

## Meeting the Challenges of Sustainable Soil and Water Resource Use for Food Production in Ontario, Canada

*Peter Stonehouse*

Department of Agricultural Economics and Business  
University of Guelph  
Guelph, Ontario, N1G 2W1  
Canada  
E-mail: stonehou@agec.uoguelph.ca

**Abstract:** Expanding urban-industrialization in southern Ontario is vying for use of Canada's best farmland. Agriculture's response has been to re-structure, to mechanize and automate, to increase usage of imported synthetic inputs, all at the expense of environmental protection, natural resource stewardship and sustainability. Widespread adoption of organic farming systems would do much to mitigate the stewardship and sustainability problems, but too many impediments exist to prevent this. Adoption of reduced-input farming techniques would offer a partial solution to sustainability problems. Additional measures in the form of public intervention should be employed. Public policies aimed at inducing farmers to expend more conservation effort on behalf of the environment and sustainable agri-food systems could encompass farmer education and extension assistance, financial assistance, cross-compliance measures, and compulsion backed by litigation and penalties. Such policies would best be targetted, especially when scarce public funds are earmarked for subsidizing farmers' conservation efforts, rather than universally applied. Targetting criteria should be not only high potential for achieving environmental protection and agri-food sustainability, but also positive net social welfare outcomes. Farm sites conferring highest positive net social welfare should be ranked first for targetting.

**Keywords:** environmental protection, agri-food sustainability, farming systems, public intervention, targetted policies, net social welfare

### 1 Ontario natural resource base under pressure

Although the province of Ontario in central Canada is large enough to embody Spain, France and Germany, the agricultural land base extends to only 6 million ha (Statistics Canada). Most of that land, and all the best farmland, lies in the southern portion of the Great Lakes region where a rapidly-expanding urban-industrial complex handily out-competes farmers. In response to this shrinking farmland base, there is constant pressure for agriculture to become increasingly industrialized and intensive in its production techniques. Separation of livestock from crop production; greater applications of synthetic inputs such as fertilizers, agrochemical pesticides, antibiotics and feed additives; more intensive tillage; and shorter crop rotations have all contributed to degradation of the southern Ontario and Great Lakes basin natural resource base (Stonehouse, 1996). Agriculture has emerged as the principal perpetrator of nonpoint source pollution (Ribaud, 1992), and the sustainability of Ontario's agri-food sector is under question (Stonehouse, 1999). Additional threats to this sustainability are engendered by both point source and nonpoint source pollution from the urban-industrial complex.

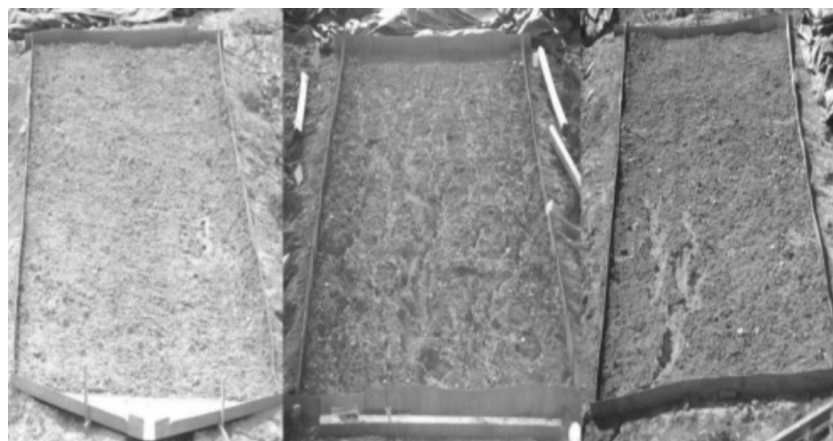
**Sustainability Issues.** The connotation of sustainability for Ontario's agri-food sector is meant to be more than a capability of maintaining or improving food output levels at profitable rates for the indefinite future. The sector must achieve this without degrading the natural resource base, without unduly damaging the environment, and without detracting from overall biodiversity, as advocated, by,

for example, Köhn *et al.* (1999), Brouwer and Crabtree (1999), McRae *et al.* (2000). On all such grounds, the sector fails to meet the sustainability criterion (Stonehouse, 1999). Furthermore, sustainability of the agri-food sector should connote the maintenance of socially viable rural farm communities; the political empowerment of rural farm communities to fulfill their multifunctionality role as food producers, landscape managers, resource stewards and species protectors; and the maintenance of health and welfare of both human and domesticated livestock species. By these measures also, Ontario's agri-food sector is failing the sustainability test (Stonehouse, 1999). In a bid to produce an ever-greater abundance of yet cheaper food, the Ontario agri-food sector is degrading the resource base and damaging the environment to the extent that the future livelihood of all species, including human is being jeopardized. Moreover, Ontario's rural farm communities are losing their social viability and political empowerment through the rapid and extensive restructuring of the agri-food sector toward fewer but larger entities.

The objective of this paper is to explore ways of meeting the challenges inherent in obtaining a sustainable agri-food sector in Ontario. The particular focus is on finding ways of meeting the challenges of using soil and water resources sustainable for food production.

## 2 Meeting sustainability challenges through alternative farming systems

The industrialized, intensive way of producing food, referred to here as the high technology (HT) system, with its emphasis on large scale structure in search of economics of size and scale, is not the only way to proceed. At the other extreme is the organic agri-food system (ORG), with its accent on less intensive production, smaller scale and local marketing in search of human and animal welfare, while protecting the environment and natural resource base. In between is a continuum of systems representing varying levels of scale and intensity, such as reduced input (RI), integrated pest management (IPM), low input sustainable agriculture (LISA) to name only several (Figure 1).



**Fig.1** Continuum of alternative farming systems

Comparisons made empirically among HT, RI and ORG systems in Ontario agriculture (Stonehouse *et al.*, 2001; Ogini *et al.*, 1999; Stonehouse *et al.*, 1996) have revealed that:

- biologically, there is not much to choose among the three in terms of crop yields and dairy cow yields, despite great differences in production inputs used and procedures followed;
- economically, RI systems generated highest revenues and ORG systems lowest, HT systems generated highest production costs and ORG systems lowest, and RI systems were most profitable, followed by ORG systems, then HT systems (Table 1).

**Table 1 Biological and economic comparisons across High-Technology (HT), Reduced-Input (RI) and Organic (ORG) Farms in Ontario, Canada**

	HT	RI	ORG
Average crop yield- maize (t/ha)	6.3	7.1	6.6
- beans (t/ha)	2.4	2.5	3.0
- autumn cereal grains (t/ha)	3.5	4.0	2.8
- hay (t/ha)	7.1	8.0	7.0
Average milk yield (litres/cow/year)	5,821	5,877	5,882
Average gross margin- maize (\$/ha)	264	444	667
- beans (\$/ha)	326	380	569
- autumn cereal grains (\$/ha)	190	344	352
- dairy (\$/cow)	1,459	1,564	1,901
Average gross farm income (\$'000/yr)	194	219	180
Average total farm production costs (\$'000/yr)	107	97	88
Average total farm overhead costs (\$'000/yr)	50	42	33
Average net farm income (\$'000/yr)	37	80	59

Using a series of sustainability indicators, (Table 2) comparisons among the three systems indicated that:

- ORG systems were most diversified in terms of numbers of crops grown, average length of crop rotation, and proportion of farms having livestock enterprises, and that this contributed to ORG systems being most self-sufficient in crop seeds and plants, crop nutrients, livestock replacement, and livestock nutrients (not shown in Table 2) through careful nurturing of resources and internal resource cycling; the greater levels of enterprise diversity and inputs self-sufficiency furthermore rendered ORG systems less vulnerable to outside market forces and price volatility, and so less exposed to risk than their HT and RI counterparts;

**Table 2 Sustainability indicators across High-Technology (HT), Reduced-Input (RI) and Organic (ORG) Farms in Ontario, Canada**

	HT	RI	ORG
Average total number of crops grown per farm	4.5	5.5	7.2
Average length of crop rotation per farm (years)	4.2	5.1	7.6
Proportion of year soil covered by crop or residue (%)	72	79	86
Proportion of tillable land in hay/pasture (%)	19	22	39
Proportion of farms having livestock enterprises (%)	44	32	100
Proportion of livestock farms composting manure (%)	0	0	100
Proportion of tillable land in high-energy maize (%)	42	41	6
Average expenditures on synthetic pesticides (\$/ha)	45	29	0
Average ruminant breeding herd replacement rate (%)	24	22	19
Labour inputs per 100 ha land (person equivalents)	0.95	1.0	1.28

- environmentally, ORG farms caused the least damage by virtue of their higher proportion of year-round coverage of soil by crops, especially hay/pasture, or crop residues and the lowest proportion of their land allocated to highly-erosive and energy-consuming crops like maize and beans; by virtue of a 100% rate of composting livestock manure in order to stabilize plant nutrients and destroy weed seeds; and by virtue of zero expenditures on imported synthetic fertilizers (not shown in Table 2) and pesticides;
- animal welfare-wise, ORG systems displayed the lowest breeding herd replacement rate (indicating greater longevity), the lowest level of livestock confinement (a proxy for greater

animal freedom and access to natural surroundings), and the lowest levels of confinement intensity (not shown in Table 2) of all three systems;

- socially, ORG systems had the highest ratio of labour inputs to land farmed, which, together with their smaller scale of operations and therefore greater numbers of smaller farms, indicated higher levels of support for viable rural farm communities than their HT or RI counterparts;
- in terms of human welfare, the proscription of potentially dangerous synthetic fertilizers and agro-chemical pesticides on ORG systems ensured lowest levels of exposure to farm operators and their families, and so least risks to human health and longevity of all three systems.

Of the three alternatives, ORG systems appeared to meet overall sustainability the best, despite ranking behind RI systems on biological and economic grounds. This implies that much of the challenge to Ontario agri-food sector sustainability could be met if sufficient numbers of HT farmers could be persuaded to convert to ORG approaches. This is rather unlikely to happen. The number of farmers currently certified to be using ORG methods in Ontario is only about 750, or a little more than one percent of the total 60,000 or so commercial farmers. The proportion may well continue to grow as it has over the past 15 years, but it is surmised that there are too many impediments to any mass conversion to ORG methods. The HT approach has been the one favoured in Ontario educational institutions and in its agricultural extension service since mid-20<sup>th</sup> century, and so has been adopted as the new traditional or conventional agriculture. The HT method represents “farming made easy”, given its focus on fewness of enterprise lines, high degree of mechanization, and extreme dependence on imported synthetic inputs. By comparison, the complexities of the holistic, integrated approaches of ORG methods are far more demanding of management skills and innovative thinking, likely leading to a view that ORG systems are highly risky and therefore not to be preferred.

True, conversion from HT to RI systems is occurring in Ontario agriculture, and this could be viewed as a compromise between the extremes of HT and ORG methods. The question is, to what extent would RI systems meet the overall sustainability criterion? It is argued here, not very well. Environmental and ecological damage would be higher under RI than under ORG systems, while rural farm community viability and animal and human welfare would be lower. Further solutions must be sought.

### **3 Meeting sustainability challenges through targetted policies**

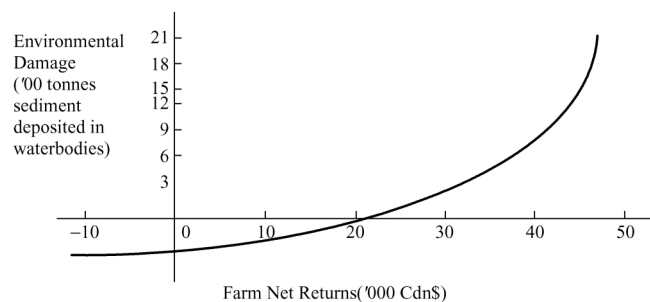
Previous research has indicated the inadequacy of voluntary conservation compliance by farmers in meeting natural resource stewardship and environmental protection needs of the public in Canada (van Vuuren, 1986; Fox *et al.*, 1991) and in the United States (Crosson, 1991; Faeth, 1993), and in many other parts of the world (Napier *et al.*, 1994). Public intervention has been called for to induce or even to compel sufficient compliance by farmers (Ribaud, 1992; Paolette *et al.*, 1993). Given heterogeneity across farm sites and among farmers in terms of a) amount of environmental damage perpetrated, b) the extent to which such environmental damage causes costs (in the form of foregone use of resources, or threats to human health or welfare), and c) the extent to which amelioration of such environmental damage results in positive net social welfare outcomes, a targetted approach to encouraging greater conservation compliance by farmers has been advocated (Ribaud, 1986; Stonehouse, 1996). Such an approach would select sites (farms) needing additional conservation effort based not only on extent of environmental damage caused but also on extent of net social welfare gains associated with damage amelioration induced through intervention policies ranging from farmer education and extension assistance to financial assistance or cross-compliance to, where necessary, compulsion supported by litigation and fines. Sites targetted first for receipt of public transfer monies would be those capable of generating highest potential net social welfare gains (Stonehouse, 1996).

It is important to undertake net social welfare impact studies especially when public funds for subsidies are scarce, because previous research has demonstrated that:

- not all land degradation on farms results in deposition of sediment and adhered phosphorus into nearby watercourses (much can be deposited between the site of erosion and the nearest waterbody);

- not all sediment and phosphorus finding its way into waterbodies causes diminution of water quality (this depends on rates of pollutant deposition, the size of the waterbody affected, and the uses to which the water is being put);
- not all improvements to water quality due to on-farm conservation efforts lead to positive net social welfare outcomes, whereby public and private (on-farm) benefits exceed public and private conservation costs (this depends on specific uses of the water, quality of water prior to conservation programmes, number of users of water for any specific use, and the willingness of those users to pay for improvements in quality);
- even when all farmers in a watershed implement sufficient conservation measures, non-farm sector firms and private households must also operate with conservation in mind in order to achieve overall resource quality standards (van Vuuren *et al.*, 1997).

It is furthermore possible for some conservation practices on some farm sites to confer considerable potential societal benefits through environmental damage mitigation without causing much private economic cost to the farmer. Recent research demonstrated initial steepness to a tradeoff curve between environmental protection gains and farm-level profits (Figure 2) (Stonehouse, 2002). Following this initial modest tradeoff between environment and economics, however, additional conservation efforts proved to be increasingly costly to the farmer, rather analogously to the diminishing returns phenomenon characteristic of bio-physical output-input relationships in agriculture. Note how the achievement of very low levels of environmental damage (average of  $3\text{t} \cdot \text{ha}^{-1}$  sediment deposited in waterbodies) generated negative farm net returns (Figure 2).



**Fig.2** Environmental-economic tradeoff for a 100 ha Ontario dairy farm

#### 4 Conclusions and implications

Based on initial empirical findings, the following tentative conclusions were drawn:

- highly technology (HT) farming systems prevailing in Ontario are more environmentally damaging and less sustainable than reduced input (RI) systems, than organic (ORG) systems;
- therefore having a majority of Ontario farmers convert to RI systems, and even better to ORG systems, would go far toward meeting the challenges of sustainability;
- unfortunately, too many obstacles to widespread adoption of ORG techniques in Ontario render this an unlikely solution, and broad conversion to RI methods would provide at best a partial solution to conservation and sustainability problems;
- additional conservation and sustainability prescriptions would appear to reside best with public intervention whereby policies are used to target farm sites where needed environmental protection measures would engender the highest economic benefits measured in net social welfare terms;
- on an overall watershed basis, it is a necessary but not a sufficient condition that farmers operate with a high enough level of conservation effort; sufficiency for meeting sustainability

requires that industry, private householders and other potential polluters in the non-farm sector put enough conservation and sustainability effort into the way they operate.

### References

- Crosson, P.R. 1991. Cropland and soils: Past performance and policy challenges. In *America's Renewable Resources*, K. Frederick and R. Sedjo (eds.). Washington, D.C: Resources for the Future.
- Faeth, P. 1993. Evaluating agricultural policy and the sustainability of production systems: An economic framework. *Journal of Soil and Water Conservation*, 48(2): 94-144.
- Fox, G.C., A. Weersink, G. Sarwar, S. Duff and B. Dean. 1991. Comparative economics of alternative agricultural production systems : A review. *Northeastern Journal of Agricultural and Resource Economics* 20(1) : 124-142.
- Napier, T.L., S.M. Camboni and S.A. El-Swaity (eds.) 1994. *Adopting Conservation on the Farm: An International Perspective on the Socio-economics of Soil and Water Conservation*. Ankeny, Iowa : The Soil and Water Conservation Society.
- Ogini, Y.O., D.P. Stonehouse and E.A. Clark. 1999. Comparison of organic and conventional dairy farms in Ontario. *American Journal of Alternative Agriculture* 14(3) : 122-128.
- Paoletti, M.G., T.L. Napier, O. Ferro, B. Stinner and D. Stinner (eds.) 1993. *Socio-economic and Policy Issues for Sustainable Farming Systems*. Padova, Italy: Cooperativa Amicizia S.r.l.
- Ribaudo, M.O. 1986. Consideration of off-site impacts in targeting soil conservation programs. *Land Economics* 62(4) : 402-441.
- Ribaudo, M.O. 1992. Options for agricultural non-point-source pollution control. *Journal of Soil and Water Conservation* 47(1): 42-46.
- Statistics Canada. 1981, 1986, 1991, 1996. *Census of Agriculture*. Ottawa, Ontario : Queen's Printer.
- Stonehouse, D.P. 1996. A targetted policy approach to inducing improved rates of conservation compliance in agriculture. *Canadian Journal of Agricultural Economics*. 44(2): 105-120.
- Stonehouse, D.P. 1999. Complex approach to the sustainability of natural resources. *Zemedelska Ekonomika*. 45: 169-173.
- Stonehouse, D.P. 2002. Policy incentives supporting soil and water conservation. Report to Ministry of Agriculture, Food & Rural Affairs. University of Guelph, Department of Agricultural Economics & Business.
- Stonehouse, D.P., E.A. Clark and Y.O. Ogini. 2001. Organic and conventional dairy farm comparisons in Ontario, Canada. *Biological Agriculture and Horticulture*. 19: 115-125.
- Stonehouse, D.P., S.F. Weise, T. Sheardown, R.S. Gill and C.J. Swanton 1996. A case-study approach to comparing weed management strategies under alternative farming systems in Ontario. *Canadian Journal of Agricultural Economics*. 44(1): 81-99.
- van Vuuren, W. 1986. Soil erosion: The case for market intervention. *Canadian Journal of Agricultural Economics*. 34(1) : 41-62.
- van Vuuren, W., J.C. Giraldez and D.P. Stonehouse. 1997. Social returns of Agricultural Practices for promoting water quality improvement. *Canadian Journal of Agricultural Economics*. 45(3): 219-234.