Framework

of final demand matrix, F, and the associated primary input matrix, YF, to have the same sum as the row totals, y_k, of the two primary input matrices, Y and YF, thus providing two equal measures of Gross Domestic Product at market prices. Finally, the row totals of the input and final demand matrices equal the total domestic outputs of each commodity, q_i, plus the value of imports of the corresponding commodities, m_i. (Conventionally, imports are included as negative elements in a column of the final demand matrix; but, for modelling purposes, it is more convenient to exclude imports from the final demand matrix and treat them as a separate vector.)

The introduction of recycling and other waste management activities into the input-output system requires the explicit identification of both industries and commodities associated with these activities. This task is made easier by the commodity-by-industry structure of the Statistics Canada input-output system. Five new classes of commodities must be introduced: recyclable wastes, non-recyclable wastes, recycled materials and collection services for both recyclable and non-recyclable wastes. Recyclable wastes include old newsprint, fine paper, boxboard, corrugated cardboard, magazines, telephone books, glass containers, plastics, aluminum, and tinplate steel. Non-recyclable wastes include mixed paper, composite packaging, white goods, used tires, yard waste, food waste, wood waste, construction/demolition waste, other household waste and industrial waste. Of course, the development of new technologies and markets over time will lead to the recycling of more types of waste.

Recycled materials are defined as materials derived from recyclable wastes. These recycled materials are used as inputs in production and may be substitutes for materials derived from virgin sources. For example, waste newsprint is de-inked and used as the raw material in producing a pulp which is equivalent to pulp from wood. Pulp from either source can be used to produce newsprint in the same technical process. Fibre from other paper wastes can be used as a raw material in producing a variety of new paper products. Waste metal, plastic and glass are also used in a similar manner. Although processing is minimal for some recyclable wastes, substantial processing is required for others, such as de-inking and pulping old newsprint. It is important to identify recycled materials since recycled materials compete with materials from virgin sources, and the market shares of each source of material must be identified in order to model the effects of recycling.

Two separate types of collection services are identified, for recyclable and non-recyclable wastes. Although these services sometimes share the same facilities (waste transfer sites, for example), they are produced using distinct and separate processes, with different mixes of inputs. Here, non-recyclable waste disposal (landfill) is included in non-recyclable waste collection services, but it (landfill) could be treated as a separate commodity and industry. Corresponding to the five new classes of commodities, three new types of industries must be introduced: waste material processing, collection of recyclable waste, and collection of non-recyclable waste. Waste material processing industries convert recyclable waste into recycled materials, and the two collection industries provide collection services for the two types of waste.

The new commodities and industries appear in the expanded input-output accounting matrices shown in Figures 2 and 3. In the adjusted output matrix (Figure 2) recyclable and non-recyclable wastes are recorded as an output of industries (RW_{rj} and NRW_{nj}) and final demand sectors (RW_{rs} and NRW_{ns}).[1]

The waste material processing industry also generates non-recyclable waste (NRW_{nm}), such as waste resulting from de-inking and processing old newsprint. This modification requires that the waste material processing industry and final demand sectors be introduced as additional columns and recyclable and non-recyclable wastes as additional rows in the output matrix. For many recyclable wastes and all non-recyclable wastes, the market price is zero and the corresponding value of output is zero. However, it is important that the physical volumes of both types of waste be recorded, either in separate rows of the output matrix or in a supplementary account, so that the physical volumes of waste can be tracked through the production system. The adjusted output matrix also shows waste collection services as outputs of the waste collection services industries (CSR_{tt} and $CSNR_{uu}$), and recycled materials as outputs of the waste material processing industries (RM_{lm}).

The new commodities and industries are also incorporated in the adjusted input and final demand matrices (shown in Figure 3). Recycled materials are recorded as inputs into industries (RM_{lj}). Recyclable waste and recyclable waste collection services are shown as inputs into the waste material processing industry (RW_{rm} and CSR_{tm}). This treatment is consistent with the producer price valuation used in the Statistics Canada input-output system. The cost of recyclable waste to the waste material processing industries is the sum of the payment for recyclable wastes received by the generators of the waste and a payment for waste collection services. This is analogous to valuing the cost of materials free on board (f.o.b.) and treating transportation costs as a purchase of transportation services (transportation margins). In contrast, non-recyclable

1. Note that, for ease of presentation, the adjusted output matrix in Figure 2 has commodity rows and industry columns.

	Industries	Waste Material Processing	Collection of Recyclable Waste	Collection of Non Recyclable Waste	Final Demand	Row Totals
Commodities	V_{ij}					q_i
Recycled Material		RM_{lm}				rm_l
Recyclable Waste	RW_{rj}				RW_{rs}	rw_r
Non-Recyclable Waste	NRW_{nj}	NRW_{nm}			NRW_{ns}	nrw_n
Recyclable Waste Collection			CSR_{tt}			csr_t
Non-Recyclable Waste Collection				$CSNR_{uu}$		$csnr_u$
Column Totals	g_j	g_m	csr_t	$csnr_u$	wf_s	

FIGURE 2 The Adjusted Output Matrix

waste collection services are treated as purchased inputs of the generators of non-recyclable waste ($CSNR_{uj}$, $CSNR_{um}$, $CSNR_{ut}$ and $CSNR_{us}$). This is consistent with current practice in Ontario, where business pays private haulers for waste disposal. This is not the case for households (a final demand sector), where waste collection services are provided by local government. However, in order to relate the use of these services to the level of consumer expenditure it is convenient to enter these costs as purchases of households and treat them as a cost of consumption. Imports of recycled material (m_l) and recyclable waste (m_r) are added to domestic output as potential sources of these commodities in the row totals. Exports of these commodities could also appear in the export columns of the final demand matrix. Recyclable waste collection services are treated as non-tradable commodities and can only be supplied domestically. This implies that imports of recyclable wastes are valued at the border, as are all imports in the Statistics Canada input-output system. Non-recyclable waste collection services are treated as tradeable and imports (m_u) are recorded, however, because they include waste disposal (landfill) services. Non-recyclable wastes are shipped to landfills across provincial borders, and these shipments are treated as imports or exports of waste disposal services. If waste disposal services were identified separately from non-recyclable waste collection services, the latter would be treated as a non-tradeable commodity.[2]

2. The interested reader may obtain the accounting identities implicit in the adjusted matrices, as well as the other assumptions in the expanded input-output model, on request from the authors.

	Industries	Waste Material Processing	Collection of Recycl-able Waste	Collection of Non Recycl-able Waste	Final Demand	Row Totals
Commodities	U_{ij}	U_{im}	U_{it}	U_{iu}	F_{is}	$q_i + m_i$
Recycled Material	RM_{lj}					$rm_l + m_l$
Recyclable Waste		RW_{rm}				$rw_r + m_r$
Recyclable Waste Collection		CSR_{tm}				csr_t
Non-Recyclable Waste Collection	$CSNR_{uj}$	$CSNR_{um}$	$CSNR_{ut}$		$CSNR_{us}$	$csnr_u + m_u$
Primary Inputs	Y_{kj}	Y_{km}	Y_{kt}	Y_{ku}	Y_{ks}	y_k
Column Totals	g_j	g_m	csr_t	$csnr_u$	f_s	

FIGURE 3 The Adjusted Input and Final Demand Matrices

The Expanded Input-Output Model

The conventional commodity-by-industry model (described in Statistics Canada 1987, pages 73-78) assumes that each industry produces a fixed market share of the output of each commodity, implying that each industry's output of any commodity, V_{ij}, is proportional to the total domestic output of the commodity, q_i, (the corresponding row total of the output matrix). This assumption is retained in the expanded model. A similar assumption is used for outputs of recycled material, RM_{lm}, which are assumed to be proportional to the total domestic output of the recycled material, RM_l. Outputs of recyclable and non-recyclable waste collection services, CSR_{tt} and $CSNR_{uu}$, are assumed to be produced solely by corresponding industries (the market shares equal one), so that the commodity and industry outputs, csr_t and $csnr_u$, are equal. Wastes are treated differently from other elements of the output matrix. Industry outputs of recyclable and non-recyclable waste; RW_{rj}, NRW_{nj} and NRW_{nm}, are assumed to be proportional to the corresponding industry outputs (column totals of the output matrix); g_j and g_m. Outputs of recyclable and non-recyclable waste by final demand sectors, RW_{rs} and NRW_{ns}, are assumed to be proportional to the corresponding total expenditure of these sectors, f_s (column totals of the final demand matrix). The assumption that outputs of waste are proportional to industry and final demand activity levels was originally introduced by Leontief (1970) and implemented for Canada by Victor (1972). The new elements in the adjusted input and final demand matrices are treated in the conventional way, assumed to be proportional to the corresponding column totals (industry outputs and final demand total expenditures).

Waste management initiatives (reducing and reusing) which lead to less waste for given activity levels are incorporated into the model by reducing the proportions of waste per unit of activity (reducing the waste generation coefficients). The estimates of the new waste generation coefficients are based on experience in other (mainly U.S.) jurisdictions, as described in a Ministry of the Environment (MOE) study conducted by VHB Research et al. (1992). Increased recycling is introduced through the waste materials processing industries, which use recyclable wastes as inputs and produce recycled material. Recycling is represented in the input matrix by explicitly identifying recycled materials and the materials from virgin sources with which they compete as different inputs into production. Increased use of recycled materials is reflected in larger input shares for recycled materials and correspondingly lower input shares for materials derived from virgin sources. New share estimates are based on detailed forecasts of changes in processes in paper products industries. Commodity balances translate increased use of recycled material into increased output of the waste material processing industries and increased collection (or increased imports) of recyclable wastes. Commodity balances also translate reduced use of materials derived from virgin sources into lower outputs of natural resource sectors such as forestry and mining. Imports and exports of recyclable wastes, recycled materials, materials from virgin sources and non-recyclable waste collection services are treated as exogenous since values are specified as a part of the recycling scenarios. This structure of the input-output model implies that the volume of recycling is determined by the demand for recycled materials by domestic and foreign industries. This demand can be satisfied by either domestic production or imports. The domestic production of recycled materials, in turn, determines the domestic demand for recyclable wastes (inputs into the production of recycled materials). This demand can also be satisfied by either imports or domestic supplies of recyclable wastes. Recyclable wastes can also be exported. Waste generation is determined by overall economic activity. The balance between waste generation and waste recycling is a residual and goes to waste disposal (landfill).

Other features of the input-output model are conventional (see Miller and Blair (1985) for descriptions of various input-output models). Imports of commodities are assumed to be a constant share (market share) of the total deliveries to industries and final demand for all tradeable commodities while exports of commodities are treated as exogenous. The model is a "closed" input-output model in that total household expenditure is proportional to the labour and unincorporated business income which is generated by the model. The regional structure of the model is based on a regional market share matrix which allocates Ontario-wide industry outputs to counties. Regional shifts in production which result when industries move closer to sources of recycled materials are reflected in changes in market shares. Forecasts of these shifts, as well as changes in the shares of recycled materials used as inputs, are based on surveys of Canadian paper products firms and studies of the corresponding

markets conducted for MOE by Resource Integration Systems Limited and VHB Research and Consulting Inc (MOE 1991a) and CH2M Hill Engineering Ltd and MacLaren Engineering Ltd (MOE 1991b). Given the four to five year time period required to introduce new plants or modify existing plants to incorporate recycled materials, the plans of firms in these industries provide the most reliable available forecast of structural changes over the decade of the 1990's and up to the final year (2000) of the forecasts.

The Recycling Scenarios

The recycling scenarios are based on three sets of forecasts; macroeconomic forecasts of final demand components for the Ontario economy, forecasts of the effects of alternative recycling policies on waste generation in Ontario, and forecasts of changes in regional structure and input use in the paper products industries. These forecasts are introduced into the input-output model in order to calculate the employment effects. The last set of forecasts has been described above; descriptions of the first two are provided below.

A common set of forecasts of final demand components in constant 1989 prices for the years 1992 and 2000 is used for all of the scenarios, with the exceptions of exports and imports of recycling-related commodities which differ across scenarios and consumer expenditure and imports of other commodities which are determined within the model. The 1992 forecasts of final demand components are weighted averages of 1992 quarterly medium growth forecasts for Ontario generated by the Conference Board of Canada (1992). The forecasts for the year 2000 were extrapolated from a fourth quarter 1994 (1994: 4) base (also medium growth forecasts by the Conference Board) and actual 1985-1989 growth rates for each final demand component. These growth rates were applied to the 1994:4 base to calculate forecasts for the year 2000.

The current trend waste management scenario represents estimates of the effects of policies in effect in Ontario at the end of 1990. These estimates (and those of the other scenarios) are based on a model developed for the Ontario Ministry of the Environment by VHB Research and Consulting Inc. (See VHB Research et al. (1992) for a detailed description of this model.) For each component of the waste stream, waste diversion parameters determine the percentages of waste diverted from landfill by reduction/reuse and by recycling in the years 1992 and 2000. Forecasts of these waste diversion parameters for the trend scenario are based on past responses to current Ontario waste management policies. This scenario provides a reference point which allows calculation of the incremental effects of potential new waste management initiatives. The overall proportions of total waste diverted in the Ontario scenarios are presented in Table 1.

Five alternative scenarios are considered: export reduction, economic incentives, regulatory measures, mixed economic and regulatory measures, and

TABLE 1 Percentage of Waste Stream Diverted: 1992 and 2000

		Recycling Scenario			
Year	Reference	Economic Incentives	Regulatory Measures	Mixed	WRAP
1992	13	23	30	33	22
2000	23	36	45	45	34

Source: VHB Research (1992).

Ontario's Waste Reduction Action Plan (WRAP). Detailed descriptions of these scenarios are presented in VHB Research et al. (1992). The export reduction scenario differs from the others in that it does not represent the effects of new waste management initiatives in Ontario. Instead, it is based on the effects which recycling activities in the United States and other trading partners are forecast to have on Ontario exports. Current (trend) waste management policies in Ontario are predicted to lead to a 25 percent reduction in 1992 and a 50 percent reduction in 2000 in the use of pulp and other paper products based on virgin materials. The result of increased recycling and restrictions on the virgin content of imports in the U.S. and other markets is forecast to lead to the same percentage reductions of Ontario exports of these products. The other four scenarios represent alternative packages of new waste management policy measures in Ontario. Forecasts of the increased waste diversion for each measure are based on responses in other jurisdictions (mainly in the U.S.) where these measures have already been implemented. The waste diversion parameters for each scenario are not based on simple addition of the diversion for each individual measure because some measures may be substitutes (act on the same components of the waste stream). For example, a deposit-refund system on glass bottles will lead to more reuse of glass bottles and reduce the number of glass bottles going to landfill. If an expanded "Blue Box" recycling program is added to the policy package it will have a smaller effect on glass bottles because of the deposit-refund system. In this example, the effect of the combined measures is less that the sum of the effects of the two measures carried out individually.

The economic incentives scenario combines eight policy measures which attempt to alter the behaviour of households and business by providing economic incentives or disincentives. This package of measures includes: expanding the deposit-return system; subsidies and increased funding to municipalities to encourage increased recycling, reuse, home composting and industrial waste audits; taxes to discourage excess packaging and use of virgin materials; a system of differential landfill tipping fees which charges higher fees for recyclable wastes; and user charges based on waste volume (number of bags) for household and business waste collection.

The regulatory measures scenario is made up of eight policy measures which attempt to modify behaviour by legal mandate. The measures included

in this scenario are: doubling the amount spent per household on education programs; banning some wastes from landfill; municipal collection of yard waste and industrial food waste; mandatory waste audits for large firms; mandatory sorting and source separation of solid wastes to remove recyclable wastes; extension of "Blue Box" programs to more dwellings and expansion to include more recyclable wastes in these programs; and requiring minimum content of recycled materials in certain products.

The mixed regulatory and economic measures scenario combines six of the regulatory measures with two of the economic incentives measures described in the preceding paragraphs. The regulatory measures are: expanded education programs; banning recyclable materials from landfill; yard and industrial food waste collection; mandatory industrial waste audits; expansion of "Blue Box" programs; and mandatory source separation of recyclable wastes. The economic incentive measures are: user charges for household and business waste collection; and virgin materials taxes.

The Ontario Waste Reduction Action Plan (WRAP) scenario is based on five of the regulatory measures which have been described above. These are: expanded education programs; yard and industrial food waste collection; mandatory industrial waste audits; expansion of "Blue Box" programs; and mandatory source separation of recyclable wastes.

For each of the four recycling policy scenarios, the costs to government, business and households are allocated across commodities and added to the final demand vector in the calculation of the economic effects. However, these costs of waste management are assumed to be financed by reduced spending within the corresponding sectors so that there is no overall exogenous increase in total final demand. Households cut consumption, businesses cut investment expenditures and governments reduce other expenditures by amounts exactly equal to the costs of the waste management measures. These cuts are allocated across commodities in proportion to their shares in the total expenditure of the sector. For example, if households pay $1 million in garbage collection fees, household expenditure is reduced by the same amount, with the reduction allocated across commodities in proportion to their shares in the input-output data. For business, the assumption implies that any cost increases resulting from recycling policies are not passed on to purchasers in the form of higher prices, but instead are absorbed by business in the form of reduced profits (and, consequently, reduced investment spending). Thus, in these scenarios, the overall exogenous change in final demand is zero but the composition of final demand is altered. The employment impacts are, therefore, the result of changes in the composition of final demand as well as changes in the production structure resulting from recycling.

Before turning to a discussion of the results, some discussion of the strengths and weaknesses of the methodological approach used in the study is necessary. Conventionally, input-output models are criticized because they do not allow for substitution and changes in "structure", that is, in the shares of

commodity and primary inputs in production and in final expenditure. In this study, the main changes in structure occur in the paper and paper products industries, and these changes are unlikely to lead to significant structural changes elsewhere in the economy. Forecasts of these structural changes are an important part of the methodology. These forecasts are based on the plans of firms in the paper and paper products industries for the construction of new facilities and the modification of existing facilities, as well as a detailed knowledge of both old and new technical processes. Because the forecasts are only for a ten year period and significant changes in production facilities and processes take four to five years to implement, these forecasts are the most accurate possible. However, the reader should be reminded that, as with any forecasts, they are contingent on presently available information. The structure of the remaining portions of the Ontario economy is based on the 1984 input-output data (the most recent data available at the time the study was carried out); and, to some extent, the forecast effects are contingent on that structure, which may change significantly over the 1990s. However, since the major source of the effects reported below is change in sectors which are directly affected by recycling, the results are not very sensitive to changes in structure elsewhere in the economy.

Discussion of the nature and role of the trend or reference scenario is also necessary. The trend scenario provides a base for the calculation of the differential or incremental effects of recycling policies. Like the other scenarios, it is based on forecasts of structural changes in sectors which are directly affected by recycling. The macroeconomic forecasts primarily determine the scale at which the economy operates. Because the forecasts for the year 2000 are simple extrapolations based on growth rates between 1985 and 1989, they may overstate the scale in the year 2000. However, since all scenarios are based on the same macroeconomic forecasts, the differential effects reported below are not affected by errors in the macroeconomic forecasts. The only reported results which are affected by errors in the macroeconomic forecasts are the percentage differences, since the base for these percentages are the employment levels in the trend scenario. These employment levels are affected by the scale of economic activity which is determined, in part, by the macroeconomic forecasts. For example, if the macroeconomic forecast for the year 2000 is too optimistic, actual employment levels will be less than those forecast in the trend scenario. This would imply that the base levels of employment used to calculate the percentage differences were too large and that the percentage differences reported here are too small. The reader should remember that the intent of this study is not to provide a complete forecast of all aspects of the Ontario economy in the year 2000, but rather to calculate the likely incremental effects of various recycling initiatives in that year.

Finally, the reader might wonder why a computable general equilibrium (CGE) model, such as those which have been used to assess the regional effects of the Canada-U.S. Free Trade Agreement (see Jones and Whalley

(1989) for an example), was not used. First, severe data limitations make it very difficult to implement such a model at the sub-provincial level. Even at the provincial level these models rely on arbitrarily chosen values for substitution elasticities which make the results equally arbitrary. Second, these models use production functions to forecast changes in input structure and in technology which are better forecast, at least over a ten year period, by the methods used in this paper, which rely on detailed knowledge of new and old technical processes. (see Hoffman and Jorgenson (1977)). Finally, CGE models rely entirely on responses to relative prices changes to forecast changes in economic structure. Many of the responses forecast here are based on other considerations, primarily increased public concern for environmental problems. For example, the decision by the *Chicago Tribune* to require 50 percent recycled fibre in its newsprint was primarily based on the preferences of its subscribers rather than on the cost advantages of recycled fibre. Production functions are not able to forecast structural change which results from sources of this type.

Effects of Recycling Policies

Although a variety of economic effects were calculated, only the employment effects are presented here. (Effects on income are similar to the effects on employment.) Employment in person years was calculated for each of the above scenarios, both by industry and by county, for the years 1992 and 2000. In order to present the regional effects, the 49 counties in Ontario were aggregated into six regions: Eastern Ontario, Central Ontario, Southwestern Ontario, Northeastern Ontario, Northwestern Ontario and the Greater Toronto Area.

The regional effects for 1992 are presented in Table 2, which shows employment levels by region for the trend scenario and employment differences from the trend scenario for each of the recycling scenarios, in both person-years and as percentages of the trend scenario employment levels. The export reduction scenario shows the greatest loss in employment relative to the trend scenario in all regions. Thus, recycling which occurs outside of Ontario has the most impact on the Ontario economy. This occurs in part because, when recycling occurs within Ontario, there is increased employment in waste material processing and recyclable waste collection industries which partly offsets employment losses in other industries. These offsetting employment increases are absent when recycling occurs outside of Ontario. As a percentage of trend scenario employment, the greatest loss of employment occurs in Northwestern Ontario, which is most dependent on the forestry and pulp and paper industries. This claim is supported by examining Table 3, which shows the industry breakdown of employment differences from the trend scenario. The largest declines in employment occur in the forestry and paper and paper products industries, as a percentage of the trend scenario. A relatively large decline also occurs in the wood products industry. As a percentage of the trend

TABLE 2 Regional Employment Levels (Person-Years) for Current Trend Scenario and Regional Employment Differences from Current Trend (Person-Years and Percent of Current Trend) 1992

	Current Trend	25% Export Reduction	Economic Incentives	Regulatory Measures	Economic/ Regulatory	WRAP
Eastern Ontario	844709	-3545	-207	-121	-135	-168
		(-0.42)	(-0.02)	(-0.01)	(-0.02)	(-0.02)
Central Ontario	215290	-801	108	126	124	116
		(-0.37)	(0.05)	(0.06)	(0.06)	(0.05)
South-Western Ontario	1283539	-6013	-849	-837	-839	-843
		(-0.47)	(-0.07)	(-0.07)	(-0.07)	(-0.07)
North-Eastern Ontario	228519	-2088	-925	-984	-974	-950
		(-0.91)	(-0.40)	(-0.43)	(-0.43)	(-0.42)
North-Western Ontario	107618	-2547	-1930	-2061	-2038	-1987
		(-2.37)	(-1.79)	(-1.91)	(-1.89)	(-1.85)
Greater Toronto	2709889	-12439	-1556	-1423	-1445	-1496
		(-0.46)	(-0.06)	(-0.05)	(-0.05)	(-0.06)
Total	5389564	-27434	-5357	-5300	-5307	-5328
		(-0.51)	(-0.10)	(-0.10)	(-0.10)	(-0.10)

Note: Figures in parentheses are the employment change as a percentage of employment in the trend scenario.

scenario, the second largest employment loss occurs in Northeastern Ontario, which is also more dependent on these industries than other regions.

As compared to the export reduction scenario, the employment effects of the recycling policy scenarios also involve losses for Ontario as a whole, but there are employment gains in Central Ontario in each scenario. These gains are, in part, a result of increased employment in the recyclable waste collection industries, which are included in the transportation/communication/utilities industry shown in Table 3. Employment gains in Central Ontario also result from shifts in the location of the production of paper products away from the forestry-based northern regions to regions located closer to supplies of recycled material. The largest employment losses, as a percentage of the trend scenario, occur in Northwestern and Northeastern Ontario, as in the export reduction scenario.

Although the province-wide employment losses in the four recycling policy scenarios are similar, there are differences in their regional distribution. In the economic incentives scenario, relative employment losses are somewhat smaller in Northwestern and Northeastern Ontario and somewhat larger in the other regions, with a smaller increase in central Ontario, as compared to the regulatory measures scenario. These differences are largely the result of differing patterns of industry effects. In the regulatory measures scenario there is a larger employment increase in the recyclable waste collection industry (transportation/communication/utilities in Table 3) and slightly larger employment

TABLE 3 Industry Employment Differences from Current Trend; Person Years and Percent of Current Trend (1992)

	25% Export Reduction	Economic Incentives	Regulatory Measures	Economic/ Regulatory	WRAP
Agriculture	-607	-263	-287	-282	-273
	(-0.46)	(-0.20)	(-0.22)	(-0.21)	(-0.21)
Forestry	-1159	-10	-12	-11	-11
	(-9.79)	(-0.08)	(-0.10)	(-0.09)	(-0.09)
Fishing	-2	0	-1	-1	-1
	(-0.27)	(0.00)	(-0.13)	(-0.13)	(-0.13)
Mining	-80	-90	-98	-97	-93
	(-0.19)	(-0.21)	(-0.23)	(-0.23)	(-0.23)
Food & Beverages	-380	-164	-179	-176	-170
	(-0.38)	(-0.16)	(-0.18)	(-0.17)	(-0.17)
Primary Textiles	-100	-46	-50	-49	-47
	(-0.47)	(-0.22)	(-0.24)	(-0.23)	(-0.22)
Knitting Mills	-148	-83	-91	-90	-86
	(-0.40)	(-0.22)	(-0.24)	(-0.24)	(-0.23)
Wood Products	-719	-30	-33	-32	-31
	(-2.90)	(-0.12)	(-0.13)	(-0.13)	(-0.13)
Furniture and Fixtures	-144	-31	-34	-34	-33
	(-0.36)	(-0.08)	(-0.08)	(-0.08)	(-0.08)
Paper & Paper Products	-7209	-65	-71	-69	-67
	(-13.45)	(-0.12)	(-0.13)	(-0.13)	(-0.12)
Printing and Publishing	-305	-118	-128	-126	-122
	(-0.39)	(-0.15)	(-0.16)	(-0.16)	(-0.16)
Primary Metal Products	-66	-34	-37	-36	-35
	(-0.10)	(-0.05)	(-0.05)	(-0.05)	(-0.05)
Fabricated Metal Products	-131	-86	-94	-93	-90
	(-0.15)	(-0.10)	(-0.11)	(-0.11)	(-0.11)
Machinery	-55	-52	-57	-56	-55
	(-0.11)	(-0.10)	(-0.11)	(-0.11)	(-0.11)
Transport Equipment	-170	-112	-121	-120	-115
	(-0.08)	(-0.05)	(-0.06)	(-0.06)	(-0.06)
Electrical and Electronic Products	-150	-96	-106	-104	-100
	(-0.15)	(-0.09)	(-0.10)	(-0.10)	(-0.10)
Non-Metallic Mineral Products	-51	-27	-29	-29	-28
	(-0.20)	(-0.11)	(-0.11)	(-0.11)	(-0.11)
Petroleum and Coal Products	-73	-16	-17	-17	-17
	(-0.36)	(-0.08)	(-0.08)	(-0.08)	(-0.08)
Chemicals and Chemical Products	-361	-83	-91	-90	-87
	(-0.67)	(-0.15)	(-0.17)	(-0.17)	(-0.16)
Miscellaneous Manufacturing	-298	-158	-173	-170	-165
	(-0.30)	(-0.16)	(-0.17)	(-0.17)	(-0.17)
Construction	-252	-550	-599	-591	-571
	(-0.07)	(-0.15)	(-0.16)	(-0.16)	(-0.16)
Transportation, Communication and Utilities	-2954	-6	537	445	233
	(-0.63)	(0.00)	(0.12)	(0.10)	(0.05)
Trade, Finance and Real Estate	-4527	-1791	-1952	-1925	-1861
	(-0.36)	(-0.14)	(-0.16)	(-0.15)	(-0.15)
Services	-7493	-1446	-1577	-1555	-1503
	(-0.46)	(-0.09)	(-0.10)	(-0.10)	(-0.09)
All Industries	-27434	-5358	-5301	-5308	-5329
	(-0.51)	(-0.10)	(-0.10)	(-0.10)	(-0.10)

declines in all other industries, as compared to the economic incentives scenario. The mixed economic/regulatory scenario combines 8 regulatory measures with 2 economic incentive measures and, as a result, has effects which are very close to those in the regulatory measures scenario. The WRAP scenario is made up of 5 regulatory measures. This scenario has somewhat less impact on the northern regions and somewhat more impact on the others, as compared to the regulatory scenario. This is due to the smaller employment increase in the recyclable waste collection industry in the WRAP scenario.

The regional employment effects for the year 2000 are shown in Table 4, with the corresponding industry results shown in Table 5. These results are similar to the results for 1992. The export reduction scenario leads to the largest employment losses relative to the trend scenario (see Table 4), with a one percent overall reduction for Ontario. The relative employment reductions are largest for Northwestern and Northeastern Ontario. As with the 1992 results, these regions suffer the greatest employment losses because they are most dependent on the forestry, wood products and paper and paper products industries. As can be seen from Table 5, these industries suffer relatively large employment losses.

In each of the recycling scenarios, there is a relatively small employment loss (-0.10 %) for the province as a whole, with large relative losses in Northwestern Ontario and, to a lesser extent, in Northeastern Ontario. Each of these scenarios also features employment gains in Central Ontario. As with the 1992 results, these gains occur because of increased employment in the recyclable waste disposal industry, which is included in the transport/communication/utilities industry in Table 5, and also because of shifts in the location of production in the paper and paper products industry, which occur because production expands in regions closer to supplies of recyclable waste. Among the recycling scenarios, the economic incentives scenario has somewhat smaller effects on Northwestern and Northeastern Ontario but a slightly larger effect on Ontario as a whole. This occurs because this scenario, while having smaller employment losses in all other industries, does not feature the large increases

TABLE 4 Regional Employment Levels (Person-Years) for Current Trend Scenario and Regional Employment Differences from Current Trend (Person-Years and Percent of Current Trend) 2000

	Current Trend	50% Export Reduction	Economic Incentives	Regulatory Measures	Economic/ Regulatory	WRAP
Eastern Ontario	892844	-7530	-223	-98	-136	-156
		(-0.84)	(-0.02)	(-0.01)	(-0.02)	(-0.02)
Central Ontario	227809	-1708	118	145	137	133
		(-0.75)	(0.05)	(0.06)	(0.06)	(0.06)
Southwestern Ontario	1359310	-13036	-1032	-1022	-1026	-1026
		(-0.96)	(-0.08)	(-0.08)	(-0.08)	(-0.08)
Northeastern Ontario	241671	-4358	-961	-1034	-1018	-1005
		(-1.80)	(-0.40)	(-0.43)	(-0.42)	(-0.42)
Northwestern Ontario	113543	-5287	-2075	-2252	-2200	-2171
		(-4.66)	(-1.83)	(-1.98)	(-1.94)	(-1.91)
Greater Toronto	2868073	-26551	-1748	-1556	-1614	-1644
		(-0.93)	(-0.06)	(-0.05)	(-0.06)	(-0.06)
Total	5703249	-58470	-5919	-5818	-5858	-5869
		(-1.03)	(-0.10)	(-0.10)	(-0.10)	(-0.10)

TABLE 5 Industry Employment Differences from Current Trend, Person-Years and Percent of Current Trend, 2000

	50% Export Reduction	Economic Incentives	Regulatory Measures	Economic/ Regulatory	WRAP
Agriculture	-1282	-293	-326	-317	-310
	(-0.91)	(-0.21)	(-0.23)	(-0.23)	(-0.22)
Forestry	-2395	-11	-13	-13	-12
	(-19.39)	(-0.09)	(-0.11)	(-0.11)	(-0.10)
Fishing	-6	-1	-1	-1	-1
	(-0.76)	(-0.13)	(-0.13)	(-0.13)	(-0.13)
Mining	-160	-34	-32	-42	-40
	(-0.36)	(-0.08)	(-0.07)	(-0.09)	(-0.09)
Food and Beverages	-807	-183	-205	-198	-194
	(-0.76)	(-0.17)	(-0.19)	(-0.19)	(-0.18)
Primary Textiles	-210	-51	-57	-55	-54
	(-0.94)	(-0.23)	(-0.26)	(-0.26)	(-0.24)
Knitting Mills	-313	-93	-104	-101	-99
	(-0.79)	(-0.23)	(-0.26)	(-0.26)	(-0.25)
Wood Products	-1488	-33	-38	-36	-36
	(-5.68)	(-0.13)	(-0.15)	(-0.14)	(-0.14)
Furniture and Fixtures	-307	-36	-39	-39	-37
	(-0.72)	(-0.08)	(-0.09)	(-0.09)	(-0.09)
Paper and Paper Products	-15453	-73	-82	-79	-79
	(-27.0)	(-0.13)	(-0.14)	(-0.14)	(-0.14)

	50% Export Reduction	Economic Incentives	Regulatory Measures	Economic/ Regulatory	WRAP
Printing and Publishing	-648	-131	-146	-142	-139
	(-0.78)	(-0.16)	(-0.18)	(-0.17)	(-0.17)
Primary Metal Products	-144	-37	-41	-40	-39
	(-0.20)	(-0.05)	(-0.06)	(-0.06)	(-0.05)
Fabricated Metal Products	-287	-96	-108	-104	-102
	(-0.32)	(-0.11)	(-0.12)	(-0.12)	(-0.11)
Machinery	-153	-58	-65	-63	-62
	(-0.28)	(-0.11)	(-0.12)	(-0.11)	(-0.11)
Transport Equipment	-362	-124	-139	-135	-133
	(-0.17)	(-0.06)	(-0.06)	(-0.06)	(-0.06)
Electrical and Electronic Products	-337	-108	-120	-116	-114
	(-0.31)	(-0.10)	(-0.11)	(-0.11)	(-0.11)
Non-Metallic Mineral Products	-106	-29	-33	-31	-31
	(-0.39)	(-0.11)	(-0.12)	(-0.11)	(-0.11)
Petroleum and Coal Products	-156	-18	-20	-20	-19
	(-0.72)	(-0.08)	(-0.09)	(-0.09)	(-0.09)
Chemicals and Chemical Products	-778	-93	-104	-101	-100
	(-1.38)	(-0.16)	(-0.18)	(-0.18)	(-0.17)
Miscellaneous Manufacturing	-636	-177	-198	-192	-188
	(-0.61)	(-0.17)	(-0.19)	(-0.18)	(-0.18)
Construction	-532	-613	-684	-663	-651
	(-0.14)	(-0.16)	(-0.18)	(-0.17)	(-0.17)
Transportation, Communications and Utilities	-6378	-11	769	537	407
	(-1.29)	(0.00)	(0.16)	(0.11)	(0.08)
Trade, Finance and Real Estate	-9606	-2000	-2230	-2161	-2122
	(-0.72)	(-0.15)	(-0.17)	(-0.16)	(-0.16)
Services	-15915	-1615	-1802	-1746	-1714
	(-0.92)	(-0.09)	(-0.10)	(-0.10)	(-0.10)
All Industries	-58470	-5919	-5818	-5858	-5869
	(-1.03)	(-0.10)	(-0.10)	(-0.10)	(-0.10)

in employment in the recyclable waste collection industry which occur in the regulatory-based scenarios (see the transport/communications/ utilities industry in Table 5).

Conclusion

This paper estimates the economic effects of various recycling policies in Ontario for the years 1992 and 2000. Forecasts of changes in economic structure which result from increased recycling are incorporated into an expanded

input-output model in order to calculate the estimates. The expanded model explicitly includes recycling-related activities, recyclable wastes and recycled materials. It also incorporates forecasts of regional shifts of production which accompany shifts from virgin to recycled materials as inputs. The costs of recycling policies to government, business and households are incorporated, but are offset by corresponding reductions in other final demand expenditures in the same sectors.

Economic effects by region and industry are calculated for six scenarios; a trend scenario based on current market conditions and recycling policies in Ontario, an export reduction scenario, and four recycling policy scenarios featuring various combinations of economic incentives and regulatory measures. The results are presented in terms of employment differences relative to the trend scenario, which provides a base for calculating the differential effects of the alternative recycling policies.

The results suggest that the largest employment reductions are likely to result from losses in export markets due to foreign requirements for recycled content in paper and paper products. In relative terms, employment reductions are likely to be most severe in Northwestern and, to a lesser extent, in Northeastern Ontario due to the greater dependence of these regions on the forestry, wood products, and paper and paper products industries. Given the great distance of these regions from sources of other raw materials and large markets, there is limited scope for spontaneous movement of other industries into these regions, implying that compensatory policies may be necessary.

All of the recycling policy scenarios lead to a relatively small employment losses for Ontario as a whole, with relatively large declines in Northwestern and Northeastern Ontario being partially offset by increases in Central Ontario. The employment gains in Central Ontario are the result of increased employment in recyclable waste collection industries and of shifts in the location of employment in the paper and paper products industry. These differential regional effects are somewhat more pronounced in the regulatory measures scenario as compared to the economic incentives scenario.

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