STRATFORD/AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT

CROPPING-INCOME IMPACTS OF MANAGEMENT WASTES TO CONTROL SOIL LOSS

Technical Report R-18

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PREFACE

This report is one of a series of technical reports resulting from work undertaken as part of the Stratford-Avon River Environmental Management Project (SAREMP).

This three-year Project was initiated in April 1980, at the request of the City of Stratford. SAREMP is funded entirely by the Ontario Ministry of the Environment. The purpose of the project is to provide a comprehensive water quality management strategy for the Avon River basin. In order to accomplish this considerable investigation, monitoring and analysis has taken place. The outcome of these investigations and field demonstrations will be a documented strategy outlining the program and implementation mechanisms most effective in resolving the water quality problems now facing residents of the basin. The project includes assessment of urban, rural and in-stream management mechanisms for improving water quality.

This report results directly from the aforementioned investigations. It is meant to be technical in nature and not a statement of policy or program direction. Observations and conclusions are those of the author and do not necessarily reflect the attitudes or philosophy of all agencies and individuals affiliated with the Project. In certain cases the results presented are interim in nature and should not be taken as definitive until such time as additional support data is collected.

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ABSTRACT

Certain crop management measures involving tillage practices and the choice of cropping systems can reduce erosion and help control resulting water quality problems. They may also impact net farm incomes by increasing production costs or reducing yields and sales revenues. These economic impacts are estimated in this report for the Avon River Basin using production cost data, crop price data and crop yield figures for Ontario. Published information on erosion control measures is combined with information acquired from agricultural workers in the Stratford area to develop estimates of likely impacts.

While the impact figures are only approximate, they do provide background information to help evaluate and develop an agricultural program for water quality control . Notable findings are that:

a) the use of short cash crop rotations to replace a corn monoculture system may be justifiable on economic grounds alone;
b) conservation tillage based on the fall use of a chisel plow on silt loam soils may be economically prohibitive;
c) cross-slope or contour till age can be usefully applied to only a limited portion of productive land in the Avon River Basin.

The analysis presented here is partial in that benefits related to reduced soil loss and to lower sedimentation of drains are not assessed.

ACKNOWLEDGEMENTS

The contributions of P. Fish, N. Bird, G. Knight and A. Graham, agricultural workers in the Stratford Area, have been instrumental to the completion of this report; while the speedy and patient response of C. Parkes working on the word processor, has made report preparation a painless task.

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1.0 INTRODUCTION

This report summarizes an economic analysis of remedial crop management measures considered for soil loss control in the Avon River Basin. Measures considered here include the use of rotations, fall cover crops, conservation tillage and cross-slope or contour tillage. Economic impacts are first assessed on a per hectare basis for each measure. Results concerning technical feasibility in the Avon River Basin are then presented followed by a basin-wide assessment of economic impact. The soil loss impacts of these measures are not discussed here.*

2.0 ECONOMIC IMPACTS

2.1 Background Data

The per hectare cost of crop management practices for control of soil loss are derived in this section. The derivation is based on crop yield data, crop prices and production cost infomation published by the Ontario Ministry of Agriculture and Food (1982, 1981, 1979). These data are summarized in Table 1 for the crops considered here. Price and yield values given in the table reflect historical trends and measure variability using the observed standard deviation about these trends**. Production costs are based on current (1982) prices for farm inputs.

Production cost data reported in Table 1 includes the annual interest and depreciation cost of operating and other farm capital. Certain measures discussed below require new equipment. The associated costs are not estimated on a per hectare basis as are other economic impacts, hut on a per farm basis based on required number of implements per farm and implement life time.

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* Soil-loss impacts are the subject of two SAREMP reports: Identification of Priority Management Areas in the Avon River Watershed Technical Report R-3

** Crop values in Table 1 are high relative to current prices which lie below the trend apparent in historical prices that are adjusted to a 1982 dollar base.

TABLE 1: Crop Production And Value Data

Crop	Yields, [a] Tonnes/ha (mean ± std. dev.)	Crop Value [b] per Tonne (mean ± std. dev.)	Crop [c] Value per Hectare (mean)	Production [d] Cost per Hectare	Net Revenue per Hectare
		-------------	1982 dollars	-------------	
Winter Wheat	3.37 ± 0.23	212 ± 48	714	583	131
Barley	3.02 ± 0.21	172 ± 37	519	493	26
Grain Corn	6.03 ± 0.38	185 ± 48	1116	862	254
White Beans	1.67 ± 0.16	562 ± 173	939	774	165
Hay	6.09 ± 0.54	65 ± 14	396	664[e]	-268

[a] From a memorandum to P. Fish from M. Fortin concerning price and yield values, February 2, 1982. Yield figures are the 1982 values on the trend line relationships described in this memo.

[b] From M. Fortin "Agricultural Crop Values for the Assessment of Rural Projects". SAREMP File Report, January 1982. Crop values are updated to 1982 using the Consumer Price Index.

[c] Mean crop value = (mean yield) x (mean price).

[d] From 1982 Crop Budgeting Aids, Ontario Ministry of Agriculture and Food.

[e] Excludes fertilizer and yield benefits cited by OMAF.

No attempt is made to forecast future prices or costs or to account for the inherent variability of yields and prices through time. The implication of these omissions is that the error accompanying final cost estimates may be considerable. Comparisions between alternative measures must therefore be made with caution. While order of magnitude cost differentials are likely to be reliably measured, apparent differences of 10 or 20% should not be given much weight.

2.2 Fall Cover Crops

This measure involved the incorporation of a fall cover crop into the cropping sequence to improve soil structure and provide greater vegetative cover. The change may involve shifts from a corn monoculture to cash crop rotations or the inclusion of fall cover crops after grain in existing rotations. The following assumptions are used in calculating economic impacts of shifting from a corn monoculture to a rotation and using a fall cover crop of red clover:

(a) The corn based rotation that replaces corn monocultures uses three successive years of corn followed by a year of barley with a fall crop of red clover that is plowed under.

(b) Monoculture yields are 5% below provincial averages while rotation system yields are 5% above provincial averages in the first year after a forage crop or red clover and equal to provincial averages otherwise. (A 30% difference in yield between a corn monoculture and a corn-oats-hay-hay rotation was observed on Brookston clay, (Vyn *et al*, 1979, pg. 21)). This assumption is applied to corn and beans.

(c) Nitrogen supplements are halved in the first year after hay and red clover.

(d) Red clover seed is applied at a rate of 10 kg/ha (9 lb/acre) at a cost of $1.21/kg ($0.55/lb.) or $12.00/ha*. Seeding is done by broadcasting with the second application of nitrogen over grain. No additional labour cost is incurred.

Using assumptions cited above, unit values of net revenues are estimated for corn and bean systems in Table 2. Based on mean net revenues given here, a shift from a corn monoculture to a rotation including red clover generates a net benefit of $13.00 per hectare.

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* Information obtained from P. Fish (UTRCA), personal communication.

The mean net revenue for the corn rotation without red clover would be $197 per hectare. For the bean rotation it would be $154 per hectare or $13 less. These impacts on net revenues result from the assumed values for yield increases.

No crop changes are considered for existing cash crop rotations, however, the addition of a red clover fall cover crop is evaluated. Likely systems for the existing cash crop rotations are *:

White Bean (2 years)/Wheat (1 year)/Corn (2 years)

or

Corn (3 years)/Spring Barley (1 year)/Wheat (1 year).

Crop budgets for these rotations are given in Table 3. Red clover would be incorporated into these crops by underseeding with wheat. As discussed in the footnote to Table 3 costs would increase in that year and revenues would increase in the subsequent year. The mean annual impact on net revenues over the full rotation for both corn and beans would be an increase of $11/ha.

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* Information obtained from P. Fish (UTRCA), personal communication.

TABLE 2: Crop Budgets For Monocultures and Short Cash Crop Rotations

Year	Crop	Cost/ha	Revenue/ha	Net Revenue/ha
		CORN MONOCULTURE		
	Corn	862	1060	198
		CORN ROTATION		
1	Corn	850	1172	322
2	Corn	862	1116	254
3	Corn	862	1116	254
4	Barley/Red Clover	505	519	14
Mean		770	981	211
		BEAN ROTATION		
1	Beans	769	986	217
2	Beans	774	939	165
3	Winter Wheat/Red Clover	595	714	119
Mean		713	880	167

2.3 Conservation Tillage

The conservation tillage system considered here involves fall tillage with a chisel plow followed by conventional secondary spring tillage. A moldboard plow is assumed to be used only after red clover or a forage crop. An economic assessment of this tillage technique is undertaken for the corn and bean crop systems presented in the previous section, and for a hay based rotation that assumes three years of hay followed by 2 of corn and one of barley. Crop budgeting for the hay rotation is given in Table 4. Assumptions given in section (3.2) above involving rotations are applied to the hay rotation budget calculations as well. The hay price used here may not accurately represent crop value to those farmers growing hay for their own livestock. At this price, however, the hay rotation generates an annual net loss of $7.00 per hectare over the entire rotation.

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* Personal communications with P. Fish (UTRCA) and N. Bird (OMAF).

TABLE 3: Crop Budgets For Long Cash-crop Rotations

Year	Crop	Cost/ha	Revenue/ha	Net Revenue/ha
		BEAN ROTATION		
1	Beans	774	939	165
2	Beans	774	939	165
3	Winter Wheat *	583	714	131
4	Corn	862	1116	254
5	Corn	862	1116	254
Mean		771	965	194
		CORN ROTATION		
1	Corn	862	1116	254
2	Corn	862	1116	254
3	Corn	862	1116	254
4	Barley	493	519	26
5	Winter Wheat *	583	714	131
Mean		732	916	184

* As a fall cover crop, red clover could be planted with the winter wheat. Costs in that year would increase by $12/ha. Costs and revenues in the next year of corn are as shown for year one of the corn rotation in Table 2. Net revenue increases to $322/ha. Over the period of the rotation, the mean net annual revenue for the two rotations would increase by $11/ha.

TABLE 4: Crop Budget for a Hay Rotation

Year	Crop	Cost/ha	Revenue/ha	Net Revenue/ha
1	Corn	850	1172	322
2	Corn	862	1116	254
3	Barley	560 [a]	519	-41
4	Alfalfa Hay	589 [a]	396	-193
5	Alfalfa Hay	589 [a]	396	-193
6	Alfalfa Hay	589 [a]	396	-193
Mean		673	666	-7

[a] Alfalfa establishment costs are incurred in year 3 and do not appear in years 4, 5 and 6.

The economic impacts of conservation tillage stem from equipment costs, yield reductions, fuel savings, and increased herbicide applications. Equipment costs are considered at the end of this section, while annual cost and revenue impacts are discussed below. One report from the University of Guelph cites fuel savings of 2 to 6 litres per hectare (Vyn *et al*, 1979, pg. 36, 39) worth up to $2.00 at unsubsidized prices. A 10% increase in herbicide use on corn would increase costs by $1.60. These values are small in comparison to total costs and they tend to offset each other. Consequently, we ignore these costs and focus our attention in yield reductions.

Several Ontario studies of yield impacts are described by Vyn, Daynard and Ketchson (1979). These studies show yield reductions for corn ranging from 2 to 15% with an 8% reduction observed on two studies involving two year trials on silt-loam soils. This soil type predominates in the Avon River Basin. An 8% reduction of yields is assumed for corn, grain and bean crops in years when conservation tillage is applied. The resulting changes in net farm revenue per hectare are given in Table 5 for various cropping systems.

TABLE 5: Impact Of Conservation Tillage On Net Farm Revenue*

Crop	Mean Net Revenue		Change in Net Revenue
	Conventional Tillage	Conservation Tillage	
	- - - - - - - -	dollars/hectare	- - - - - - - -
Continuous Corn	198	113	-85
Short Corn Rotation**	197	120	-77
Long Corn Rotation**	184	111	-73
Short Bean Rotation**	167	85	-82
Long Bean Rotation**	194	117	-77
Hay Rotation	-7	-29	-22

* Equipment costs are not included here.
** based on rotations without fall cover crops after winter wheat.

To assess equipment costs per farm, it is assumed that the chisel plow is added to the farmer's tillage equipment and does not replace a moldboard plow which he would continue to use. A range of equipment is available; for instance a model 129 Massey Ferguson chisel plow with mulcher unit costs $4375.00 in 1980 while the Glencoe soil saver (10 foot width) costs $7584.00 in 1980. Based on farm machinery cost escalations of 25% over the intervening period*, these prices would likely range from $5500.00 to $9500.00 today. A capital cost of this magnitude would be incurred by each farmer who chose to use a chisel plow to prevent soil loss.

2.4 Contour and Cross-Slope Tillage

Contour and cross-slope tillage reduce soil loss by aligning furrows across the direction of flow of overland runoff. Cross-slope tillage requires alignment of straight furrows across the predominant slope while contour tillage uses a curving furrow to maintain a perpend-

* Statistics Canada, Farm Machinery and Vehicles Input Price Index for Eastern Canada - 1980 to 4th quarter 1981.

icular alignment of furrows with the direction of slope. In both cases, it is assumed that tillage equipment and cropping do not change so that the only economic impact arises from changes in the efficiency of field and labour utilization. For instance the elimination of fence rows to facilitate contour tillage will increase the efficiency of field work and enlarge total cropped areas. Costs will increase however if realignment of tillage patterns results in more frequent turning in head lands or the enlargement of less productive head land areas.

The Avon River Basin is characterized by short complex slopes in the upper reaches and by rather level fields in lower reaches. In the first case, contour tillage is difficult if not infeasible and would likely cause an increase in production costs. On very level ground cross-slope or contour tillage becomes less effective in preventing soil loss*.

It is assumed here that, where applied, contour or cross-slope tillage increases production costs. Little data is available on the magnitude of the cost increase. A report by Ecologistics (1981, pg. 31) cites a 1977 cost of $6.00 per hectare. Using the consumer price index for all Canada as a measure of inflation, this translates into $12.00 per hectare in 1982. This figure is adopted as a measure of cost for both of these tillage practices.

3.0 TECHNICAL FEASIBILITY

The question of technical feasibility deals here with physical constraints on implementation rather than economic or institutional constraints.

Existing cropping and tillage practices in large part determine the degree to which changes can be made. For instance, measures such as rotations and cross-slope tillage are already in place to a large extent. Any discussion of their use must account for this existing practice. A description of current cropping practice broken down by land slope is given in Table 6. Only intensive cropping systems are presented here; less intense systems characterized by small grains, hay and pasture are excluded. The intensive systems comprise only 49% of the total non-urban area within the basin but may account for -90% of gross erosion and 87% of sediment delivered to the stream channel from this area (Coleman, 1982). These figures explain why we focus on intensive cropping systems here.

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* Wischmeier and Smith, Predicting Rainfall Erosion Losses - A Guide to Conservation Planning, USDA Agricultural Handbook No. 537, December 1978, pg. 34-35.

TABLE 6: Distribution Of Cropping Systems In The Avon River Basin [a]

Crop System [b]	Description	Slope Category (%)						Total Area
		0-2	2-5	5-7	7-10	10-15	G 15	
		hectares						
Corn Monoculture	row crops only with corn predominating	1504	185	6	4	37	3	1739
Bean Monoculture	row crops only with beans predominating	582	9	-	-	-	-	591
Corn System	rotation with at least 40% in corn and possibly beans, grain and/or forage appear as well	1837	317	20	26	28	12	2239
Bean System	rotation with at least 40% in beans and possibly corn, grain and/or forage appear as well	528	20	21	11	2	5	587
Mixed System	rotation with equal proportions of corn/beans, small grains and forage	10373	1300	127	130	150	52	12132

a Information for Table 6 taken from Coleman, 1982.

b These crop designations are from Coleman, 1982. They are assumed to correspond to the systems discussed in this report as follows:

- corn monoculture - corn monoculture
- bean monoculture - short bean rotation
- corn system - long corn rotation
- bean system - long bean rotation
- mixed system - hay rotation

If we assume that the corn monocultures are strict monocultures (only corn is grown), then the associated area sets an upper limit on the areas to which the short corn based cash crop rotation of Table 2 could be applied. A red clover fall cover crop could be used with three cash-crop rotation systems given in Table 6: the bean monoculture, the corn system and the bean system since these are assumed to correspond respectively to the short bean rotation, the long corn rotation and the long bean rotation described in Section 2.2 above.

The applicability of contour and cross-slope tillage described above depend on existing practices and on the size and complexity of slopes. For reasons of safety we assume that they cannot be applied on slopes in excess of 15%. Furthermore, there is some evidence that these techniques are ineffective on slopes less than 2%*. Of the areas that remain, some will already be tilled across the slope presumably for reasons of efficiency or conservation, some will have slopes too complex to enable consistent application of contour or cross-slope tillage, and others could reasonably be recommended for contour or cross-slope tillage.

By way of determining the extent to which these cases apply, three sub-catchments, depicted in Figure 1, were screened in some detail using chronoflex maps. Results of this screening, summarized in Table 7, suggest that additional cross-slope farming is of limited applicability in flat areas like the Douglas Drain catchment. In more hilly areas like the two other catchments there is greater potential for application of cross-slope and contour tillage. Throughout the basin cross-slope tillage would appear to be widely used now.

* For applications of the universal soil loss equation, no P-factor is defined for cross-slope and contour tillage on slopes below 2% (Coleman, 1982).

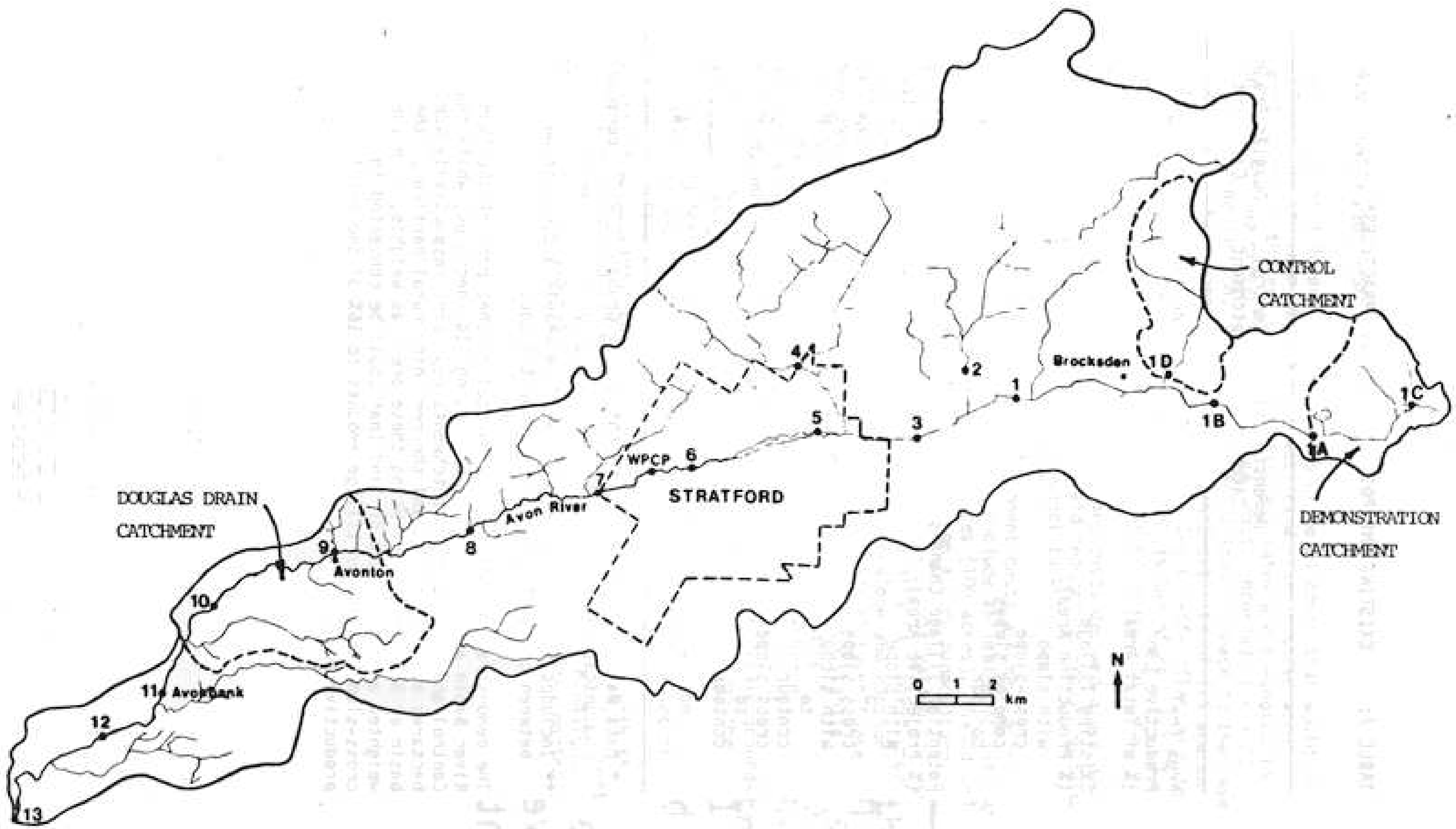

FIGURE 1: Catchments Used For A Detailed Review Of Existing Tillage Practices

TABLE 7: Existing And Potential Tillage Practices*

	Demonstration Catchment	Control Catchment	Douglas Drain Catchment
Area (ha)	518	498	1106
Productive Land (% of Total Area)	77	76	87
Existing Tillage (% Production Area):			
with slope	45	26	4
cross-slope	49	68	91**
complex slopes	5	5	0
contour	0	0	0
Potential Tillage Changes (% Projective Area):			
with slope to cross slope	24	23	4
with slope to contour	21	3	0
cross slope to contour	8	6	0
TOTAL	53	32	4

* Data was obtained from G. Knight and A. Graham (UTRCA), personal communication.

** Includes areas which are too level to enable a distinction between cross-slope and with-slope tillage.

The demonstration catchment is typical of that part of the Avon River Basin above Station 1B comprising 1147 hectares, while the Control and Douglas Drain catchments represent respectively 4264 hectares above Station 3 and the remaining rural portion of the basin or 9832 hectares. Using these areas as weights, then the weighted average amount of land that could be converted to cross-slope or contour tillage amounts to 16% of the total productive area.

4.0 BASIN WIDE ASSESSMENT OF COST

This final section presents estimates of total costs that would be incurred if the crop management practices discussed above were applied across the entire basin. Cost estimates are presented in the form of the present value of annual costs incurred over a 20 year planning horizon. Future costs are discounted back to the base year, 1982. For planning purposes, an interest rate of 17% and an inflation rate of about 10% are assumed. The net-of-inflation rate of interest, called the real interest rate, is therefore about 7%. These values are used in discounting future costs back to 1982.

The cost estimates are based on per hectare costs derived above and ignore any long term impacts such as yield reductions resulting from gradual loss of top soil from areas subject to erosion.

Conservation tillage costs include implement costs assumed to be $8,000 per farm. Additional assumptions include an implement life of 10 years and a farm size of 40.5 hectares (100 acres). Based on assumptions that were made, a shift &way from a corn monoculture will decrease total farm income only slightly. Conservation tillage could prove to be quite costly, while the use of a fall cover crop may increase farm incomes. The cost of cross-slope and contour tillage is low due in part to the limited applicability of these measures. The implication of these results is that substantial beneficial soil loss and water quality impacts should be conclusively demonstrated in order to justify a wide-scale application of conservation tillage; while the use of short rotations and full cover crops may be justified on economic grounds alone.

These implications will of course depend in part on the assumptions that are made above. Caution must be used in interpreting these results since soil-loss and sedimentation benefits are not assessed here. Moreover, only a limited set of control options are considered. For instance alternative conservation tillage techniques such as moldboard tillage with the trash covers removed are not accounted for. Omissions of this sort reflect information constraints faced by the author and highlight the need for more applied research in the area of soil-loss control.

TABLE 8: Total Costs Of Crop Management Practices That Reduce Soil Erosion

Remedial Measure	Existing Land Use	Annual Cost per Hectare	Total Capitalized Cost of Management Measures Applied to Slopes Exceeding: 7%	5%	2%	All Slopes
Corn Monoculture to Short Corn Rotation	Corn Monoculture	1	500	600	2,700	20,000
Red Clover as a Fall	Short Bean Rotation	-13 [b]	0	0	-1,300	-87,000
Cover Crop After Grain	Long Corn Rotation	-11 [b]	-8,200	-11,000	-50,000	-279,000
	Long Bean Rotation	-11 [b]	-2,200	-4,900	-7,400	-73,000
	TOTAL		-10,400	-15,900	-58,700	-439,000
Conservation	Corn Monoculture	85 [e]	56,000	63,000	297,000	2,194,000
Tillage [c]	Long Corn Rotation	73 [e]	74,000	97,000	454,000	2,520,000
	Short Bean Rotation	82 [e]	0	0	11,500	726,000
	Long Bean Rotation	77 [e]	21,000	46,000	69,000	687,000
	Hay Rotation	22 [e]	182,000	251,000	963,000	6,643,000
	TOTAL		333,000	457,000	1,794,000	12,770,000
Cross-Slope or	Corn Monoculture	12	5,600	6,400	32,000	32,000
Contour Tillage [d]	Long Corn Rotation	12	7,300	10,000	53,000	53,000
	Short Bean Rotation	12	0	0	1,200	1,200
	Long Bean Rotation	12	1,800	4,600	9,000	9,000
	Hay Rotation [e]	12	12,000	21,000	109,000	109,000
	TOTAL		27,000	42,000	204,000	204,000

Notes: [a] This capitalized cost is the present value of total annual costs estimated assuming a 17% interest rate, a 10% inflation rate, and a 20 year time horizon.

[b] A negative cost indicates a benefit.

[c] Conservation tillage costs include implement costs in the capitalized costs section but not in the column of annual costs.

[d] Cross-slope and contour tillage are assumed to be applied only to areas with slopes below 15% and above 2% (see text for details).

[e] The hay rotation tillage cost is only applied to those years of the rotation involving cash crops (3 out of 6 years).

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ADDENDUM

New information regarding tillage system impacts or yields has been published since the preparation of this report*. For Ontario conditions, the following grain corn yield impacts are cited:

	Silt loam soil	Clay loam soil
fall chisel plow	-4% to -8%	-6%
spring moldboard plow	-4% to -8%	not available

Based on this information, a 6% loss of yield is assumed for grain corn and other cash crops when conservation tillage is applied. Crop income impacts are re-estimated below for the price levels given in Table 1 and for alternative prices more characteristic of current values. These alternative prices are**:

winter wheat	-	$544/ha
barley	-	$326/ha
grain corn	-	$731/ha
white beans	-	$659/ha
hay	-	$590/ha

Alternative Estimates of Conservation Tillage Impacts on Cropping Incomes.

Crop System	Crop Value: Long-Term Trend Values	Crop Value: Observed 1982 Values
Continuous Corn	-64	-42
Short Corn Rotation	-59	-38
Long Corn Rotation	-55	-37
Short Bean Rotation	-53	-38
Long Bean Rotation	-58	-40
Hay Rotation	-16	-11

* T.J. Vyn *et al*, "Progress in Tillage Research", Advisory Information, Ont. Ministry of Agriculture and Food and Ont. Agricultural College, Guelph, Ont. AGDEX No. 111/516, April, 1982.

** OMAF crop budgeting aids, 1982.

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