Land Degradation Issues in Canadian Agriculture

D. PETER STONEHOUSE
Department of Agricultural Economics and Business
University of Guelph
and
MARTIN BOHL
Economics and Policy Coordination Branch
Ontario Ministry of Agriculture and Food

Des changements technologiques récents en agriculture exacerbent les problèmes de dégradation du sol et de la pollution des cours d'eau en aval. Ce dernier problème justifie plus l'intervention gouvernementale que les coûts des fermiers ou la sécurité alimentaire. Différentes interventions pourraient être utilisées, chacune ayant des conséquences différentes en terme d'acceptabilité publique ou privée, et de faisabilité globale et administrative. Jusqu'à maintenant l'intervention publique a fait appel à des incitations financières universelles et au respect volontaire des politques. La limite inhérente à ceci est que les différences entre fermiers dans leurs efforts de conservation ne sont pas pris en considération. Une approche mieux ciblée est proposée comme une façon d'incorporer les différences entre inter-fermes et inter-fermiers, ce qui accroît la possibilité d'obtenir un meilleur effort de conservation.

Recent technical developments in farming have exacerbated problems of land degradation and downstream watercourse pollution. The latter justifies governmental intervention more than on-farm costs or food security. Several intervention alternatives could be employed, each having different implications for private and public acceptability, administrative feasibility, and workability. To date, Canadian public intervention has relied on universally-applied financial incentives and voluntary compliance. The inherent limitations are that differences among farmers in conservation effort are not considered. A targeted approach is suggested as one means of incorporating inter-farm and inter-farmer differences, thereby raising the potential for eliciting greater conservation effort.

Introduction

Despite having the second-largest land mass in the world, Canada depends on a very small proportion of its land base for its agricultural activity. Approximately 9 per cent of the land mass is suitable for farming, while approximately 7 per cent is actually being farmed. This farmland resource supports an agriculture and food sector which is responsible for about 12 per cent of Canada's gross domestic production, about 10 per cent of employment, and about 10 per cent of its export earnings. Canadian farmers produce enough food to support a population of between 50 and 60 million people, making Canada one of only a handful of net food-exporting countries in the world.

Present high levels of productivity in Canadian agriculture may not be sustainable in the long term because of a process referred to as 'land degradation' (Senate Standing Committee, 1984; Science Council of Canada, 1986). Degradation of agricultural lands occurs naturally, in the form of wind-borne or water-borne erosion, plant nutrient depletion, acidification, and salin-

ization, but its incidence can be greatly extended by human activity (Coote, 1983). In western prairie regions, the widespread practice of summerfallowing by farmers for purposes of soil moisture and nutrient conservation has resulted in increased wind erosion and salinization (Anderson and Knapik, 1984; Bentley and Leskiw, 1984). In eastern Canada, more intensive soil tillage and heavier fertilization practices, along with an increasing proportion of row crops such as corn, beans, potatoes and tomatoes as farms become more specialized, have caused increased water-borne and wind-borne erosion, and/or acidification, plus soil structural breakdown and compaction (Kay and Stonehouse, 1984; Miller, 1986; Fox and Coote, 1986; Miller et al., 1988). Aerial pollution from the urban-industrial complex, mainly in eastern Canada, also contributes to soil acidification.

All forms of degradation result in considerable on-farm costs, estimated to be around $1.3 billion annually (Science Council of Canada, 1986). While this may suggest a theoretical need for farmers to take remedial action, the lack of sufficient action may indicate that net private returns to soil conservation are not as great as on-farm costs. In fact, most studies of on-farm conservation practices show that these are not profitable, so that farmers who permit erosion can be viewed as making economically rational and socially correct decisions, at least from an internal perspective (Batie, 1986). In addition, degradation in its many forms may be generating off-farm costs (or externalities). If the social benefits from soil conservation were to be greater than the social costs, a divergence between private (farmer) welfare and social welfare would be indicated. There may therefore be an implied need for public intervention.

In this paper, attention is focused on farmers' contributions to degradation and on externalities in the contexts of agricultural productivity, food security, and renewable and non-renewable resources management. The need for and desirability of public sector intervention is examined and five alternative intervention scenarios are evaluated on the basis of their acceptability, feasibility and likelihood of achieving success. Finally, an overview of current federal and provincial government programs designed to encourage soil and water conservation is provided, together with some recommendations for a general approach in future policy initiatives.

The Private Decision on Conservation Investments

The traditional view of farming as a way of life is increasingly being supplanted by an attitude of 'farming has to pay its way' (Kay and Stonehouse, 1984). Especially for the commercial farmer, land is to be viewed as any other asset which must earn a return equal to its opportunity cost, i.e. the rate of return equal to that earned on other capital assets (McConnell, 1983). The return on agricultural land is composed of a stream of annual contributions to net returns (or net rental income) and a capital gain at the end of the ownership horizon. Both components can, at least theoretically, be adversely affected by land degradation through declining productivity, and declining future productive potential, respectively.

In practice, the relationship between land degradation and farmland productivity is complex, subject to the influences of many variables, incompletely researched and controversial. Results of some Ontario site-specific studies indicate that long-run yields are sustainable in the face of 'moderate' rates of erosion (e.g., Ketcheson and Webber, 1978). In contrast, results of other site-specific studies indicate productivity reductions of 30 per cent on average and up to 80 per cent at the extreme on 'highly-eroded' sites (Battiston and Miller, 1984). More broadly-based (non-site-specific) Ontario studies indicate that, although more intensive cropping and soil tillage practices have incurred higher rates of soil erosion (Ketcheson, 1980; van Vliet et al., 1976), soil productivity rates have increased (Ontario Ministry of Agriculture and Food, n.d.).

This apparent paradox can in part be explained by the rapid pace of technological progress[1] in North American agriculture providing for productivity increases that more than compensate for the negative impacts of land degradation on productivity (Kay and Stonehouse, 1984; Lovejoy and Napier, 1986).

Moreover, the net returns to crop production practices that help conserve soil are, and are perceived by farmers to be, lower than those to more intensive farming practices for soil tillage (Henderson and Stonehouse, 1988; Zantinge et al., 1986), for crop rotations (Baffoe et al., 1987; Stonehouse et al., 1987; Stonehouse et al., 1988), and for combinations of tillage and rotations (Johnston-Drury et al., 1987). With positive correlations established among more intensive crop production practices, soil productivity levels, land degradation rates, and net returns (including on-farm costs of degradation), there is no economic incentive for farmers to take remedial action against degradation.

Decisions to ignore degradation problems at the individual farm level have been reinforced by other factors. First, many of the soil depletion processes through erosion are insidious in nature,[2] so that farm decision-makers may be made aware of the depletion effects rather than the depletion itself, and then only eventually (Dickinson and Wall, 1978). Second, because of several imperfections in capital markets for farmland, market prices fail to reflect the effects of depletion on soil productivity (Turner, 1977:36–37).

Farm decision-makers, being given no or insufficient economic incentive to reduce soil depletion rates, can hardly be expected to implement conservation measures on private economic welfare grounds (Miranowski, 1984). The fact that some farmers have been and are adopting soil conservation measures may perhaps be explained on the basis of ethical or aesthetic, rather than purely economic, considerations (Ontario Institute of Agrologists, 1984; Batie, 1986; Lovejoy and Napier, 1986) or, in some cases, by differential costs and returns that provide net private benefits. The majority of farmers may, in the future, follow suit, but perhaps not until soil conservation practices become sufficiently well-established as to be regarded as the (new) tradition or routine (von Ciriacy-Wantrup, 1968:89).

Society's Interest in Conservation

From a public perspective, account should be taken of any externalities associated with land degradation, as well as on-farm costs (von Ciriacy-Wantrup, 1938; Gaffney, 1965). Externalities can be ignored by farm decision-makers because the impacts of such costs are either not felt directly or not felt immediately.

The two principal externalities associated with land degradation are a reduced capacity for future food production, and degradation of downstream watercourses (McConnell, 1983). The societal problem for the former concerns the allocation of scarce farmland resources among competing uses, and among competing time horizons[3] (Griffen and Stoll, 1984). Although 'sustainable development' is of topical public concern, there appears to be no evidence that present land degradation rates represent a threat to long-term food production potential, at least in Canada (van Kooten and Furtan, 1987; Smit et al., 1988). Using a prediction model, Smit et al. demonstrate that degradation would cause less than a 25 per cent reduction in crop yields across 95 per cent of farmland, and that this would not adversely affect aggregate food production potential over the long term. It is also noted that food production potential in localized regions could be severely curtailed, so that degradation should remain a concern, but would best be remedied by a targetted, rather than a universal policy approach. Nevertheless, the use of common property gives rise to private-public conflicts. Degradation of downstream watercourses occurs through the transfer of soil particles and associated

chemical fertilizer and pesticide residues from farmland to streams, rivers, lakes and reservoirs at lower altitudes. The real economic motive for controlling erosion therefore emanates from these externalities, with abundant evidence showing that estimates of off-farm costs through watercourse pollution far exceed estimates of on-farm costs (Crosson, 1984; Clark, 1985; Ribaudo, 1986; Buttel and Swanson, 1986). Beyond the individual decision-maker's farm boundaries, these water-borne pollutants may be considered costless from a private perspective. From a societal perspective, costs may be measured in terms of the reduced potential usage of downstream waterbodies as sources of drinking water, irrigation water, fish and wildlife habitat and human recreational space.

Given the lack of economic motive within the individual farm to conserve soil, but given the compelling arguments for conserving soil through externalities, a case can be made on economic grounds alone for the need for public sector intervention in order to resolve divergence and conflict between private and public interests. The notion of intervention should not, however, be viewed as a panacea, for the political process may do no better a job of allocating resource use across time than private corporations (Solow, 1974:12). Governmental intervention should then be undertaken only after careful evaluation of all anticipated impacts, direct and indirect, at both private farm and general societal levels.

Alternative Approaches to Public Sector Intervention

A government considering policies to promote soil conservation has a number of alternatives to choose from mandatory programs to voluntary compliance (Held and Clawson, 1965; Timmons, 1979). The choice of policy may depend on such factors as societal and governmental philosophy concerning intervention, practicality and applicability of policies, and potential for success in achieving the deemed objectives of erosion control, pollution abatement and food security.

Litigation

The first method of intervention is litigation. Such a policy would be predicated upon the institution of private ownership of land and individual property rights and responsibilities. The ethical responsibility to maintain soil productivity levels for future generations, or at least to slow the rate of depletion, and to refrain from causing externalities, would be transformed to a legal responsibility. Failure to comply would result in litigious proceedings initiated by government, leading to possible fines, requirements to compensate for assessed damages, or other penalties.

The litigious option would permit the maximum adherence to the free market principles of right to land ownership and private property rights to use that land freely. Exceptions to these principles would be applied under the heading of land use actions resulting in damage to common property resources and/or externalities, leading to possible litigation. The distinction is drawn between the two types of damage because legislation may be designed to cover either one or both of these.

Apart from problems of implementation of such legislation due to difficulties with measuring the extent of damages (problems shared with all intervention alternatives), it would be difficult to attribute externalities to one particular source. Instead, watercourse pollution is typically ascribed to a large number of non-point sources having both a spatial and a temporal dimension. In the absence of clear attribution rules, litigation would be difficult if not impossible to initiate. With severe implementation difficulties, the litigious approach would fail on both feasibility and potential for success criteria. Also, its political acceptability by farmers may be presumed to be in doubt, even though its acceptability by the public may be high.

Regulation

A second alternative is the use of forced regulation using the legislative power of the state. Compliance with a legislated soil conservation program may be achieved and soil erosion may be controlled through, for example, establishing a maximum allowable soil loss level in a region exhibiting high erosion rates; or by prohibiting certain soil management practices which are deemed detrimental to the soil; or by insisting that certain management practices conducive to soil conservation be used.

Theoretically, this approach would impose maximum allowable limits on soil erosion rates as a means of preventing the occurrence of excessive common property resource damage or externalities. Such an approach would not be well received because of incursions on private property rights made by any government decree or legislation used to enforce the maximum limits. Measurement difficulties would be severe, again because of the insidious nature of much erosion, leading to probable infeasibility. It may be possible to circumvent the measurement problems by using proxies in the form of farming practices with estimable erosion rates. For example, the application of the universal soil loss equation (USLE) would permit estimates to be made of erosion rates as a function of types of crops grown, crop rotations, tillage practices used, soil type, topography and other factors (Wischmeier and Smith, 1978). Although theoretically applicable, the USLE would be impractical from the standpoint of monitoring and analysis requirements. The costs of monitoring and implementation could well exceed the benefits from reduced abuses of common property rights and reduced externalities.

Financial Incentives

A third alternative would be to consider financial incentives of either a positive or negative type or a combination of both. An example of a positive incentive would be subsidies for the purchase of soil conservation implements. An example of a negative incentive would be taxes imposed on the operator who uses methods known to cause greater erosion. Subsidies or penalties may induce a farmer to achieve the objectives of the policy-maker, but there is no guarantee that farmers will respond to these policy alternatives.

Positive incentives would be deemed more acceptable by farmland owners than negative incentives. Both types of incentives would pose difficulties for implementation, but these would be less severe than those for the litigation or regulation alternatives.

Positive financial incentives in the form of subsidies or tax credits on resources or products associated with good soil conservation potential would be paid only upon receipt of written evidence of the requisite financial transaction. For example, input subsidies to encourage the purchase of conservation tillage equipment, the seeding of pasture crops, the planting of trees or the emplacement of more permanent conservation measures such as terraces and stream embankments, would be paid only upon presentation of a receipt. Similarly, output subsidies to encourage the production of conservation crops such as hay would be payable only upon proof of sale.

The implementation of the positive financial incentive schemes would be relatively easy, but some financial complications may arise. To induce the farmer to adopt the conservation practice, the financial incentive offered would need to be sufficient to cover not only the explicit cost of adoption, but also the implicit (or opportunity) cost of practices foregone. The cost to the public purse may, as a result, be raised to levels that may be viewed as unacceptably high by the non-farm sector. Moreover, continuous and appropriate usage of the conservation practice by the farmer may not be assured. In theory, continuous maintenance of permanent conservation structures such as terraces, or the on-going usage of conservation tillage implements, can be monitored, but only with considerable labour resources and at considerable

public expense.

Negative financial incentives in the form of tax penalties levied on practices associated with increased erosion rates would likely suffer from lack of political acceptability, lack of technical feasibility, and therefore from lack of potential success in achieving their objectives. Any tax penalty carries a negative connotation in the minds of those having to pay it. Measurement problems would be severe in that first, direct monitoring of erosion rates would not be practical (as in the case of litigious and regulatory policies), and second, indirect monitoring of erosion through surveys of the types of crops grown, soil tillage practices and other management techniques would require considerable resource inputs in order to ensure compliance with conservation standards. The costs of monitoring farm practices and of administering a more complex taxation system may exceed the benefits to be gained from reduced externalities and from less rapid exhaustion of common property resources.

Voluntary Compliance

A fourth alternative, voluntary compliance, would entail formal and informal education programs to make the farming community more aware of the problems and consequences of erosion, the many conservation technologies available to contain erosion, and the benefits and costs associated with their adoption. It would be hoped that, through better knowledge of the problem and the range of remedial measures, farmers would be encouraged to adopt conservation techniques on a voluntary basis.

This alternative has all the elements of political acceptability by the farm sector because of its voluntary nature. While theoretically feasible, voluntary compliance may not have high potential for achieving the objectives of soil conservation policies. Failure to achieve these objectives would presumably result in poor political acceptability by the non-farm sector. Farmer education could be used as part of a general education program designed to reorientate society toward resource conservation, thereby laying the groundwork for greater acceptance of voluntary compliance programs. Program elements directed specifically at farmers could include post-secondary, correspondence and distance courses, special workshops and seminars, and farm community self-help groups. The objectives would be to raise awareness levels of conservation problems and needs, and to impart knowledge about technical and economic aspects of available conservation technologies. Informal education instruments such as agricultural extension programs and demonstration plots in both research and commercial farm settings, and publications and electronic media may also assist. Meantime, research and development programs could be aimed at developing more effective conservation techniques with more enhanced economic appeal for farmers.

Because of their voluntary nature, the success of such programs would be by no means assured. One reason for this could be the non-receptivity of some farmers and land-owners to educational programs in soil conservation. A second reason could be the lack of a land stewardship ethic in some farmers. Third, the economic viability of many available conservation techniques may be questionable; or farmers may be faced with more pressing economic imperatives. Fourth, the risks associated with adopting some conservation practices may be perceived as unacceptably high. There may be many other reasons why the voluntary compliance route to greater conservation efforts may not succeed. Although the potential for achieving greater conservation may not appear high, the voluntary compliance approach has so far enjoyed arguably the highest element of public acceptability and practicality (Lovejoy and Napier, 1986).

Combinations of Approaches

A fifth policy alternative is to employ some combination of the above four options with

the aim of increasing the response rates by farmers to conservation needs through mutual reinforcement of two or more alternatives. The United States' experience with conservation policy combinations has led to the coining of the term 'cross-compliance,' whereby eligibility for participation in government farm support and stabilization programs is made dependent on the adoption and on-going use of conservation measures (United States Department of Agriculture, 1985).

Prior to the '1985 Farm Bill,' such farm support and stabilization policies had been openly available with no conservation requirements attached. Also prior to 1985, conservation policies had existed for many decades in the United States in the form of voluntary compliance, and, since the 1930s, in the form of financial incentives (Lovejoy and Napier, 1986).

American experience with voluntary compliance approaches has been one of partial success only, judged by estimates of overall erosion and externalities. Education about conservation practices by itself has been found wanting in several respects. First, the ability to perceive the existence and extent of erosion problems is a function of social, economic, and education factors (Green and Heffernan, 1987). Second, by accentuating only the visible effects of erosion, past programs have engendered a false sense of security in the minds of many American farmers (Nowak, 1983). Third, the universality of past education programs has failed to account for inter-farm differences in erosion problems and remedial needs (Christensen and Norris, 1983; Norris and Batie, 1987). Fourth, little post-adoption information has been made available to help farmers adapt specific conservation practices to meet their particular needs (Jolly et al., 1985). Fifth, insufficient account has been taken in past education programs of limitations in management skills (Korsching and Nowak, 1983) and of the effects of risk levels and attitudes on adoption and use rates (Ervin and Ervin, 1982; McSweeney and Kramer, 1986). In view of such a long list of drawbacks of education programs, it should not be surprising that voluntary compliance has met with only mixed success in the United States.

The addition of financial incentive programs in the United States, mainly in the form of subsidies and grants for capital structures to enhance conservation, has likewise had little influence on adoption rates of conservation practice (Christensen and Norris 1983; Norris and Batie, 1987). Again, this should not be surprising because of the many non-financial limitations of past voluntary compliance programs. Nevertheless, the United States is proceeding as though the limitations of voluntary compliance can be expected to be overcome by stronger financial incentives alone.[4] Failure of this program would imply that, in order for intervention programs to be effective, measures to enhance the voluntary compliance route should address the inherent shortcomings of past programs, rather than depending heavily on cross-compliance or other combination approaches.

Canadian Experiences with Public Sector Intervention

Canada has experienced wind-erosion problems and attempts have been made to find solutions through governmental intervention since the 1930s in all three prairie provinces (Prairie Farm Rehabilitation Administration, 1982; Anderson and Knapik, 1984). However, there has been only limited experience with water-erosion problems. Most water-erosion problems have occurred on a widespread scale, since the start of the 1970s, and then mostly in southern Ontario's corn and soybean-growing regions and in the Maritime provinces' potato-growing areas (Senate Standing Committee, 1984; Dumanski et al., 1986; Fox and Coote, 1986). The province-by-province overview below provides an indication of the extent and types of public sector intervention designed to combat land degradation and to reduce agriculture's contribution to downstream watercourse

pollution (Coote, 1983; Ontario Ministry of Agriculture and Food, 1989; Ecologistics Ltd., 1988).

(a) *Newfoundland* entered the policy arena in a major way in 1988, through a five-year, federal-provincial Agri-Food Regional Development Subsidiary Agreement (ARDSA). This four-part agreement includes a Soil and Land Management Program, with a commitment to spend up to $200 million to increase the long-term financial and environmental sustainability of Newfoundland farms through technical, material and financial assistance for land clearing and levelling, drainage, and measures to increase soil organic matter. In addition to these voluntary compliance measures, the province has an on-going program of positive financial incentives which encourage correction of soil acidity through subsidizing applications of lime.

(b) *Nova Scotia* offers voluntary compliance assistance through education and positive financial incentives. On-going programs offer financial assistance to install land drainage outlets and to purchase, transport, and field-spread lime. Four working committees have been established by the Nova Scotia Soils Institute to develop research strategies and priorities in the areas of soil drainage, soil and water conservation, soil fertility and plant nutrition; and education and extension. A provincial land-use policy committee has been set up and charged with raising public awareness about degradation issues and developing policies and programs for soil and water conservation. A Land Improvements Policy has been enacted by the provincial government to provide financial assistance for land clearing, drainage and levelling, and land ripping to counteract compaction. The on-going committee work suggests that solutions are still being sought, but also that past emphasis on voluntary compliance and financial incentives is likely to continue.

(c) *New Brunswick* signed a five-year federal-provincial Agri-Food Regional Development Subsidiary Agreement (ARDSA) in 1984, through which farmers have been provided with technical and financial assistance for subsurface drainage, deep-ripping of compacted soils, construction of drainage diversion terraces and grassed waterways, strip-cropping and winter cover crops to counteract erosion, and liming to counteract soil acidity. It is not yet clear whether this voluntary compliance approach is addressing the problem satisfactorily.

(d) *Prince Edward Island* has in place a federal-provincial Economic and Regional Development Agreement (ERDA) through which farmers may voluntarily obtain planning and design assistance from the province and two-thirds cost assistance from the federal government for approved soil conservation projects: much of the money has so far been spent on farmland drainage. This program is limited in scope, and may not solve degradation problems to a sufficient extent.

(e) *Quebec* programs rely on voluntary compliance and financial incentives to correct farmland degradation and watercourse pollution problems. A three-year federal-provincial ARDSA was signed in 1987, part of which was a Soil and Water Conservation and Improvement Program with four subprograms offering financial assistance for municipal watercourse development, farmland drainage installation, land improvement projects (such as levelling, rock-clearing, deep ripping, etc.), and soil conservation and management undertakings (such as grassed waterways, windbreaks, stabilization of eroded areas, etc.). Over $33 million was offered in financial assistance under this program during its first two years. Second, a 10-year Agricultural Water Quality Improvement Program was inaugurated in 1988. The purpose of this voluntary program was to reduce downstream watercourse pollution through financial assistance offered to improve livestock manure-handling-and-storage facilities and to establish demonstrations on how to improve manure-spreading techniques. Third, several educational and promotional

packages have been developed to raise public and farmers' awareness and understanding of conservation issues.

(f) *Ontario* undertook serious public intervention commitments to reduce land degradation and downstream watercourse pollution from agricultural activities only as recently as the mid-1980s. This was in response to the rapid spread of specialized farming, simplified crop rotations, with higher proportions of row crops and lower proportions of pasture/forage crops, and increasingly intensive soil tillage practices during the 1970s (Kay and Stonehouse, 1984). Most of the effort focuses on voluntary compliance and positive financial incentives.

In 1984, the Ontario Soil Conservation and Environmental Protection Assistance Program (OSCEPAP) was introduced. This provincial government initiative was allotted a budget of $18 million to assist farmers financially in controlling erosion, sustaining soil productivity, and protecting water resources through approved soil conservation and livestock manure storage projects. In 1985, the province launched a five-year 'Tillage 2000' project in conjunction with the Ontario Soil and Crop Improvement Association and the University of Guelph. This education and farm demonstration project was designed to develop and evaluate conservation-oriented crop rotation and soil tillage techniques with the co-operation of 40 farmers across Ontario. In 1986, a five-year, joint federal-provincial agreement called 'Soil and Water Environmental Enhancement Program' (SWEEP) was initiated. The objective of this project was to reduce Lake Erie basin phosphorus run-off from farmland non-point sources by 200 tonnes/year (and from urban-industrial sources by 100 tonnes/year) by 1990. The reduced farmland run-off would be accomplished through conservation tillage and crop rotation practices whose more widespread use would be encouraged (voluntarily) through local demonstrations, technical assistance, and management incentives. In 1987, the province introduced a three-year, $40 million Land Stewardship Program (LSP) with the objectives of improving soil resources and reducing environmental contamination arising from agricultural practices, through the four components: research, education and extension, financial assistance, and local program delivery.

In addition, Ontario provides financial assistance to farmers to establish shelterbelts and forage cover crops in the tobacco belt through the Tobacco Assistance Program's Soil Maintenance Grant Program; to develop tree crops through the Ministry of Natural Resources Woodlot Improvement Agreement Program; and to install tile drainage through subsidized-interest loans from local municipalities which sell 10-year debentures to the province.

(g) *Manitoba*, along with the other prairie provinces, has had the longest-standing public intervention programs in Canada to combat land degradation and off-farm pollution, primarily because these problems emerged first and foremost in this region of Canada. These programs are based on the adoption of specialized farming techniques with no or few forage crops and livestock on many farms, and the popular practice of summerfallowing to conserve soil moisture and nutrients (Coote, 1983). First, existing regulatory legislation remains in force with subsidiary conservation provisions; for example, the 1970 *Fire Prevention Act* places restrictions on the setting of fires on organic soils as one provision of the main intent which is to reduce the risk of forest fires. Second, more conservation-specific legislation based on voluntary compliance and financial incentives, was introduced in 1984 as a five-year federal-provincial ARDSA. The *Prairie Farm Rehabilitation Act* (PFRA), originally introduced in the 1930s as a regulatory vehicle for conservation and stabilization of eroded lands, represents the delivery agent for the federal government's part of the ARDSA. Manitoba Agriculture is the provincial government's representative for providing technical, material and financial assistance to

farmers establishing shelterbelts, run-off control, crop rotations, permanent forage crop cover, and other techniques for combatting land degradation. The combination of regulatory and voluntary compliance with financial incentive schemes may prove more effective in combatting degradation problems than the simpler approaches used in provinces to the east.

(h) *Saskatchewan*, in addition to federal government involvement through the PFRA, has a 1981 provincial government *Drainage Control Act*, the Saskatchewan Agriculture Development Fund, and joint federal-provincial ERDA and ARDSA programs. The Development Fund, a five-year, $200 million voluntary compliance effort, was renewed in 1989 to support land development research and demonstration projects including a component on soil and water conservation. Under the auspices of the Development Fund and the ERDA, a special three-year 'Save Our Soils' program was introduced in 1987, designed to encourage the voluntary use of soil and crop management practices that reduce wind- and water-erosion, salinization, and soil organic matter depletion. The SOS program is to be renewed in 1990 for a further three years with $18 million in funding. The PFRA and Saskatchewan Agriculture are the federal and provincial government's agents, respectively, responsible for offering technical, material and financial assistance to farmers voluntarily adopting soil conservation measures, through the ARDSA program. The *Drainage Control Act* is a regulatory instrument that requires farm-ers to obtain permits for land drainage projects, and offers a means of assessing wind-erosion or salinization damage potential before the damage occurs.

(i) *Alberta* relies on a combination of voluntary compliance, financial incentives, and regulation. There is an on-going voluntary Lime Freight Assistance program to combat soil acidity. In contrast, a 1980 *Soil Conservation Act* is regulatory in nature, empowering the provincial government to direct farmers to undertake emergency measures to reduce erosion. In 1987, Alberta signed a six-year, $5 million federal-provincial Soil, Water and Cropping Research Technology Transfer Program (SWCRTTP) designed to support field-scale research and demonstration plots for conservation tillage, snow entrapment, plow-down crops, conservation crop sequences, and other erosion-control measures. In 1989, a three-year, $34.8 million, federal-provincial agreement was signed under the Canada-Alberta Accord on Soil and Water Conservation and Development (ASWCD). The objectives were to reduce voluntarily farming-related land degradation and water pollution through financial incentives designed to encourage the transfer of marginally productive lands to permanent vegetative cover, and the establishment of field shelterbelts; second, through provision of conservation demonstrations to promote awareness and conservation planning; and third, through a review of government programs in search of components that may discourage conservation efforts.

(j) *British Columbia* signed a five-year, $40 million, federal-provincial ARDSA program in 1985. Like its counterparts in Newfoundland and other provinces, this program contains a resource development section. Technical assistance and grants of $3 million are available to farmers who voluntarily undertake soil and water conservation measures.

Conclusion

It is apparent that heavy reliance is being placed on a combination of voluntary compliance and positive financial incentives at both federal and provincial government levels across Canada to induce farmers to make greater conservation efforts. The introduction of new programs aimed at greater soil and water conservation in every province during the 1980s, and the increases in funding allocated to resource conservation at both federal and provincial government levels are testimony to rising

governmental concerns about land degradation and watercourse pollution. Presumably such concerns reflect a perceived need to intervene in a farming industry whose practices are viewed as contributing significantly to land degradation and watercourse pollution. It is posited that the means of intervention are neither appropriate nor adequate by themselves to achieve the stated objectives because not all farmers are motivated by voluntary compliance and financial incentives programs. The empirical evidence from the United States would suggest that voluntary compliance and financial incentives alone will not suffice (Nielson, 1986; Essens and Kraft, 1986; Napier and Camboni, 1988; Essens and Kraft, 1988; Ribaudo et al., 1989) and there seems little reason to suspect that the Canadian experience will be any different.

In not one of the provincial or joint federal-provincial programs now in place or contemplated for introduction to counteract agriculture's contributions to land degradation and watercourse pollution is any account taken of inter-farm and inter-farmer differences. Instead, all programs are universally available and universally applied, subject only to financial incentive limits per farmer and the prior approval of conservation plans. While administratively simplistic in approach, and therefore appealing to governments, the universal application of a voluntary approach will not necessarily bring a universal response. Should voluntary compliance with positive financial incentives prove to be inadequate for purposes of achieving conservation objectives, a more comprehensive approach may be needed.

On the one hand, account needs to be taken of differences in needs for conservation, a function of inter-farm differences in natural resource endowments (climate, topsoil depth and composition, topography, natural soil pH levels, etc.), as well as history of farming practices. On the other hand, consideration should be given to inter-farmer differences in attitudes toward conservation, and particularly toward the associated costs, and whether off-farm as well as on-farm costs should be considered; differences in economic versus non-economic goals, ethical and aesthetic values and orientations toward farming (commercial, part-time, or hobby status); differences in demographic factors and in economic circumstances reflecting the ability to pay for necessary conservation measures (universally-applied financial incentives by government may be more than adequate for some farmers, but wholly inadequate for others); differences in willingness to take risks and in other behavioural factors, and differences in management skills. All such factors are likely to influence the degree of conservation effort by farmers. More careful targetting of government conservation programs may be more effective than universal approaches, given the plethora of inter-farm and inter-farmer differences to be considered. A targetted approach would require considerable information on inter-farm and inter-farmer differences, information that may only be obtainable through surveys. Such surveys may be expensive to conduct. The expense would presumably not be considered prohibitive as long as the potential benefits (from reduced on-farm costs and externalities) exceeded the administrative costs of a comprehensive, targetted approach.

Implicitly, there could be a trade-off between a higher likelihood of achieving success and a higher level of administrative complexity (and therefore a possible lower level of feasibility) in adopting a more comprehensive approach based on targetting. Presumably, acceptability by farmers would depend upon the extent to which public programs intervened in their business decisions and affected their independence and freedom of action; there may also be equity considerations influencing farmers' acceptance of targetted conservation programs. Acceptance by the public will presumably be dependent primarily on the ability of such programs to achieve the goals of soil and water resource conserva-

tion.

Notes

1 Technological progress includes the development of higher-yielding crop varieties, of more efficient crop production machinery, and of a broader spectrum of chemical pesticides, as well as the general improvement in management techniques such as superior timing and precision of field operations, increased application of inorganic fertilizers, etc.

2 Soil depletion through water-borne erosion can occur visibly as in the case of rill (shallow channel) erosion, gully (deeper channel) erosion, a non-observable kind entailing gradual top-soil removal from broad expanses of sloping land, due to impacts of rain droplets on exposed soil; soil depletion through wind erosion tends to become more visible as the degree of severity increases.

3 Implicit here is the concept of soil resources being viewed as common property or public goods. Although individual farmers may legally own the resource, and therefore may retain the right to use the resource as they will, they are under an ethical (but non-legal) obligation to return the resource to the market-place in as good condition as when it was purchased.

4 In addition to financial incentives through cross-compliance, the 1985 Farm Bill is also attempting to address the need for individual farm conservation plans based on specific needs and acknowledged inter-farm differences.

References

Anderson, M. and L. Knapik (1984) 'Agricultural Land Degradation in Western Canada: A Physical and Economic Overview.' Working Paper, Agriculture Canada, Regional Development Branch, Ottawa.

Baffoe, J.K., D.P. Stonehouse and B.D. Kay (1987) 'A Methodology for Farm-Level Economic Analysis of Soil Erosion Effects Under Alternative Crop Rotational Systems in Ontario,' *Canadian Journal of Agricultural Economics*, 35:1:55–73.

Batie, S.S. (1986) 'Why Soil Erosion: A Social Science Perspective.' In S.B. Lovejoy and T.L. Napier, *Conserving Soil: Insights from Socioeconomic Research* (Ankeny, IO: Soil Conservation Society of America).

Battiston, L.A. and M.H. Miller (1984) 'Soil Erosion and Soil Productivity in Ontario.' University of Guelph, Department of Land Resource Science, Guelph, Ontario.

Bentley, C.F. and L.A. Leskiw (1984) *Sustainability of Farmed Lands: Current Trends and Thinking* (Ottawa: Supply and Services Canada), Report No. 15, Canadian Environmental Advisory Council.

Buttel, F.H. and L.E. Swanson (1986) 'Soil and Water Conservation: A Farm Structural and Public Policy Context.' In S.B. Lovejoy and T.L. Napier, *Conserving Soil: Insights from Socioeconomic Research* (Ankeny, Iowa: Soil Conservation Society of America).

Christensen, L.E. and P.E. Norris (1983) 'Soil Conservation and Water Quality Improvement: What Farmers Think,' *Journal of Soil and Water Conservation*, 38(1):15–20.

Clark, E.H. (1985) 'The Off-Site Costs of Soil Erosion,' *Journal of Soil and Water Conservation*, 40:1:19–22.

Coote, D.R. (1983) 'Stress on Land under Intensive Agricultural Use.' Pp. 227–59 in *Stress on Land* (Ottawa: Environment Canada, Policy Research and Development Branch).

Crosson, P. (1984) 'New Perspective on Soil Conservation Policy,' *Journal of Soil and Water Conservation*, 39:4:222–5.

Dickinson, W.T. and G.J. Wall (1978) 'Soil Erosion by Water – Nature and Extent,' University of Guelph, *Notes on Agriculture*, 14:3: 4–7.

Dumanski, J., D.R. Coote, G. Luciuk and C. Lok (1986) 'Soil Conservation in Canada,' *Journal of Soil and Water Conservation*, 41:4: 204–10.

Ecologistics Ltd. (1988) 'Provincial Soil Conservation Updates: A review of Provincial Soil Conservation Initiatives,' a Report prepared for Sen. H.O. Sparrow, Waterloo, Ontario.

Ervin, C.E. and D.E. Ervin (1982) 'Factors Affecting the Use of Soil Conservation Practices: Hypotheses, Evidence and Policy Implications,' *Land Economics*, 58:277–92.

Essens, J.D. and S.E. Kraft (1986) 'Landowner Views of Obstacles to Wider Participation in the Conservation Reserve Program,' *Journal of Soil and Water Conservation*, 41:6:410–4.

—— (1988) 'Why Eligible Landowners Did Not Participate in the First Four Sign-ups of the Conservation Reserve Program,' *Journal of Soil and Water Conservation*, 43:3:251–6.

Fox, M.G. and D.R. Coote (1986) 'A Preliminary Economic Assessment of Agricultural Land Degradation in Atlantic and Central Canada and Southern British Columbia.' Working Paper, Agriculture Canada, Regional Development Branch, Ottawa.

Gaffney, M.M. (1965) 'Soil Depletion and Land

Rent,' *Natural Resources Journal*, 4:537–57.
Green, G.P. and W.D. Heffernan (1987) 'Soil Erosion and Perception of the Problem,' *Journal of Rural Studies*, 3:2:151–7.
Griffen, R.C. and J.R. Stoll (1984) 'Evolutionary Processes in Soil Conservation Policy,' *Land Economics*, 60:1:30–39.
Held, R.B. and M. Clawson (1965) *Soil Conservation in Perspective* (Ankeny, IO: Soil Conservation Society of America).
Henderson, J.S.W. and D.P. Stonehouse (1988) 'Effects of Soil Tillage and Planting Time on Corn Yields and Farm Profits in Southern Ontario,' *Canadian Journal of Agricultural Economics*, 36:1:127–41.
Johnston-Drury, D.L., D.P. Stonehouse, B.D. Kay and T.J. Vyn (1987) 'Evaluation of the Relative Economic and Erosion Control Merits of Tillage and Crop Sequence Combinations on Ontario Cash-Cropping Farms,' Canadian Society of Soil Science Annual Meeting, Carleton University, Ottawa.
Jolly, R.W., B. Elveld, J.M. McGram and D.D. Raitt (1985) 'Transferring Soil Conservation Technology to Farmers.' In R.F. Follett and B.A. Stewart, *Soil Erosion and Crop Productivity* (Madison, WI: American Society of Agronomy, Soil Science Society of America, Crop Science Society of America).
Kay, B.D. and D.P. Stonehouse (1984) 'The Growth of Intensive Agriculture in Ontario,' University of Guelph, *Notes on Agriculture*, 19:2:5–8.
Ketcheson, J.W. (1980) 'Long-range Effects of Intensive Cultivation and Monoculture on the Quality of Southern Ontario Soils,' *Canadian Journal of Soil Science*, 60:4:403–10.
—— and L.R. Webber (1978) 'Effects of Soil Erosion on Yield of Corn,' *Canadian Journal of Soil Science*, 58:4:459–63.
Korsching, P.F. and P.J. Nowak (1983) 'Flexibility in Conservation Policy.' Pp.149–59 in D.E. Brewster, *Farms in Transition* (Ames, IO: Iowa State University Press).
Lovejoy, S.B. and T.L. Napier (1986) 'Conserving Soil: Sociological Insights,' *Journal of Soil and Water Conservation*, 41:5:304–8.
McConnell, K.E. (1983) 'An Economic Model of Soil Conservation,' *American Journal of Agricultural Economics, 65:1:83–89.*
McSweeney, W.T. and R.A. Kramer (1986) 'The Integration of Farm Programs for Achieving Soil Conservation and Non-point Pollution Control Objectives,' *Land Economics*, 62:2:159–73.
Miller, M.H. (1986) 'Soil Degradation in Eastern Canada: Its Extent and Impact,' *Canadian Journal of Agricultural Economics*, 33:1:7–18.
——, P.H. Groenevelt and D.P. Stonehouse (1988) 'Stewardship of Soil and Water in the Food Production System,' University of Guelph, *Notes on Agriculture*, 22:1:5–12.
Miranowski, J.A. (1984) 'Impacts of Productivity Loss on Crop Production and Management in a Dynamic Economic Model,' *American Journal of Agricultural Economics*, 66:1:61–71.
Napier, T.L. and S.M. Camboni (1988) 'Attitudes Toward a Proposed Soil Conservation Program,' *Journal of Soil and Water Conservation*, 43:2:186–91.
Nielson, J. (1986) 'Conservation Targeting – Success or Failure,' *Journal of Soil and Water Conservation*, 41:2:70–76.
Norris, P.E. and S.S. Batie (1987) 'Virginia Farmers' Soil Conservation Decisions: An Application of Tobit Analysis,' *Southern Journal of Agricultural Economics*, 19:1:79–90.
Nowak, P.J. (1983) 'Adoption and Diffusion of Soil and Water Conservation Practices,' *The Rural Sociologist*, 3:2:83–91.
Ontario Institute of Agrologists (1984) *Soil Erosion: The Threat to Food Production* (Downsview, Ontario: Concord Graphics Inc.).
Ontario Ministry of Agriculture and Food (Annual) *Agricultural Statistics for Ontario*, Publication No. 20, Toronto.
—— Agricultural Representatives Branch (1989) *Provincial and Federal Programs for Ontario Farm Businesses* (Toronto: The Queen's Printer).
Prairie Farm Rehabilitation Administration (1982) *Land Degradation and Soil Conservation Issues on the Canadian Prairies* (Ottawa: Regional Economic Expansion Canada).
Ribaudo, M., D. Colacicco, A. Barbarika and C.E. Young (1989) 'The Economic Efficiency of Voluntary Soil Conservation Programs,' *Journal of Soil and Water Conservation*, 44:1:40–43.
Ribaudo, M.O. (1986) 'Consideration of Off-site Impacts in Targeting Soil Conservation Programs,' *Land Economics*, 62:4:402–11.
Science Council of Canada (1986) *A Growing Concern: Soil Degradation in Canada* (Ottawa: Supply and Services Canada).

Senate Standing Committee on Agriculture, Fisheries and Forestry (1984) *Soil at Risk: Canada's Eroding Future* (Ottawa: The Senate of Canada, Clerk of the Committee).

Smit, B., M. Brklacich, R. McBride, Y. Yongyuan and D. Bond (1988) 'Assessing Implications of Soil Erosion for Future Food Production: a Canadian Example,' *Geoforum*, 19:2:246–59.

Solow, R.M. (1974) 'The Economics of Resources or the Resources of Economics,' *American Economic Review*, 64:2:1–14.

Stonehouse, D.P., J.K. Baffoe and B.D. Kay (1987) 'The Impacts of Changes in Key Economic Variables on Crop Rotational Choices on Ontario Cash-cropping Farms,' *Canadian Journal of Agricultural Economics*, 35:2:403–20.

Stonehouse, D.P., B.D. Kay, J.D. Baffoe and D.L. Johnston-Drury (1988) 'Economic Choice of Crop Sequences on Cash-Cropping Farms with Alternative Crop Yield Trends,' *Journal of Soil and Water Conservation*, 43:3:266–70.

Timmons, J.F. (1979) 'Agriculture's Natural Resource Base: Demand and Supply Interactions Problems and Remedies.' In *Soil Conservation Policies: An Assessment* (Ankeny, IO: Soil Conservation Society of America).

Turner, D.M. (1977) *An Approach to Land Value* (Berkhaustead, England: Geographical Publications Ltd.).

United States Department of Agriculture (1985) *Farm Bill*. Washington, DC, Economic Research Service, Agricultural Information Bulletins 465–78.

van Kooten, G.C. and W.H. Furtan (1987) 'A Review of Issues Pertaining to Soil Deterioration in Canada,' *Canadian Journal of Agricultural Economics*, 35:1:33–54.

van Vliet, L.J.P., G.J. Wall and W.T. Dickinson (1976) 'Effects of Agricultural Land Use or Potential Sheet Erosion Losses in Southern Ontario,' *Canadian Journal of Soil Science*, 56:443–51.

von Ciriacy-Wantrup, S. (1938) 'Economic Aspects of Land Conservation,' *Journal of Farm Economics*, 20:2:462–73.

—— (1968) *Resource Conservation* (Berkeley: University of California Division of Agricultural Sciences, Agricultural Experimental Station).

Wischmeier, W.H. and D.D. Smith (1978) 'Predicted Rainfall Erosion Losses: A Guide to Conservation Planning.' (Washington, DC: United States Department of Agriculture, Handbook No. 537).

Zantinge, A.W., D.P. Stonehouse and J.W. Ketcheson (1986) 'Resource Requirements, Yields and Profits for Monocultural Corn with Alternative Tillage Systems in Southern Canada,' *Soil and Tillage Research*, 8:201–9.