WEALTH ACCOUNTS FOR AGRICULTURAL LAND: A HEDONIC PRICING APPROACH

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ABSTRACT

The System of National Accounts inadequately reflects levels of, or changes in, the natural resource base. Natural Resource Accounts are designed to redress this shortcoming. A wealth account for Québec agricultural land was constructed, taking an inventory of land with capability for agriculture and monetizing the stocks. The changes to the wealth account over a 15 year period represented a loss to the resource base of $260 million and an average annual charge against net farm income of $17.3 million. Prices for the valuation exercise were determined with the use of a Hedonic Pricing Model. The estimated implicit prices for the classes of the Canada Land Inventory revealed premiums for differences in productivity between the classes. Regional variables that accounted for many non-agricultural effects were also highly significant.

RÉSUMÉ

Le système de comptabilité nationale ne reflète pas de façon adéquate la valeur de la base de ressources naturelles ou l'évolution de cette valeur. Les comptes de ressources naturelles sont conçus pour redresser cette lacune. Un compte de patrimoine a été créé pour les terres agricoles du Québec. On y a porté un inventaire des terres arables et la valeur monétaire des stocks. Sur une période de 15 ans, les changements à ce compte représentent une perte de 260 millions $ contre la base de ressources et une imputation moyenne annuelle de 17,3 millions $ contre le revenu agricole net. Les prix aux fins de cet exercice d'évaluation ont été déterminés à l'aide de la méthode hédonistique de fixation des prix. Les prix implicites estimatifs des classes de l'Inventaire des terres du Canada révèlent que les différences de productivité entre les classes donnent lieu à des primes. Les variantes régionales, à l'origine de plusieurs effets non attribuables à l'agriculture, étaient elles aussi, très significatives.

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I dedicate this thesis to God, my family and to new leases on life...

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CHAPTER 1. INTRODUCTION

Sustainable development has been defined as "development which ensures that the utilization of resources and the environment today, does not damage prospects for their use by future generations". (National Task Force on the Environment and Economy (NTFEE), 1987:3). Sustainable income could then be the maximum income that can be spent in a given period without reducing t' amount of potential consumption in a future period.

Sustainable development, although a relatively new term, is not necessarily a new idea. The Hicksian definition of income states that it is the maximum amount a person can consume during a given period and still be as well off at the end of the period (Hicks, 1946). Hicks, in turn, built upon Adam Smith's 'neat revenue':

> The gross revenue of all the inhabitants of a great country, comprehends the whole annual produce of their land and their labour; the neat revenue, what remains free to them after deducting the expense of maintaining; first, their fixed; and second, their circulating capital; or what, without encroaching upon their capital, they can place in their stock reserved for immediate consumption, or spend upon their subsistence, conveniences and amusements. Their real wealth too is in proportion, not to their gross, but to their neat revenue. (Adam Smith, 1776:283).

So it can be seen that sustainable development is not novel at all. It is a notion that was long ago understood by the classical economists but largely ignored by the neoclassicists (Potvin, 1989). The formal recognition of this term and of the urgency to alter capital formation activity and our economic accounting was given credence largely because of Our Common Future, the Report of the World Commission on Environment and Development (WCED, 1987). This report stemmed from the Stockholm Conference on the Human Environment chaired by Maurice Strong in 1972. The Club of Rome Reports published in the 1970's (Mesarovic and Pestel, 1974) dealt with the same issues but did not initiate the flurry of activity and interest as did the Bruntland Report: The United Nations adopted the Bruntland Report and passed a resolution to hold the 'Earth Summit' in Rio, Brazil in 1992 (UNSO, 1990). Similarly, Canada supported the main conclusions and recommendations of the WCED report and created Round Tables on the environment and on the economy (NTFEE, 1987:1). The main verdicts of the Bruntland Report included the ideas that natural resources were not free gifts of nature (as modern macroeconomic paradigms would indicate) and that the planet had specific limitations. It was suggested that it is infeasible to modify economic activity when the figures and indicators that decision-makers base their policies on are derived with anachronistic assumptions. These indicators are usually the inventories, Input/Output (I/O) tables and income statements that make up the System of National Accounts (SNA), and measure the total products and total costs of production for an economy over a one year period. The SNA includes the concepts of Gross National Product (GNP), National Income (Net National Product or NNP) and Gross Domestic Product (GDP). Economic growth has historically been depicted by monitoring both the magnitude and the change of each of these measures. There are three main problems with this macroeconomic accounting model:

1) Natural capital is not given the same treatment as human-made capital:

A tractor is valued as an asset and as it depreciates, the amount of depreciation is recognized as an expense, and charged against the income the tractor helps to generate. It is recognized that the tractor becomes less valuable as its useful life diminishes and in the future it cannot sustain its current output. Agricultural land, as a natural asset, is not accorded the same treatment. If the productivity of the soil diminished and its ability to produce within an expected range of yield decreased, these events are not assigned a value and the land is not depreciated. There is no debit against the earnings from farm land showing that practices that degrade the asset base result in lower future yields.

2) Some expenditures are poorly defined and/or misclassified.

Consumption, savings, investment, and government expenditures were well defined and classified by Keynes (Repetto, 1989), but defensive expenditures were not a concern when the SNA was developed in the 1930s. Victor (1990b: 3) has called defensive expenditures the category of "expenditures which are undertaken to avoid or to mitigate the disamenities associated with industrialization". A famous example of this is the Exxon Valdez oil spill. The tremendous research efforts and clean-up costs following this disaster appear in the accounting system as contributions to gross domestic product instead of being charged as intermediate costs. No where is any damage recorded or debited in the accounts (Potvin, 1989).

3) Non-market goods and services are ignored.

Activities that do not enter into the market place are not valued. This is especially true of subsistence activities and housework. In many countries subsistence farming and the procurement and preparation of food take up a large part of the working day of much of the population yet this labour goes unnoticed in GDP calculations. A national accounting system is needed that will correct these flaws and account for the contribution of natural capital to national wealth. A corrected system would give an accurate indication of whether or not our income and policies for growth are on a sustainable path.

Repetto (1989:3) gives a vivid example of how the current accounting system does not deliver adequate information to make public policy decisions. Repetto's point can be easily transferred to a Canadian agricultural context. In New Brunswick farmers were told in 1993 that they would no longer be able to remove topsoil from agricultural land to sell as sod. There was a grace period of one year and many farmers rushed to scrape off sod and topsoil on their properties. Some of them invested the proceeds in new buildings, opting for enterprises that were less dependant on the land and others spent their earnings. In the SNA, income and investment would rise as a result of increased sales, and as the new buildings were constructed. The permanent loss of the topsoil and the loss of use of the land for farming is not recorded. If the farmer did not use the proceeds from liquidating his natural capital (the soil) to transform them into some other income generating assets (the buildings), then he would have no land, he would have consumed the funds available to develop an alternative enterprise but the national income would still have reflected an increase in wealth, instead of a loss. The revenue from the sod is not sustainable and will never occur again. A revision of the SNA would not correct this or the aforementioned practices. It would, however, alert decision makers as to changes in the wealth of the resource base and indicate when assets are being depleted or substituted for other forms of capital.

1.1 PROBLEM STATEMENT

This research is concerned with addressing one of the difficulties facing the System of National Accounts, namely that the inventory of agricultural land in Québec is not treated in the same way as human made capital. To make a contribution to this new field in a constructive way, a means of Natural Resource Accounting (NRA defined in section 2.3) will be attempted for the agricultural industry in Québec.

A wealth account will be estimated for Québec by taking an appropriate inventory of farm land units, grouped according to productivity, and multiplying the units by a per unit value. In a multiperiod comparison of the inventory of farm land, the change in land classes and the corresponding change in value, can be assigned as the gain or loss of wealth. This approach of investigating deleterious changes in the land inventory and its value would reveal a measure that parallels capital consumption or depreciation, so that urbanization (loss) or degradation of farm land could be included in the flow accounts. *The number of* *hectares that have been affected and the value of the change in productive assets will be estimated.*

Market transaction prices may not be giving adequate signals about the scarcity of prime land and degradation that has occurred. At some point in time, the market price would be expected to begin to reflect the scarcity of the prime land resource but by that time irreversible damage or paved development may have occurred. Market price is often uncoupled from expected returns of a soil's fertility and sustainable capacity. Other factors affect the market price of farm land and can mask the contribution of productivity and depletion (e.g.) price of food, increasing incomes in farming, inflation, rising productivity through technology, alternate uses, zoning etc. "This results in a set of values being placed on land [referring to land in Canada in the urban shadow] which have little or no relation to values of farming and food production." (Manning, 1979:13).

Manning goes on to say that "isolated from external factors, the value of farmland reflects the inherent physical capacity of the land to produce food and fibre" (Manning, 1979:12). If farm land transactions were used in a Hedonic Pricing Model (HPM), an implicit price for productivity levels can be isolated from external factors and identified. This would enable a value per hectare to be estimated for each land class within the agricultural land inventory. A wealth account could be set up in a way previously unattempted.

Objectives:

1) Farm land prices from real estate transactions in Québec will be examined. Implicit prices for productivity will be estimated using a hedonic pricing model. *The hypothesis that implicit prices account for different levels of agricultural productivity will be tested.*

2) Wealth accounts (also referred to as balance sheet or stocks) will be estimated through multiplying the physical inventory by the implicit prices identified in #1.

3) When a measure paralleling capital cost allowance is developed for the land inventory, its effect upon industrial output will be evaluated through its inclusion in a flow account. *The hypothesis that the value of Québec agricultural income is overestimated will be tested by applying some of the principles of NRA to the Québec agricultural stock and flow accounts.*

The SNA and NRA will be described in Section 2.0 through 2.3. Alternative methods for evaluating farm land and its depletion, culminating with the rational for choosing the HPM are found in Section 2.4. Section 2.5. gives descriptions of the Canada Land Inventory (CLI), the Québec land resource and highlights some studies that are important in identifying changes to the land inventory. The data and functional form specification and diagnostics for the HPM can be seen in the Methods Sections 3.0 -3.4. Here, the method for taking the opening farmland inventory and adjusting it for losses and changes is also described (Section 3.5). The results from the Ordinary Least Squares (OLS) and Weighted Least Squares (WLS) estimation of implicit prices and the construction of the monetized wealth account are presented in Chapter 4.

CHAPTER 2: NATURAL RESOURCE ACCOUNTING AND VALUATION ISSUES

This chapter begins by outlining the SNA and the criticisms of it. It reviews recommendations by researchers for modifications to the SNA and construction of NRA. Valuation methods are examined, both for changes in wealth and for the wealth account itself. Finally, Québec agricultural land, the resource in question, is characterized.

2.0 THE SYSTEM OF NATIONAL ACCOUNTS

National accounting originated in the seventeenth century formulation of Sir William Petty and Gregory King in England (Eisner, 1989:1). It has evolved into the present System of National Accounts. The guidelines are published by the United Nations Statistical Office (UNSO, 1990) and followed by most developed countries with the notable exception of the United States. These recommendations outline the methods for measuring the total output of a nation. Total output is recorded in a double-entry type of accounting that reconciles all expenditures incurred to buy the nation's output, with all the incomes earned to produce it.

The accounts are lauded as "undoubtedly one of the most significant social inventions of the twentieth century. Their political and economic impact can scarcely be overestimated" (Repetto, 1993:5). Well known measures, like GDP, are calculated with the SNA and are used by governments for forecasting, monetary and fiscal policy decisions. Additionally they are used by Non-Governmental Organizations (NGOs), for example the United Nations and the World Bank, as a yardstick that separates the industrial world from the developing world. Aggregate income accounting and balance sheets are the cornerstone of Keynesian economics.

Despite the many benefits, the system suffers from a variety of flaws that were introduced in chapter one. It could be argued that these inconsistencies only occur on paper, but many policy decisions are based upon the aggregate measures of the national accounts. As presently structured, these measures are inadequate indicators of welfare or continuing prosperity. The accounts show activity, but not changes in resource wealth and are not suitable for giving an accurate picture of long-term economic performance (Goldsmith, 1985; Eisner, 1985; Repetto, 1989; Ahmad et al, 1989).

2.1 SHORTCOMINGS

Of the three types of shortcomings introduced in chapter one, this research will focus on depreciation and the treatment of natural capital (2.1.1). The second category, defensive expenditures (2.1.2.), could have a significant impact on industrial output in Quebec but will not be addressed in this research. The third set of problems mentioned, non-market goods and services, (2.1.3) is very significant in some developing economies but was beyond the scope of this study.

2.1.1. Treatment of natural capital

With the present SNA and its underlying assumptions:

a) income is overestimated when GDP benefits from the sale of assets without being balanced by a measure for depreciation on the other side of the ledger,

b) a belief is fostered, that present levels of consumption can be maintained,

c) there is an appearance that expansion of economic activity brought about by liquidating or depleting assets is good economics - the proceeds from this liquidation are confused with growth that comes from labour, capital formation, technological progress and efficient organization (El Serafy, 1989).

These misconceptions are reinforced because natural resources are not valued and accorded the same treatment as are human-made assets; they are viewed as free goods because they do not have an investment cost and they are not depreciated or given a capital cost allowance (Repetto, 1989). "What is unsatisfactory in this treatment of wealth is that it puts the calculation of the net worth of Canada on the same footing as that of Hong Kong, almost completely ignoring resource endowments" (Hamilton, 1989:1). All this gives impetus, notably within the Least Developed Countries (LDC's) to think that GDP can be rapidly increased by selling off natural bounty. Most farmers know that a portion of income is always set aside for reinvestment into capital assets and that as the asset ages or moves into obsolescence the depreciation shows up as a cost written against the income derived from it. Sometimes assets are drawn upon legitimately to finance development or investment. When proceeds are used for immediate consumption however, this is tantamount to giving up part of the means of future income.

2.1.2. Defensive expenditures

Income can be overestimated when expenditures arising from the mitigation of environmental risk, clean up costs and the costs of preventative measures (defensive expenditures), are counted as final output instead of intermediate expenditures. There is widespread agreement amongst authors that this flaw in the SNA, is one of commission rather than omission (Harrison, 1989; Victor, 1990b; Potvin, 1989). Some current examples of defensive expenditures in Canadian agriculture are the control of groundwater pollution and clean-up of sediment damage from water transport mechanisms or dams.

Expenditures incurred to *maintain* a resource and its productivity levels ie) liming farmland, replacing soil organic matter, may already be charged against income. This depends upon who pays these costs. If they are paid by the farmer or forester then the costs would appear as intermediate expenditures. If the costs are borne as a result of a government program or repairs are made to Crown Lands, then they will be credited to final output. The Input-Output model, combined with some essential theories in thermodynamics like the Materials-Energy-Balance Approaches (MEBS- Kneese et al, 1970) and the Stress Response Environmental Statistical System (STRESS-Friend and Rapport, 1979) have been used to identify state, flow, activity and cost associated with defensive expenditures. "The first law [of thermodynamics] - the conservation of mass and energy - reminds us that all material and energy that finds its way into the economy must eventually find its way out as [by-products and] waste" (Smith, 1990: unnumbered). This is briefly discussed by Victor (1990a) and Smith (1990), but an in depth methodology is described by Schafer and Stamer (1989) in an example from Germany. Although it is not dealt with in this research, this facet of suggested modifications is described here because of its important contribution to NRA.

2.1.3. Non-market goods and services

Victor (1990b) has completed perhaps the most comprehensive case work in a Canadian context, with the creation of supplementary economic accounts for the Yukon Territories. While these revised accounts dealt with all three categories of errors/omissions to the SNA, the focus was on non-market activity. In the Territories, non-market production activities play a larger role in the economy than in more populated Canadian areas. Some industries included were hunting, forestry, medicinal agriculture, fishing, logging and subsistence activity. In some areas of Africa and Asia up to 95% of a person's workday could be devoted to subsistence activity but this type of work would go unaccounted for.

The GDP and GNP measures should not be used as long term indicators or as gauges of welfare, in light of the the deficiencies reported. An extensive discussion of these shortcomings is found in Ahmad et al. (1989), which is a collection of papers sponsored by the UNEP and the World Bank. Repetto (1989) and Victor (1990b) give lighter discussions of the issues along with some of the few existing case studies of revised accounts.

2.2. SUBSTITUTABILITY AND IRREVERSIBILITY

There is a neoclassical assumption that goods are continuously substitutable, so that natural wealth falls on some indifference (trade-off) curve with capital wealth, and labour (Lipsey and Steiner, 1969). This is correct over some range. What is not recognized in the model is that there are limitations and perhaps, a threshold level to this substitutability. For instance, a loss of prime agricultural land may, to some extent, be compensated for by technology and the ability to grow increased yields per acre. If more and more prime land was lost though, there would be some point where technology might not keep up or replace the lost resources.

Irreversibility is another factor that is not built in to the indifference curve. This comes into play when damage is so extensive that reparations are impossible. Technology does not yet exist for replacing extinct species. The theory of scarcity and rising prices cannot be relied upon to make adjustments in the marketplace before irreversible barriers are crossed. It has been argued that natural capital and man-made capital should be thought of as complements and not substitutes (Anielski, 1992). Macro indicators must be able to encompass environmental concerns and alert decision makers as to thresholds that would endanger sustainability. Economic activity is adjusted according to results that are shown by the indicators. If the indicators mask a jurisdiction's ability to maintain its current income and production, then informed policy decisions cannot be made.

2.3 HISTORY AND EVOLUTION OF NRA

Natural Resource Accounting (NRA) is a fairly new phenomena that has evolved largely because of the resurgence of the concept of finite resources. Decades ago, Ricardo and Marx talked of dependence upon soil fertility and of how rising land rents could stagnate an economy, but this knowledge seemed to be overlooked during times of plenty (Anielski, 1992; Potvin, 1989). Scarcity, and theories dealing with it, are back in the spotlight, and the assumptions of substitutability and reversibility are being questioned. It is because of this focus upon the limits of the natural resource base, that the shortcomings of the SNA became evident.

In the 1970's the Conference on European Statisticians of the Economic Commission for Europe in Geneva established the first formal measurement of environmental statistics. This was about the same time the OECD began producing State of Environment (SOE) Reports for member countries. In those days there was no common paradigm or dialogue so any work undertaken was independent of other efforts (Friend and Rapport, 1979). France and Norway were the pioneers in monitoring and valuing their natural patrimony (Lone, 1987; Weber, 1983a). 'Les Comptes du Patrimoine Naturel' (Weber, 1983a) were pilot accounts for flora and fauna, forest resources and inland water. Victor (1990) gives a country by country description of work going on in the world. His report is also helpful as a summary of the main themes in the NRA iiterature. In Canada, STRESS became a building block for work done at Statistics Canada. This work has been continued by Kirk Hamilton (1989), (1991); Doug Trant (1990), and Hamilton and Trant (1988).

The SNA has not been revised since the early sixties. Recommendations came forth from the UNSO (1990) preliminary draft, but the current revision will not be available before the 21st century. Potvin (1989) notes this lapse of time and points out that in light of environmental pressure facing Canada, this wait is too long. Potvin included an appendix entitled "Report on the Joint UNEP / World Bank Expert Meeting on Environmental Accounting and the SNA: Paris 21-22 Nov. 1988". This report clarifies many of the new terms emerging from resource accounting discussions, outlines the direction and aims of the non-government organizations in establishing the accounts, and finally it lists the participants and major research contributors.

Since 1972, when the first Stockholm conference was held, many governments and agencies have become involved in finding ways to amend the SNA. There is a large consensus amongst non government organizations (NGOs) such as the Organization for Economic Cooperation and Development (OECD), United Nations Environmental Program (UNEP), and the World Bank, to keep the SNA's intact, for historical continuity, and to set up a parallel system of satellite accounts (El Serafy, 1989). These accounts would incorporate three types of values or measures: 1) qualitative indexes of health and welfare levels (SOE reporting), 2) a physical accounting for a balance sheet of the resource base and 3) a monetary accounting for the physical stocks where it would be feasible to do so.

Policies and capital formation are geared towards GDP growth. If the methods that are used to measure GDP are adjusted so that increases in GDP have to take into account the maintenance of natural capital and avoid practices that incur clean-up costs, then different policy decisions may ensue. GDP will then not only be a measure of economic success but also a better indicator of viable sustainable economic development.

2.3.1 Modifying the Accounts

Any modification to the accounts should aim to address the shortcomings of the SNA. Hamilton (1991) summarized these as incorrect measurement of:

- product (therefore GDP),
- depreciation (therefore NDP) and
- wealth (therefore Balance Sheet).

As mentioned earlier, defensive expenditures relating to product measurement will not be addressed in this study. If revised accounts acknowledged the contribution of natural capital to the economy and conferred upon resources the same treatment as human-made capital, then they would deal with two of the major flaws- depreciation and wealth. A stock (wealth) and flow accounting could be used to achieve this. Stock accounts could be developed by taking a physical inventory of the resource and then multiplying each unit of the resource by a price per unit. This would yield the 'wealth', a value for the entire stock. This price should be a net price, the net return per physical unit of resource minus the costs of extraction, which "when multiplied by reserves and commercial living resources gives *wealth* in the national balance sheet; when multiplied by extraction..it gives *depletion* for measures of net national income" (Hamilton, 1989:6). In an agricultural example, this is analogous to valuing land for its productive value, and adjusting for improvements needed to get the land into production.

These aforementioned actions would yield balance sheet assets. Any changes from the beginning wealth account to the ending wealth account would be assigned as degradation or loss when the ending balance was lower, and improvements or discoveries when the ending balances were higher. These measures could then be fully integrated into the flow or income accounts as adjustments to inventory or depreciation. Hamilton (1991:4) argues though that "it would be more accurate to view discoveries as akin to revaluations or capital gains -at any event discoveries represent a change in knowledge rather than current income and are more correctly reflected in wealth measures." This may be the case for mining industries, for which valuation theories abound. There are many unknown mineral resources and discoveries take place each year.

Smith (1990)[1] writes that reflecting discoveries in the income or product account confuses additions to product with additions to wealth and creates spikes in income from year to year. In Québec agriculture however, the resources are already known and mapped out including 'reserves'. Reserves for the purposes of this study, are defined as the marginal lands whose locations and capabilities are known, but because of high costs of improvements, infrastructure or insufficient profits from yields on these lands, do not merit investment today. If new marginal land came into production because of improvements (drainage, fertilizer, organic matter management) then the hectares should be recognized in a new category in the wealth account, reflecting the improved productivity. The premium on the land and the investments in it should be reflected in the income accounts or a satellite account as a positive adjustment to inventory value. Conversely, if land is taken out of production or depreciated, this should also be recorded as a loss in the inventory, or movement to a category reflecting diminished productivity. These events would also be linked to income accounts, showing a depreciation measure, or a negative adjustment to the inventory.

While there is general agreement on the establishment of proper measures of wealth through a stock type of accounting, there are several ideas on where depreciation should be reflected. Victor (1990b) uses three approaches in a comparative analysis for estimating adjustments after a) those like El Serafy (1989) who advocate adjustments directly to the GDP b) those like Repetto (1989) who state the correct place to include natural resource depreciation is at the NDP or Net Domestic Income level and c) those who talk of 'net price' and suggest that some adjustments be placed in separate wealth accounts (Hamilton, 1989). If capital cost allowance is to be truly parallelled by a natural resource measure though, depreciation would have to be included in the estimation of NDP.

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1 Smith (1990), was reviewing Hamilton (1989) and Victor's (1990a) critique of Repetto's (1989) landmark, *Wasting Assets*.

El Serafy suggested that the monetized stock account was inadequate by itself and that adjustments must be linked to the flow accounts. While many authors agree on this point, El Serafy goes further by insisting that part of net receipts be charged directly against GDP. A method was proposed whereby net receipts from the sale of natural resources i.e. minerals, are split into an income portion for consumption, and a capital depletion portion for reinvestment. The capital portion (non value-added) would then be subtracted from GDP. In the example of farmland, this is equivalent to selling farm land for urbanization and isolating the productive value, as the capital portion to be charged against GDP. This splitting of receipts can be problematic. Repetto (1989) places a similar emphasis on carrying adjustments through but to the Gross National Product (GNP) measure.

It would be ideal to complete all of these revisions but often there is a of lack of information to take an inventory or to value accounts. As well, costs of developing inventories or methodologies for valuation are restrictive. An alternative would be to use other qualitative indicators such as State of the Environment (SOE) reports (Anielski, 1992). Pearce (1989) and the NTFEE (1987:4) noted though, that methods are superior when economic weights or values can be applied to resources and attributes.

The shortcomings of the accounting practices and proposed solutions have been described extensively in the literature (Ahmad et al., 1989; Peskin, 1980; Victor, 1990b; Potvin, 1989; Repetto, 1989), yet few actual revised accounts exist. This could be due to the dissension over how changes actually are to be made and over the valuation issues of non-market activities and goods (Harrison, 1989). The most contention revolves around the monetization of resources. Some resources never undergo market transactions so a value must be imputed. This can be difficult especially if the benefits of the resource are remote with respect to the marketplace. There is also disagreement over whether adjustments should be made to satellite accounts or whether existing accounts should be modified. In light of the capabilities of databases and software, this argument is redundant. All accounting, whether SNA or NRA, relies upon common underlying databases. There is therefore no difficulty in viewing or querying the data in one paradigm for NRA and another for SNA or some hybrid, without any disruption of the SNA and its benchmarks.

A pluralistic approach is likely the safest and most practical way to confront the criticisms of the SNA. No one model or procedure could possibly meet the needs of different economies in different regions. Norgaard (1989b: 57) points out that multiple methodologies would alert decision makers to many aspects of resource change. This would be advantageous because the planners don't always know which questions to ask *a priori* and the confines of using a single model are avoided. For this research, wealth accounts as per Repetto (1989), Hamilton (1991), UNSO (1990) and Victor (1990b), will be constructed and evaluated. Changes in wealth will be carried through, if appropriate, to income accounts as depreciation or adjustments to inventory.

2.3.1.1 Modification to the Canadian Agricultural System of Accounts:
The United Nations Statistical Office proposed guidelines for NRAs of which a general outline is shown in Table 2.1 (UNSO, 1990). These suggestions will be compared to the practices in place for estimating Canadian agricultural income statements, titled *Net Farm Income* (flow account); capital value accounts titled *Current Values of Farm Capital* (input to balance sheet) ; and *Balance Sheet of the Agricultural Sector* (wealth account). When the Census was taken in 1991 there was not a reconciliation between Agriculture Economic Statistics (AES), Agriculture Financial Statistics (AFS), FCC Farm Survey, Census of Agriculture, and the Taxation Data Program (TDP). There was found to be over $ 1.8 billion difference between the methods with AES claiming $ 5.6 billion in net cash income and TDP calculating $3,8 billion net cash income for the 1991 year.

Table 2.1 Natural Resource Accounts

	Biological assets		Land (incl. terrestrial ecosystems)			Sub-soil assets (proven reserves)	Water (incl. aquatic ecosystems)		Air	
	economically produced	wild	cultivated		uncultivated (area)		quantities	qualities (constituents)	quantities	qualities (constituents)
			soil	area						
	1	2	3	4	5	6	7	8	9	10
1. OPENING STOCKS										
2. INCREASE										
2.1 gross nat. increase										
2.2 discovery of new resources										
2.3 area increase by econ. influence										
3. DECREASE										
3.1 depletion due to natural causes										
3.2 depletion due to economic causes										
3.3 area decrease by economic influence										
4. ADJUSTMENTS										
4.1 techn. improvements										
4.2 changes in prices, costs										
4.3 improved estimation methods										
5. CLOSING STOCKS										

Source: UNSO, 1990: 73b

There is a recognition that these various measurement efforts need to be reconciled first and foremost (Statistics Canada, 1994b).

Land values are included in the Balance Sheet of the Agriculture Sector, but land wealth accounts are not set up as conventions in NRA would dictate for natural resource stocks. There is not a wealth account for agricultural land. Currently a value for land is estimated and recorded in the balance sheet using this subsequent procedure. The Census of Agriculture questionnaire (quinquennial) asks the farm operator to estimate the ***combined*** total fair market value for land, service buildings and homes owned, and land, service buildings and homes leased (Appendix A.1). These values are tabulated in Census years and are indexed on intercensal years. Once this combination of all three is aggregated, an average value per acre is determined by dividing this estimate of total real estate value by the number of acres reported in step seven of the Census. This yields the 'Capital Value Land and Buildings Series'. Up to this point, real estate value has not been separated into the three components and is still a single entity based upon the farmers' opinion of value estimates. It is then split into three categories, employing a 1958 income and expenditure study with a methodology for determining proportion of land value to the farm building and house value. Once the building value is isolated, it is used in a declining balance model to estimate depreciation for the Net Farm Income account. Houses are depreciated at 2% and buildings at 5%. Land is not valued in a separate account, depreciated, nor is it linked to the flow accounts in any way (Statistics Canada, Concepts and Methods, 1994a:29).

Change to the land stocks, yielding flow variables, could be recognized in a few ways: 'depreciation' could reflect depletion of land quality and the monetized 'adjustment to inventory' could reflect changes in numbers of hectares and/ or changes in price. As it currently appears in the Net Farm Income account, 'Value of Inventory Change' is limited to mean inventory change in grains and livestock:

> "The physical change in inventories is valued at weighted average annual prices in the case of crops and at simple average annual prices for livestock commodities. " (Statistics Canada, 1994a:29).

Land is not included in the change in inventory, although a change in hectares farmed can be determined from the Census. Hectares in the Census of Agriculture are tabulated from the Census of Agriculture Survey every 5 years. In intercensal years, hectares are adjusted by looking at the land change trend from the past two Census results and annualizing the trend. As the successive survey's results are added, a backwards adjustment is made. The aggregate change in value of land can also be seen in a comparison of Balance Sheets, or Census data, however it is not readily apparent if the changes are due to land prices or surface areas being farmed (Appendix A.2).

If farm land is sold outright to urbanization, it is considered a 'non-produced asset', so the profits do not contribute to GDP. The proceeds received by the farmer or investor for the sale of farm land, do not make their way into investment income or base profit figures in the SNA, but neither is there a loss of the asset recorded anywhere. In the sense that GDP does not rise, farm land is not subject to the same types of fallacies that befall other resources. For instance, if topsoil or sod was the asset being liquidated, these proceeds would be additions to product and therefore GDP. No where would the damage to the stripped land be recorded. In this scenario, as depletion heightens, GDP rises without being counterveiled. These accounting dichotomies have been compellingly portrayed by Repetto (1989), Victor (1990b) and Potvin (1989). There are several crucial arguments that point out why the current treatment of the agricultural land resource in the national accounts is inadequate:

- the land is not recognized/valued separately as a productive asset in Census or in the Capital Value series;
- the total land value is not calculated on a unit * price basis;
- the evaluation method (opinion of value) is subjective;

- price is not based upon market transactions;
- land, buildings and houses are separated mainly for depreciation purposes using an aged study, but no acknowledgment of depletion or degradation is bestowed to land;
- only short-term assets (grain and livestock) are explicitly recognized in 'Value of Inventory Change';
- if land is sold for urbanization no loss is recognized.

There is no linkage between a balance sheet and the income account for agricultural land. A stock and flow approach would reflect exactly what was occurring with the land resource in transparent and linked sets of accounts.

Below, in summary:

CURRENT SYSTEM

Price		Value		Units
Solved on a real estate value per acre. Foundation for Capital Value Series.	=	opinion of value of all farm real estate, Census survey. Aggregate value split into 3 categories based on 'proportion' study. Building depreciation derived from this.	divided by	acres of farmed land as reported on Census survey

NRA SYSTEM

Value		Price		Units
Solved as a productive asset value. Change in this figure represents monetized depreciation/ appreciation and/ or inventory adjustments.	=	Based on market transaction, or willingness to pay. Objective empirical estimates.	multiplied by	Inventory of farmland, classified according to productive capabilities.

2.4. EVALUATION FOR NRA:

The valuation approaches outlined in this section, identify several types of wealth loss related to land (change in inventory), or flow variables such as water erosion, (degradation) and estimate a value for the damage. This can be seen under Table 2.1, Part 3 as 'DECREASE'. This approach is useful when there is a specific policy question that needs answers and it contributes a piece of the puzzle. Some of the research that is cited, highlights different valuation methods but these were not necessarily developed with natural resource accounting in mind. However, when the objective is to value only the damage, a change in wealth, this ignores the exercise of valuing the total wealth value of the stock accounts. The total wealth would be reflected in Table 2.1, Part 1 where 'OPENING STOCKS' are identified as a function of classification of soil, area, and price.

To construct a wealth account, the inventory of land will need to be quantified in physical units and multiplied by a per unit price to yield a total value for the stock of land. Presumably the inventory would have uniform units, i.e. a hectare, but not all units would have equal productivity or quality. Thus an inventory would also have to have divisions or classes that easily distinguish between different levels of attributes. A price or value per unit could be estimated for the different classes within the resource by a) using a shadow price found by determining the present value of the future benefits from the resource; b) willingness-to-pay; c) a user cost method. Alternatively, given valuation challenges, many studies have avoided wealth account construction and have instead estimated flow account measures. These studies demonstrate changes in wealth by determining costs of depletion prevention, costs of restoration (both defensive expenditures) or costs of reduced yields (opportunity costs) as proxies of renewing to a full value.

There have not been many studies conducted to construct wealth accounts and of the few that are comprehensive, three arose from the same working group at the World Resources Institute: Indonesia's soil and timber accounts (Repetto, 1989), USA's farm bill accounts of on and off-farm costs of depletion (Faeth et al, 1991) and Costa Rica's forest, soil, fishery and coastal resource accounts (Solorzano et al, 1991). There have been many studies conducted on flow variables (Section 2.4.1.) and studies to place value upon farmland (Section 2.4.2.) but most of these studies did not have the ultimate purpose of constructing stock and flow accounts. Examples of some of the flow variables which have been quantified and valued are costs of higher inputs to avoid yield reduction (Magrath and Arens, 1989; Repetto, 1989), opportunity costs from reduced yields due to soil depletion (Coote et al, 1981; Mehuys, 1984; Agriculture Canada, 1986; Repetto, 1989; Magrath and Arens, 1989) and finally defensive expenditures from mitigating pollution flows like carbon emissions (Adger and Whitby, 1991).

Some land value studies have been conducted to investigate if off-site characteristics are incorporated into land prices. Examples of these studies include: Pardew, Shane, and Yanagida (1986), who examined the effects of scenery; Coelli et al (1991), who attempted to find out if water projects capitalized into the land values; and Shonkwiler and Reynolds (1986) who analyzed the effects of urban shadow on farm land values. The aforementioned flow value and wealth value studies fall short of resource accounting, but provide a strong foundation for establishing prices or proxies of wealth and depletion of wealth.

2.4.1. DETERMINATION OF DEGRADATION COSTS - PRODUCTIVITY MEASURES

This is the category of measures where attempts are made to place dollar values upon the depreciation of the asset without placing a value upon the asset itself. A direct or indirect approach can be taken: calculation of the decline in yields (therefore income) as a result of diminished soil quality or evaluation of physical and biological characteristics lost through erosion (Solorzano, 1991). The latter is often estimated by using costs of increased inputs required to maintain yields as a proxy for loss. Depletion can theoretically be offset by restoration or avoided by preventive measures, but the costs of these defensive expenditures must be charged against the gross product of the soil. For example, liming costs to counteract acidification and fertilizer costs for depleted nutrients already are charged against net farm income (NFI) on a micro scale but these are considered to be operating costs instead of true depreciation charges. If one looked at local ditch reinforcement though, or clean-up costs for downstream sedimentation and wildlife harmed by water pollution, these costs are not charged against net agricultural product at all. The estimated cost of counteracting depreciation or the opportunity cost of foregone income due to reduced yields should be subtracted from NFI to give a sustainable measure of income.

2.4.1.1. Opportunity Costs of Declining Productivity:

Most models under this category are refinements of earlier estimates of crop loss or opportunity costs, and not necessarily departures into new methodologies. Some of the following studies model a linear relation between soil degradation and decreased yield, although Battison (1987) makes a case against this. These models have been as simple as equation 2.1 below, up to the data intensive and complex equation 2.3.

Anderson and Knapik (1984) conducted a major study, which lead the way for the development of soil conservation policies in Canada. The oft cited results[2] and economic estimates of damage were rather crude however. Equation 2.1. outlines the variables used to estimate these annual costs:

$$AC = (AI) * (YL) * (CV) \qquad \text{equation 2.1}$$

[2] The Anderson and Knapik (1984) study was often mentioned by Senator Herbert Sparrow who was chairman of a Senate Committee mandated to investigate soil degradation. (Agricultural Institute of Canada, 1986)

where:

AC	=	Annual Costs (dollars)
AI	=	Total Area Impacted (acres improved land)
YL	=	Yield Loss (% estimate)
CV	=	Crop Value (wheat-barley-canola weighted) / Improved Acre (dollars/acre)

Economic losses were estimated for four types of physical damages : soil salinization, water/aeolian erosion, acidification, and organic matter loss. Benefit-cost ratios were determined for ameliorative measures for each of the four types of degradation with varying results. Practices employed to offset loss, such as reduced sumerfallow or increased nutrient application, had a benefit-cost ratio (B/C) between 2 and 3. This held for all soil types except the brown soils where B/C varied between 0.4 and 0.8. For these types of soils, farmers would never be able to recapture their conservation investment *ceteris paribus*. All these ratios could fluctuate with different crop prices or input prices. For 1984 the following costs were estimated. These annual costs were projected to increase steadily over the next 25 years:

Table 2.2. Estimated Costs of Prairie Losses in 1984
(Alberta, Saskatchewan, Manitoba)

TYPE	COST/YR (millions)
Salinization	$ 104
Erosion	$ 468
Acidification	$ 49
Organic Matter and Nutrient Loss	$ ****
TOTAL	$ 621

Source: adapted from Anderson and Knapik (1984).
****Authors felt this value was not possible to isolate. Input costs were not used as a proxy for O.M. loss since input levels are sensitive to all types of soil degradation. "Yield reductions were estimated on a basis of "no compensating inputs being added" to avoid masking the problem. (Ibid: 7).

The next major study of economic costs of soil degradation (Agriculture Canada, 1986) focussed upon Eastern Canada and B.C., areas not covered under Anderson and Knapik (1984). Costs of water erosion, wind erosion, acidity, soil compaction, and off-farm damage were estimated as in Table 2.3. A similar equation to the 1984 study was used. Here, the yield reduction factors were estimated by study participants, whereas in the earlier study they had been estimated by the authors. Because of the diversified production in the eastern provinces, a weighted crop value was not suitable and crop value was estimated as the farm-gate price for each of the different crops.

Table 2.3 Estimated costs of degradation from provinces east of Manitoba and B.C.

Type of degradation	Annual Costs (Millions)
Water Erosion	156-218
Compaction	126
Wind Erosion	11
Acidity	9
Off-farm damage (sedimentation only)	91-111
Total	393-475

Source: Agriculture Canada (1986:2-3).

Other authors (Faeth, 1991; Repetto, 1989; Solorzano, 1991) have used more detailed bio-physical models to estimate the relationship between farm practices, different crops and costs of soil degradation. One such biophysical model is the Erosion-Productivity Impact Calculator (EPIC) - a linear programming model that uses thousands of observations for simulation. Equation 2.2 is an example of how this model can be used to form the basis for estimating the value of soil depletion. Faeth et al (1991) looked at the on and off-farm costs of erosion in the United States using EPIC with the Food and Agricultural Policy Research Institute (FAPRI) model.

$$SDA = \left[\frac{(Y_o - Y_n)}{\left(\frac{n}{RL}\right)}\right] \times P_c \times \left(\frac{\left[1 - \frac{1}{(1+i)^n}\right]}{i}\right) \qquad \text{equation 2.2}$$

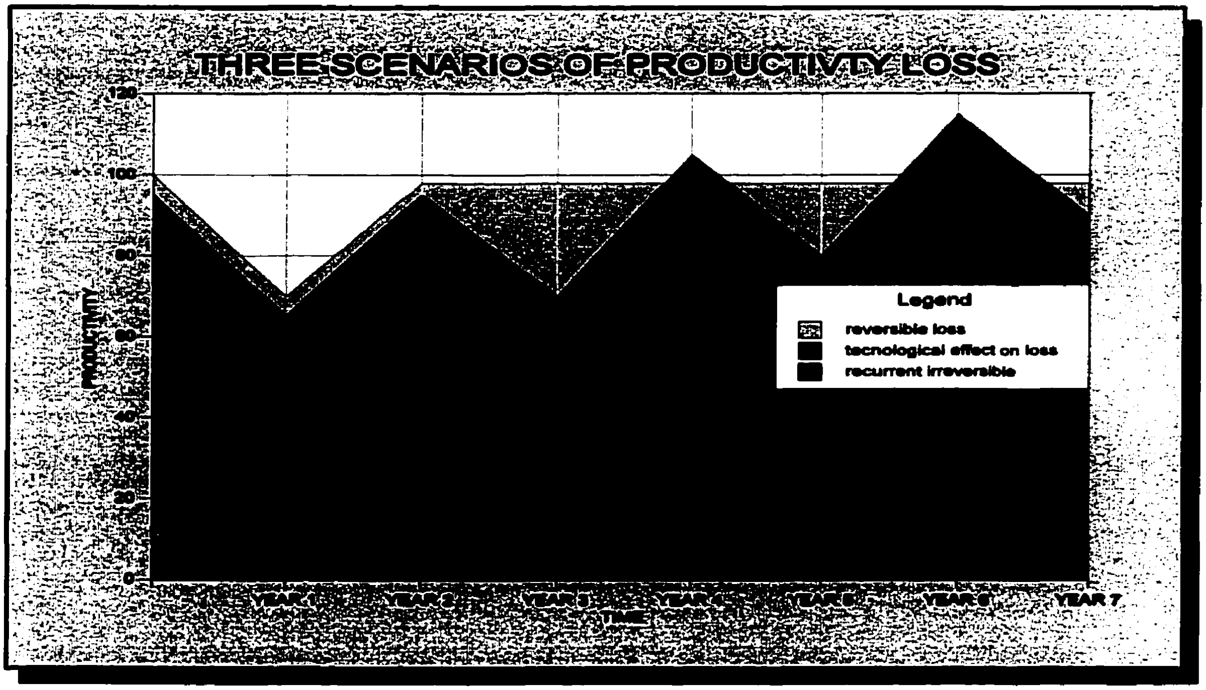
where:

SDA	=	soil depreciation allowance
Y_o	=	initial yield estimated using EPIC
Y_n	=	final yield estimated using EPIC
RL	=	rotation length
n	=	period considered
P_c	=	crop price estimated by FAPRI
i	=	real interest rate

The EPIC model is theoretically superior when considering productivity estimates, yet it requires an enormous database to perform well. When comprehensive data is absent, as in many developing economies, alternative measures of soil loss need to be developed. This was the instance in a Costa Rican study conducted by Solorzano et al (1991). The authors originally suggested a productivity loss model, but resorted to using a replacement cost model (equation 2.3) due to a paucity of soil studies and bench mark data.

Other studies have calculated on-site loss of productivity and off-site costs of siltation (Magrath and Arens, 1989). This study was interesting because it recognized the initial cost of depletion but it explored two models that allowed for the possibilities of restoration. Three situations with different economic arguments were modelled (Figure 2.1). The first assumes irreversible losses and impacts in subsequent periods. The second assumes irreversible, recurring damage that is compensated for or masked by technological advancement. Finally, a situation where complete restoration is possible is estimated.

Figure 2.1. Three different economic arguments of resource depletion, Java.



SOURCE: adapted from Magrath and Arens (1989:31-33)

2.4.1.2 Replacement Cost Methods:

A replacement approach for estimating costs computes the extra inputs and labour needed to maintain a sustainable yield as degradation occurs. No gains in welfare are achieved with these expenditures, but they prevent further losses. Replacement costs are also called defensive expenditures. This method is not as conceptually sound as the productivity loss methods, but it is sometimes necessary when data is lacking. Here the Universal Soil Loss Equation (USLE) was used in the Costa Rican soil and forest NRA study (Solorzano, 1991).

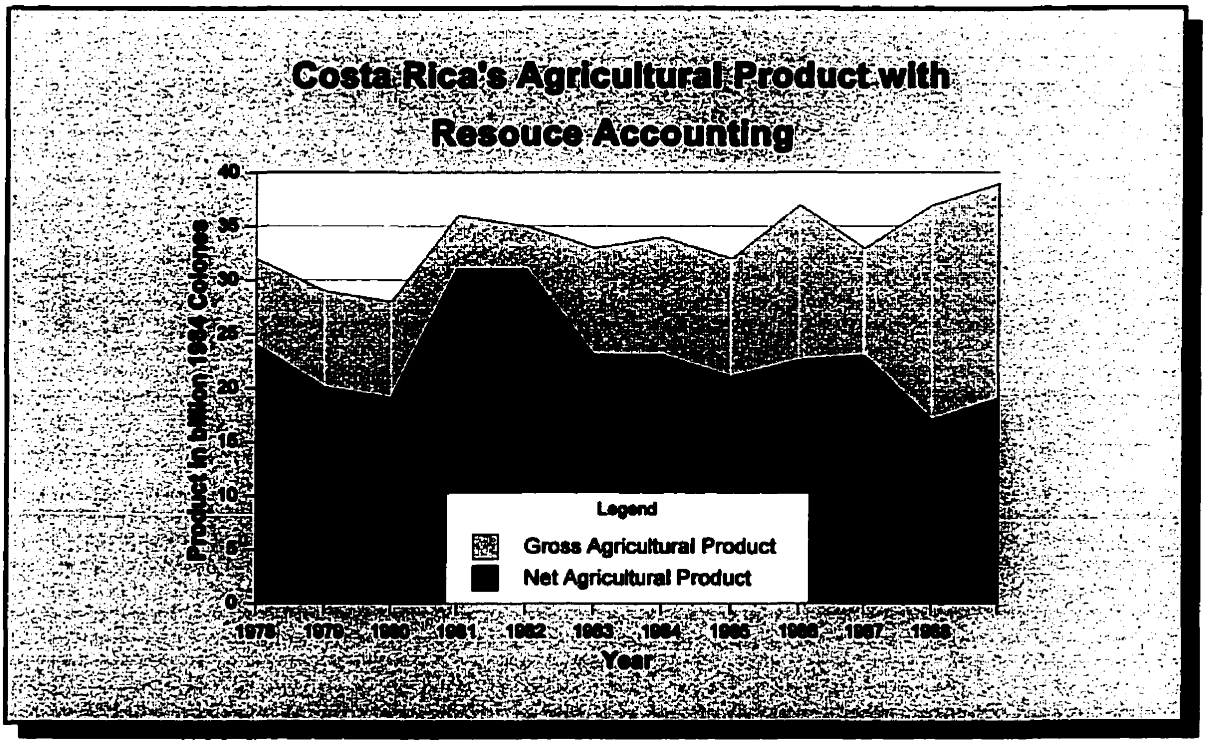
$$VSD = (QN_{tot} - QN_{tol}) \cdot \oint_{a} (P_{\oint} + C_{\oint}) \qquad \text{equation 2.3.}$$

where:

VSD	=	value of soil depreciation
QN_{tot}	=	total quantity of nutrients lost
QN_{tol}	=	tolerable quantity of loss
$\oint_a$	=	factor for fertilizer efficiency
$P_{\oint}$	=	price of fertilizer
$C_{\oint}$	=	cost of applying fertilizer

The quantity of nutrients that were lost was estimated using the USLE. Estimation of the tolerable quantity of loss was "difficult and imprecise" (Ibid :34). When the costs associated with nutrient losses were identified, they were identified in the appropriate place in the income accounts. As can be seen in Fig. 2.2, the corrected income is significantly different when these costs are incorporated.

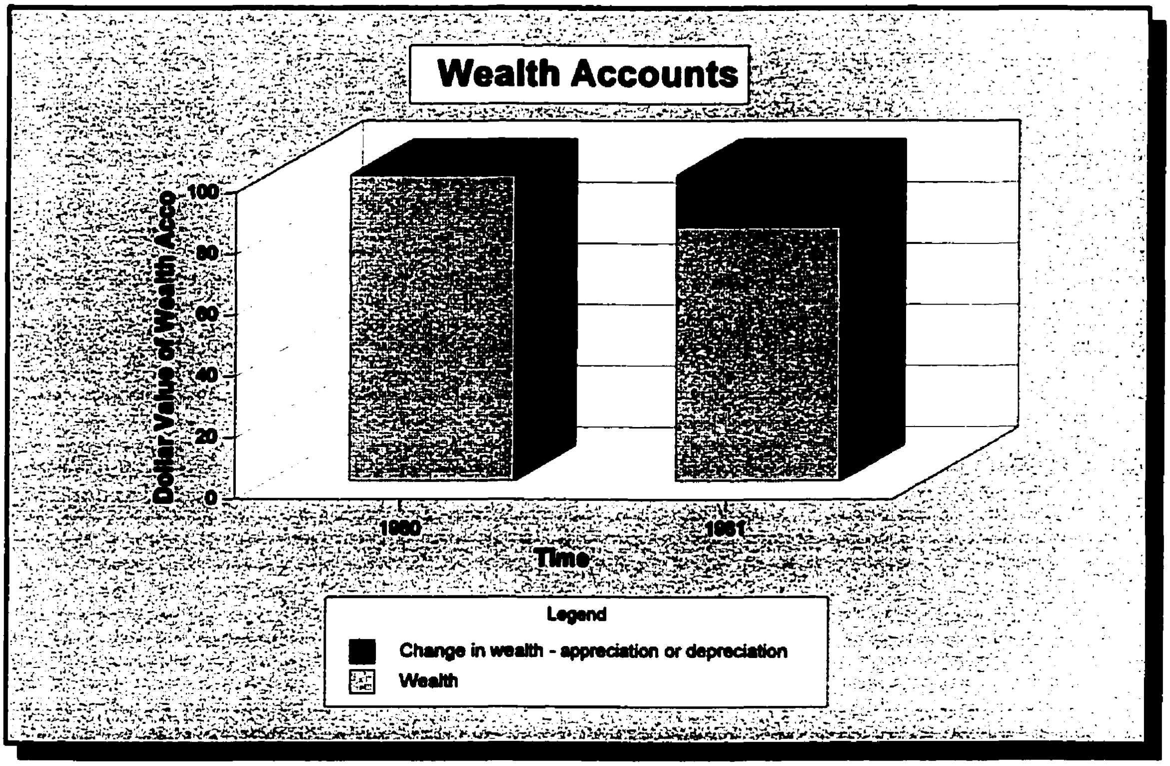
Figure 2.2. Agricultural Product, Before and After Resource Accounting



Source: Solorzano (1991)

The opportunity costs and replacement costs methods investigated here have potential for use in Québec. Identification of costs associated with loss of productivity or maintaining productivity contributes greatly to NRA. To illustrate, in Fig. 2.3 below wealth (stocks) has been identified for two different time periods.

Figure 2.3. Wealth Accounts and Flow Variables



The positive or negative difference between these two time periods is the appreciation or depreciation, respectively, of the wealth. It is this amount of change that enters the income accounts as a flow variable. The studies in this section have dealt with all, or part, of this adjustment portion, without estimating a value for the wealth (stocks) itself. Estimation of the stocks are crucial to test the hypotheses outlined in Chapter 1. For this reason, these methods are deficient for the purposes of this research. The following section will investigate methods of wealth valuation for agricultural land.

2.4.2 DETERMINATION OF LAND PRICES - WEALTH MEASURES

The first step in constructing a wealth or stock account is taking an inventory of the units. In Canada, there are several ways in which units of land are recorded and categorized. The system of land classification as defined under the Canada Land Inventory (CLI) described in section 2.5. is a thorough, detailed land inventory whose coverage is comprehensive. Productive resources as well as potential resources (reserves) are reflected in the CLI (Lajoie, 1975). The CLI will be used to interpret the physical units of agricultural land. Because the CLI classifies the land into different groups based on productivity, identifying one price per unit of land may not be appropriate. A value will have to be determined for each class within that system. The hypothesis that prices account for different levels of productivity found in the different land classes will be tested.

2.4.2.1 Capitalization Models:

Agricultural economists, assessment offices and governments have been estimating farm land values for years. One of the methods whose precepts were understood in Ricardo's (1911) time and even earlier is the idea of capitalization. Pope (1985), Gardner and Barrows (1985), Leathers (1992), Phipps (1984), and Williams (1994) are just a few of the authors who have used capitalization models to explain or investigate land prices and policy effects upon these land prices. "The agricultural productive value of land is commonly described as the present discounted value of expected returns to land." (Pope ,1985:82).

$$AV = \sum_{t=1}^{\infty} \left(\frac{R_t}{1-k} \right)^t \qquad \text{equation 2.4.}$$

Where:

AV = agricultural land value, the discounted present value of

future expected earnings
R = returns to land
k = discount rate
t = time period

Estimating the value of land through capitalization is appropriate under certain assumptions. In any capitalization model the question as to the selection of a suitable discount rate arises: should a social or private rate be used ? Hamilton (1991) suggests that a social rate be used when resources are on public lands. Bank rates or private rates, are also used with various justifications. Gardner and Barrows (1985) mention that a reason for divergence between social and private discount rates is a difference in the degree to which society, as opposed to an individual, wishes to hedge against uncertainties of future increases in the demand for agrifood products. Typically the decision over choice of a rate has had nebulous links to the productivity of the land.

Capitalization can become problematic for productivity studies when expectations are formulated in the model. Williams (1994) points out that expectations tend to be uncoupled from productivity, and are reflective of real estate speculation, potential for off-farm income and of expectations that different government programs will be capitalized into land value e.g. quota and benefits of the Crow Rates.

Finally, there are problems with trying to estimate annual revenue values. Many models depict constant annual returns to the land suggesting constant productivity. Returns are linked to productivity either on the income side (yield * price) or the cost side (inputs * price). In turn, both yield and level of inputs have a relationship to productivity. This poses a challenge both in terms of data availability and in terms of the components beyond productivity that contribute to returns to the land.

The capitalization model does not directly incorporate the value of the physical productivity differences in the land resource. The discount rate and formulated expectations, if any, have weak links with land productivity, and introduce several extraneous effects. This study will aim to insulate land values from such effects. A model is needed that will estimate a price directly for productive value using market transactions. Because of these reasons capitalization is inappropriate for this analysis.

There are other valuation methods which are useful when evaluating non-market benefits. They include contingent valuation, travel cost and wage risk. These methods use either hypothetical situations or indirect costing methods to estimate the value of non-market benefits. Pearce and Markandya (1989) provide an explanation of the various methods and underlying theories. However, since market transaction data was available, it was decided that a direct estimation approach, a hedonic pricing model, would be more appropriate.

2.4.2.2. Hedonic Pricing Models:

Hedonic Pricing Theory arose from the consumer behaviour theory of Houthaker (1952) and Lancaster (1966) and was elaborated on by Griliches (1971) and Rosen (1974). Hedonic Pricing Models (HPM) have been used extensively to explain variation in the sale price of economic goods, and have been applied to farm properties (Miranowski and Hammes, 1984; Ervin and Mill, 1985; Danielson, 1986; Shonkwiler and Reynolds, 1986; Pardew, Shane, Yanagida, 1986; King and Sinden, 1988; Palmquist, 1989; Coelli et al, 1991; Herriges, Barickman, Shogren, 1992). HPM uses the variability in the characteristics of farm land to estimate the price of different parcels of land.

In perfectly competitive markets, there are heterogeneous bundles of attributes that make up farms. A market, however, does not exist for these attributes individually. For example, precipitation differs from farm to farm but a buyer cannot purchase one inch of precipitation. Hedonic theory posits that each attribute can be treated as a quantifiable homogeneous good such that a price of a bundle (the farm) would be composed of implicit prices per unit of observable attributes multiplied by the quantity of those attributes (Pardew et. al.,1986). The implicit price or coefficient of each unit of these non-market attributes is estimated by regressing the dependant variable, sale price of a farm, $P(Z_i)$, on the attributes that make up a farm $(z_1...z_n)$. This yields the Hedonic Price Function (HPF):

$$P\ (Z_i) = f\ P(z_1...z_n) + U_i$$

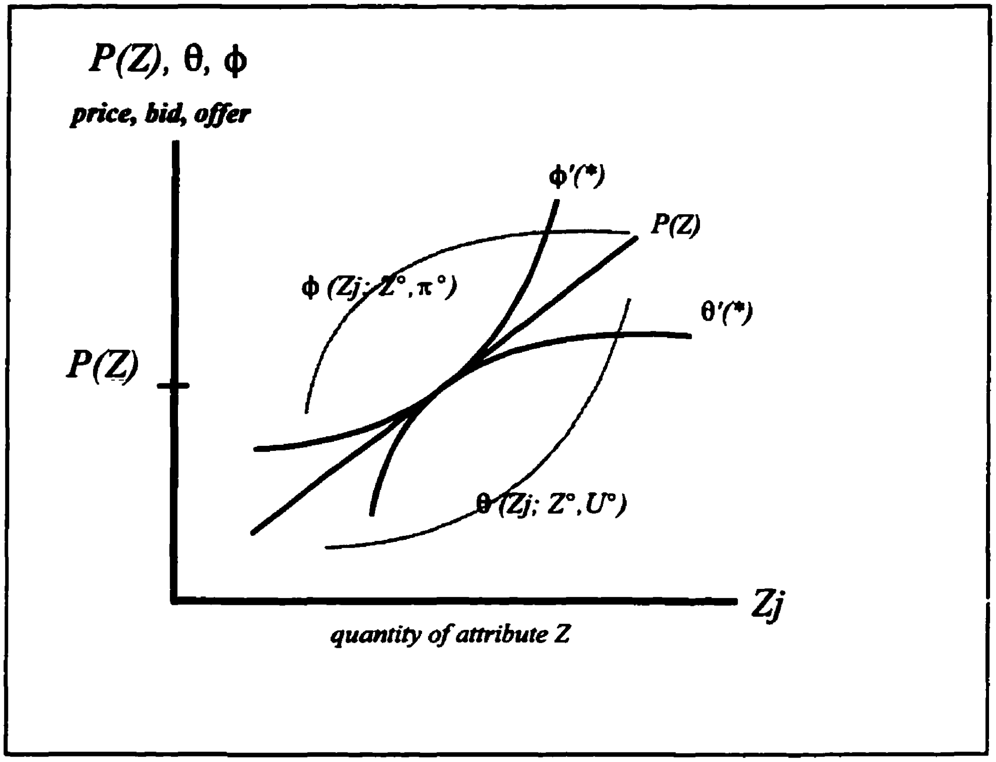
equation 2.5 The Hedonic Price Function

where:

i	=	1,...,n
Z_i	=	(k x 1) vector of the kth attribute of the ith farm
U_i	=	random disturbance term

The HPF (P(Z)) in Figure 2.4. is the locus of points of tangency $\phi'(*)= \theta'(*)$ between bid curves (amount buyer is willing to pay for a given bundle of observable attributes, $\theta(Zj;Z°,U°)$ and offer curves (amount a vendor is willing to accept, $\phi(Zj;Z°,\pi°)$. The HPF can be estimated without information about the underlying bid and offer curves, using market data. Likewise, it does not provide any illumination about the structure of these curves. There is little theoretical guidance when it comes to specification of functional form. The form tends to be hypothesized on the basis of expected relationships, then tested for suitability. This will be further discussed in the methods section in Chapter 3.

Figure 2.4. The Hedonic Pricing Function



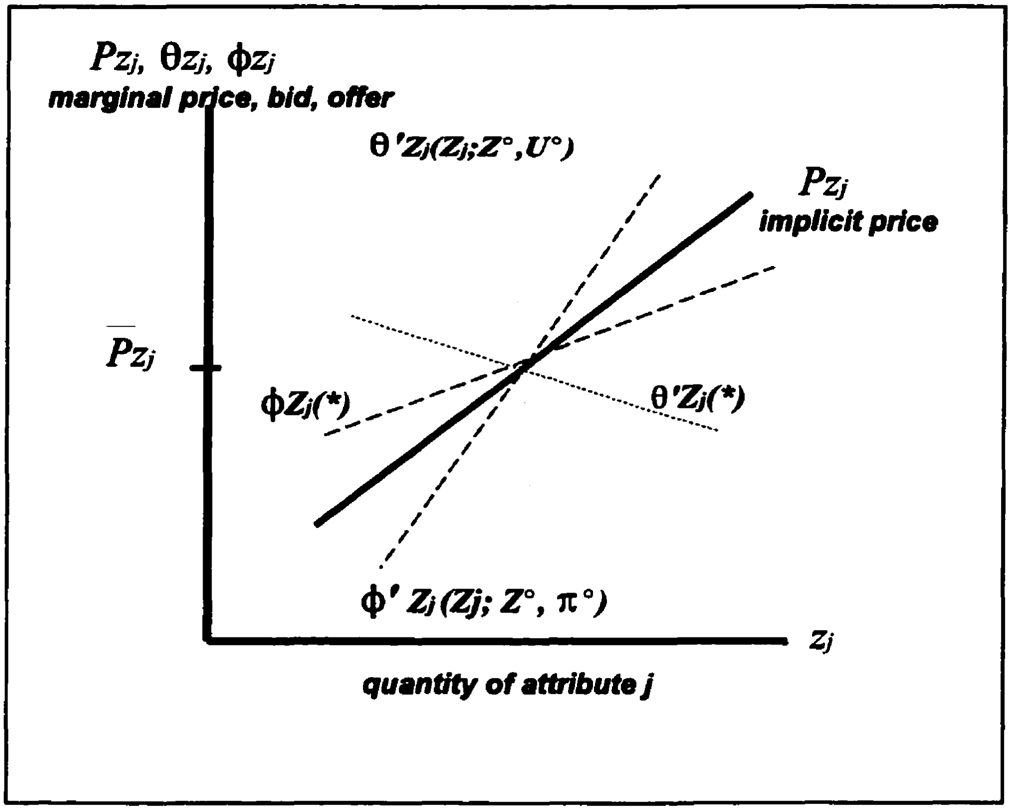
SOURCE: adapted from Pardew et al (1986: 53).

By taking the first partial derivatives of the HPF with respect to the ith attributes, implicit marginal prices can be found (equation 2.6 and Figure 2.5).

$$P_{ik} \equiv \frac{\delta P(z_i)}{\delta Z_{ik}} \qquad \text{equation 2.6}$$

These prices (P_{ik}), the regression coefficients, are the implicit market prices the buyer would offer or the seller would accept for one additional unit of the ith attribute, *ceteris paribus,* when a bundle of attributes are bought and sold. The bundling gives complicated interdependencies. In the long run, the prices equal the marginal costs, just as there is equilibrium in the real market. The coefficient resulting for the kth attribute is its capitalized net present value (NPV) for one unit of the attribute, (i.e.) value of one acre of class 1 land.

Figure 2.5. Implicit Marginal Prices



SOURCE: adapted from Pardew et. al. (1986: 53)

Rosen (1974) proposed a second stage to the HPM. In the two stage model, the first stage estimates the implicit marginal prices. If the bid and offer curves do not have different functional forms (non-linear), they will be an identity, recreating the HPF (Pardew et al, 1986: 53). The second stage is only possible if the bid and offer curves have different specified functional forms giving rise to a non-linear implicit price function. Results from the first stage (implicit marginal prices) are regressed on to the various levels of attributes and income, to yield bid and offer functions. This provides information on the underlying demand functions for specific characteristics.

The HPF can only be used with transactions from a market that has the following characteristics:

1) The area must be considered a single market. Buyers have information on goods in the marketplace.

   The Lower St. Lawrence River Valley falls within the urban shadow of Montreal, is recognized as an agricultural region within the same ecological/climatological region. Agricultural land in Québec was zoned and protected at the time data was collected under Bill 90 (Vaillancourt and Monty, 1985). All transaction parcels were zoned for agricultural use.

2) Consumers are fully informed and can maximize their utility.

   There is an active real estate market. Buyers are aware of the zoning laws. Current farmers who are expanding, have close to perfect information and new farmers generally work with one of many professional agents in this concentrated area of mixed farming.

3) Sellers are fully informed and able to maximize their profits.

   Only arms-length transactions were acceptable for inclusion in the analysis; any forced sales or family sales would not necessarily allow profits to be maximized.

4) The land market is in equilibrium.

   The land market must be in equilibrium to interpret the implicit prices as measures of marginal willingness to pay and marginal willingness to accept. The market is only just cleared (King and Sinden, 1988). The point is made that true equilibrium is impossible because of transaction and moving costs but that this is the case with almost any model (Ibid).

5) There must be a large number of properties (packages of combinations of different levels of the attributes) available to the purchaser.

   Since attributes are fixed and buyers cannot untie and repackage to find desired combination there must be sufficient selection to allow purchaser to optimize from the properties available. In the period between 1988 and 1991 over one thousand farm parcels were sold in the market area (OCAQ, 1991). This large number of available properties allows the buyer to find an acreage which will maximize his utility.

6) There is sufficient variation in the attributes such that the HPF is continuous with continuous first partial derivatives (and second partial derivatives in the case of a non-linear HPF).

7) The variation in the attributes is capitalized into differentials in land prices.

Conditions 1 through 5 were adapted from Miranowski and Hammes (1984:746) and 6 and 7 were taken from Danielson (1986). A good discussion of the HPM and its limitations can be found in Bartik and Smith (1987), Garrod (1992) and Tarassoff (1993). Marginal bid was assumed to mean the buyer's willingness to pay (WTP) for one unit of a given attribute. With this assumption the results from this study could be interpreted as direct valuation estimates as opposed to the indirect valuation methods. With the HPM technique, non-market benefits are capitalized as the WTP "hence the method is appropriate for measuring the welfare costs or benefits associated with an environmental amenity" (Tarassoff, 1993:25). Pearce and Markandya (1989) classify the HPM as a direct valuation method.

2.4.2.3. Hedonic Pricing of Farm Land:

The HPM has been used successfully to explain price variation and is suitable for estimation of values for different classes of farm land. These estimates of value are necessary in order to construct the wealth account. Productivity of land can be quantified into homogeneous classes through the Canada Land Inventory. Each type of unit can then be treated individually such that an implicit price can be estimated for this homogeneous component of the heterogeneous good through use of partial derivatives.

The HPM has been used to identify some of the causes of price variation. The following studies were reviewed because they use the HPM in investigations of farm land markets. In particular, they focus upon isolating productivity or non-market benefits and proceed to estimate dollar values for these. A few main categories of farm land studies have emerged and are described in the following sections. These include a) investigating the effects of the urban fringe upon price (Shonkwiler and Reynolds, 1986; Pardew, Shane, Yanagida, 1986), b) performing cost-benefit evaluations of land improvements, amenities or government programs (Coelli et al, 1991; Herriges, Barickman and Shogren, 1992), c) revealing capitalization of conservation effort (King and Sinden, 1988; Miranowski and Hammes, 1984; Ervin and Mill, 1985; Gardner and Barrows, 1985) and finally d) imputing prices of non-market commodities like land quality attributes and wildlife (Danielson, 1986; Messonier and Luzar, 1990; Garrod and Willis, 1992).

2.4.2.3.1. Urban Fringe Analysis

Many studies of land evaluation at the urban fringe isolate an implicit price for urban pressure by looking at an alternate use variable or group of variables that are specified to capture the effects of urban pressure. Shonkwiler and Reynolds (1986) highlight the importance of including land use variables. "It is shown that the potential use valuation of a property when properly incorporated in a hedonic model summarizes a host of factors which may not be directly observed or easily quantified (Ibid: 58)". In models where such an alternate use variable was not included, distance from cities was found to be significant and accounted for multiple nonagricultural effects. Williams (1994) notes that land price expectations are formulated in part by the probability of off-farm income, a factor which is also highly correlated to distance from urban centres and proximity to the urban fringe.

Different uses of the land were found to have different shadow prices, (i.e.) land in an intensive hog operation is merely a surface area to spread manure, while land for cash crop farmer is viewed as a very different commodity. Aggregation across participants was thought to be impossible when land had different uses, thus violating the first HPM assumption of a single market. Instead of limiting transactions to those within a specific use segment to satisfy the first assumption, two binary dummies measuring potential for commercial or residential alternate use were introduced into the model. They found that when parcels had development potential there was likely to be successful pressure to urbanize:

> "Clearly farmland preservation efforts should be directed to those areas where farming operations are most likely to remain viable over time. Yet a parcel's agricultural viability may have little effect on its commercial or residential demand. In such cases a site's potential return under urban development is what determines its value (Ibid: 63)."

This is a fair statement, although a coefficient was not estimated for a variable that would have captured productivity in some way, to compare against the value estimated for the coefficients of the two binary dummies.

Pardew, Shane, Yanagida (1986) examined the benefits of several urban government-funded amenities on land in transition from agriculture. This research went beyond estimating the implicit prices, to determining the bid and offer functions. The first partial derivatives from the first stage were regressed on to the levels of their attributes in the second. The authors highlight a distinction amongst the variables they specified, as belonging to man-made/policy variables, location or accessibility variables, and natural attribute variables. Other researchers have called these groups: production, consumption and location (King and Sinden, 1988). Coelli et al (1991:6) called the latter category 'characteristics influencing both production and consumption'. The recognition of these different categories points out a very salient feature of land prices that has already been highlighted and is repeated here for emphasis: there are many factors reflected in farm land prices that have little or nothing to do with productivity. Market failure occurs when prices do not give adequate signals of changing productivity or when scarcity is masked by alternate use pressures.

Pardew's main attention was on road improvements, effective tax rates and sewer hookups. Increases in average parcel price were found where road improvements were present; effective tax rate was capitalized into land prices and forced prices down as rates increased; and a 50% increase in price was found in tandem with sewer hookups. It was concluded that government policies can have unintended affects on parcel prices. They can add windfalls but can also cancel out capital gains and as such, have an important role in the determination of land prices.

2.4.2.3.2. Cost-Benefit Analysis

HPM has also been used to estimate the value for one attribute of a farm parcel in order to conduct cost-benefit analysis, where the benefits accruing to this attribute are non-market. The results have been used to evaluate costs and benefits of government programs (Coelli et al, 1991; Herriges, Barickman and Shogren, 1992) and more recently, individual conservation efforts (King and Sinden, 1988; Miranowski and Hammes, 1984; Ervin and Mill, 1985; Gardner and Barrows, 1985).

Coelli et al. (1991) were commissioned *ex ante* to see if the benefits of connection to a publicly funded water supply scheme were less than the costs. Variables were included that were collinear because the researchers felt that to delete any variable would cause bias to the water scheme coefficient. Even so, the variables in question had high t-statistics and a strong *a priori* foundation. Resulting coefficients were recognized as less reliable and were sensitive to the specification. Soil variables were included by assigning a dummy variable to a heavy, medium or light soil density. These dummies were found to be insignificant. The authors later conceded that soil density was a poor proxy for soil quality or productivity, so were unable to draw any conclusions about productivity. Benefit cost ratio (BCR) of the capital costs of scheme water, to the value farmers attribute to the scheme water, varied from 0.09 to 0.25. As a result the authors could not support a recommendation to expand the publicly funded water scheme.

Herriges et.al. (1992) attempted to see how benefits of a US commodity programs were capitalized into farm rents. The hedonic pricing method was used to estimate the implicit value of the base acreage, with base acres defined as those being eligible for the commodity program. Population density was used as a variable to measure urban pressure. Its results were poor until dummy variables were included for the 4 counties in the study, in an attempt to capture other regional factors. A NPV of approximately $200.00 per acre was found for acres qualifying in the program. This is not surprising, since having base acreage guarantees access to the commodity program in future years, acting as insurance (Ibid: 57).

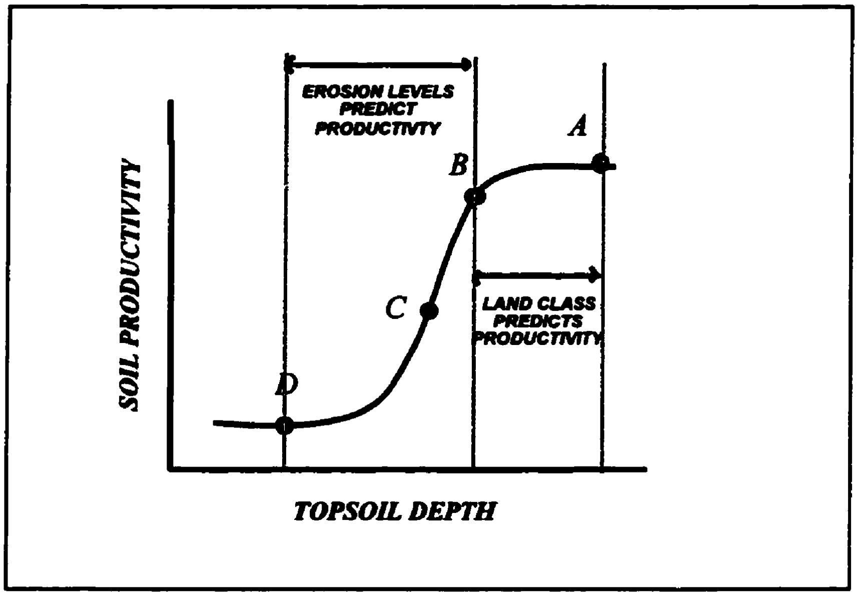
2.4.2.3.3. Capitalization of Conservation Effort:

Most studies under this category are conducted to examine policy implications of conservation works. If the capitalized benefits of conservation investment are greater than the costs, and farmers have this information, there is no need for the state to intervene. If, however, the costs of conservation efforts are not recaptured through the land price, and the greater welfare depends upon conservation, then the state may choose a path of intervention. The following studies investigate whether the farm land market provides clear signals about land quality and whether improved, well managed land is rewarded in the marketplace, given the costs of information.

King and Sinden (1988) attempted to find out if price changes with the condition of land and if the benefits of improving farm land exceed the costs. They estimated a land condition variable based upon the costs of recommended conservation works. Before the research began they proposed that market failures existed where farm transactions were concerned. They point out that farmers may ignore their own impact upon the land when land values fail to reflect soil quality and that if the farmers had access to perfect information, (i.e.) if they knew that the capitalized benefits and prevention of loss of the soil base positively affected the resale value of the farm, they would conserve it. Using a two stage model, results indicated that there was no evidence that the market undervalued conserved land. Market signals were actually found to be working to conserve the land and the market recognized land conditions. A BCR of 3.0 was found, although the authors assumed that a dollar spent on contour banks, had the same effects as a dollar spent on grassed waterways or other mixes of works.

There is very little empirical evidence that conservation investment is capitalized into farmland prices according to Gardner and Barrows though (1985). Many studies use gross soil classification systems when specifying the conservation or productivity variable, but in so doing, ignore recording erosion practices or field measurements of soil quality. Results from these studies would not be a test of the capitalization of conservation effort if practices or field measures are not included (Ibid: 944). Similar to Magrath and Arens (1989), the concept of thresholds are discussed: it was hypothesized that over some range of topsoil depth, productivity remains for the most part unaffected by erosion (Gardner and Barrows, 1985: 944). The classification of the soil (topsoil type) will be more closely related to productivity (Fig 2.6), as long as the topsoil is deep enough for the root zone (between points A and B). This holds true until some threshold (point B) is reached , at which time productivity declines rapidly (point C) or irreversibly (point D).

Figure 2.6. Topsoil Depth in Relation To Productivity



adapted from: Gardner and Barrows, (1985:944).

Beyond the threshold (between points B and D), it is the severity of the erosion (topsoil depth) which now becomes the driver of soil productivity.

The thresholds discussed here are relevant to the inventory chosen for this study. The CLI is built upon soil classifications and their limitations as a means of cataloguing productive capacity. The CLI can therefore be thought of as being the proper measure in the A to B zone. When however, land is in the B to D zone, another classification system built upon on-farm measurements would be needed to recognize the drivers of productivity, given the amount of erosion. It is assumed that on a macro level, farm land in Quebec is in the A to B zone. Proper accounting would alert decision makers of a shift towards B-D zone, if any, and the need for revised classification systems.

Gardner and Barrow's results showed that investment into conservation methods was not capitalized into farm land prices. "In general, it appears that investment is not capitalized, except in the presence of severe readily visible erosion problems (Ibid: 945) ." The authors concluded that buyers' have imperfect information; differences in productivity due to erosion can be masked by technology and cropping practices. If the buyers do not see visible signs of erosion, they are unwilling to pay for the sellers' conservation investments.

Ervin and Mill (1985: 938) give two reasons why there is little empirical evidence testing the link between erosion and prices: there has been no compelling need to see if prices were transmitting proper signals and secondly, rigorous testing has many data, conceptual and measurement challenges. It was noted that the dependant variable should be individual parcel transaction prices, because average land values lack the detail to identify differences across parcels (Ibid: 940). It was assumed that these farmland transaction prices had no significant consumptive attributes, but this is a highly unlikely assumption. Specification of the model included effects of past erosion and future erosivity. A corn suitability rating was used in lieu of a productivity index to indicate uneroded productivity. Coefficients for base productivity were large and reliable, while the coefficients for potential future erosion were large and unstable. It was suggested that, where land quality is concerned, there may not be a market failure after all. It could be that the costs of discovery for degradation type information are too high to be justified. This has an analogy in the mining industry. There are many known sources of mineral deposits but minerals are not scarce enough to justify the high costs of extraction at certain sites. In these cases, the market is working efficiently. There are many known causes and effects of degradation, but as long as food and farm land are not too scarce perhaps the cost of quantifying and valuing these effects is too great. The market may provide sufficient warnings of scarcity efficiently but it may not be able to forewarn participants about imminent thresholds and irreversible damage. They comment, as do most, that the methods available for measuring productivity/erosion are inadequate.

Miranowski and Hammes (1984) attempted to see if the price paid for poor farmland was too high (and thus to see if purchasers are irrational or poorly informed). The HPM is well suited for isolating benefits associated with environmental quality. To test this hypothesis, variables were specified for topsoil depth and potential erosivity. This method seemed to be an intuitively correct method for estimating a total land inventory value, but one must be able to collect primary data and measure on-farm soil variables. The Universal Soil Loss Equation was used to develop the erosivity measure. A positive gross return to a farmer for protecting his farmland was indicated. Results identified an implicit price per inch of additional topsoil between \$12-\$31/acre and a \$5.60 savings per ton of reduced top soil erosion.

2.4.2.3.4. Valuation of Qualitative Attributes

This last category of HPM, looks at placing values on qualitative indicators like erosion, productivity or wildlife. Valuing these types of attributes poses a great challenge: it is very difficult to quantify these attributes in units that would explain price variation. Proxies are often employed as an alternative to attempts to quantify attributes that are difficult to measure. An example of a proxy would be animal carrying capacity (Collins, 1983) specified to measure sustainability of pasture or forage type land, a substitute which has also been suggested by Repetto (1989) and Anielski (1992).

Methods that are typically used in non-market valuation of natural resources include contingent valuation (CVM) and travel cost methods (TCM). Randall (1987:273) makes the following distinction between these types of methods and HPM:

> "Observations generated by CVM can be directly interpreted as estimates of benefits (or costs) consistent with accepted economic theory. In this respect, CVM is preferable to the ... IP [implicit price] methods that require various more or less benign assumptions and benefit estimates. On the other hand, ... IP methods use observations generated by actual transactions whereas the transactions that generate CVM data are

> nonbinding because they are contingent on circumstances defined by "if..." statements."

Pearce and Markandya (1989) found that CVM often overestimates values, because peoples' willingness-to-accept can be two to ten times higher than their willingness-to-pay. When actual market transactions are available a more direct evaluation of the attribute in question can be achieved.

Messonier and Luzar (1990) attempted to estimate attributes of deer hunting leases in their HPM. Lease agreements, rental costs and attributes were obtained through a mail out survey. The final specification included dummy variables for squirrel and quail, but not directly for deer. Instead a variable was formulated where the number of times hunters had opportunities to shoot was divided by the number of hunting trips. It was not apparent why this indirect approach was taken.

A few results seemed counter intuitive. Two separate models were developed for two different districts. In one of the districts the presence of a cabin on the hunting grounds had a large positive coefficient and in another district the cabin variable had a negative unstable coefficient. One of the assumptions of the HPM has been interpreted differently by researchers. The transactions must take place in a single market. Some researchers interpret this to mean a single limited geographic market (Miranowski and Hammes, 1984), and others take this to mean that all buyers must be using the land for the same purpose (Shonkwiler and Reynolds, 1986). The problem of geography can be dealt with in two ways. The non-agricultural effects of the similar and adjacent counties can be recognized in a single model with the use of several dummy variables ie) district 1, district 2, or other quantification of these effects. Another option exercised, has been to use separate models for separate districts. If, however, these separate models don't explicitly include variables that capture the non-agricultural effects, the remaining explanatory variables can be biased if the constant term is not properly (and implicitly) including them. This would explain how it appears that a set of rational hunters would place a high value on cabin facilities in one area and not in an adjoining one.

As discussed earlier, Rosen (1974) brought the HPM into a second stage and entered the arena of demand estimation. This has been a controversial extension of implicit price techniques (Tarassoff, 1993). Danielson (1986) used a two stage HPM in his investigation of demand for agricultural land. In particular he wanted to estimate a demand function for productivity, recognizing that there were many other factors influencing demand for farm land:

"The demand for [land] is influenced by factors such as the rate of population growth and the public's desire and appreciation for rural living. An increase in these factors translates into higher bids for farmland tracts that possess these attributes. If farm product prices increase or if the crop and livestock yields rise because of improvements in agricultural technology, there will be increased demand for land favourable for farming. Increased buyer income may raise the demand for land with urban and/or agricultural characteristics. (Danielson, 1986:57)"

Four variables that related to urban potential were elaborated: road access, community water, nearby industry and nearby housing. It is likely that these four could have been grouped together to form a single urban pressure estimate. Soil productivity was measured by using the percentage of crop cover but this was found to be an inadequate and imprecise proxy. Difficulties were encountered in the second stage with the productivity variable, that were never fully resolved. The equations were reformulated and segmentation of the markets was attempted but this made no improvement. Notwithstanding, this study made an important contribution in terms of its estimation results of buyer and seller characteristics. Danielson recommended continued research with HPM and better data sets, both because of the empirical results that are possible and its ability to improve our understanding of prices and explain farm land markets.

So far, all the studies reviewed have examined effects of certain characteristics upon farmland prices. The Garrod and Willis (1992) research is a departure in that it examines the effects of "public goods", namely aesthetic countryside goods, upon house prices. Unlike productivity attributes or wildlife on a property, these characteristics are not purchased and are not a property right. Some of the countryside goods specified were proximity to forests, rivers, wetlands, slope, woodland view, and urban view.

The authors emphasize that HPMs only reflect marginal WTP if measured level of attributes correspond to the perceived level. For some attributes, individuals may not have sufficient information on non-observable attributes, (i.e.) pollutants. In this case, "marginal WTP may over or under estimate the true damage. However for many countryside attributes, such as pleasant views, the attribute and its consequences are likely to be immediately apparent to the household (Ibid: 61)." Garrod and Willis revisit the theory behind the HPM from a very pragmatic standpoint. They claim that HPM fares well for explanation of price, but there is concern when prices of individual characteristics are scrutinized. Interpreting the regression coefficients to represent WTP assumes that an individual values the attribute independently of the other goods he or she consumes (Ibid). The ability to separate and implicitly monetize characteristics may be hampered by collinearity between the variables, both for the individual and within the HPM itself.

Presence of rivers and forests and nearby rural settlement turned out to have strong positive coefficients, while view of a forest had a negative effect. This latter result was unexpected. Many of the variables had been measured on a neighbourhood basis and not a parcel basis, with the help of county maps. Additionally, the view variables were quantified deductively from working with the maps and house locations; not from the transaction record itself.

In conclusion, the HPM is believed to be the most promising method to estimate implicit prices for productive value, the basis for the construction of wealth accounts. Of all the HPM uses outlined in this chapter, the most compelling are the HPM's success in isolating the value of nonmarket attributes (Miranowski and Hammes, 1984), and that implicit prices are based upon market transactions. Under certain conditions or assumptions these implicit prices can be interpreted as the willingness to pay (WTP).

Summary

In the SNA section three crucial points were made, outlining why the current system of measuring land values for the SNA is inadequate: a) valuation procedures are not empirical but subjective. Appraisals and surveys are "subjective assessments of the values of characteristics based on comparable cases while the implicit price approach yields objective empirical estimates of the values of particular land and locational characteristics (Miranowski and Hammes, 1984: 745).", b) the valuation is not based upon real market transactions and finally c) productive value is not identified, or distinguished from the consumptive value, which is imperative in an NRA. An advantage of HPM for farm land is that it can estimate the value farmers allocate to productivity in the marketplace (Coelli et.al., 1991). The HPM offers solutions for each of these shortcomings.

2.5. AGRICULTURAL LAND INVENTORY:

Canada is the second largest country in the world. Despite its vastness, over one half of Canada's surface area has no value for agriculture or forest because it is subject to adverse climate and has little or no topsoil (Nowland and McKeague, 1977). Farm land represents only 13% of the country's surface area and less than 5% of this is prime agricultural land which is considered classes 1-3 (Table 2.4).

Table 2.4. Extent of Land Coverage in Canada

Hectares (millions)	% of total	Type
922	100	total land excluding waterways
534	58	rock, muskeg and unrated organic soils
267	29	forest not suitable for agriculture.
120	13	potential agricultural land
Of Which		
38	4	classes 5, 6 and 7
36	4	class 4
41.5	4.5	classes 2 and 3
4.6	0.5	class 1

SOURCE: adapted from Agriculture Canada (1985:3), Coote (1983), Nowland (1977).

When you consider that most of this prime land in eastern Canada lies within the Quebec Windsor axis[1] and urbanization occurs largely on classes 1 to 3, any

1 (Nowland and McKeague, 1977). The Quebec-Windsor axis supports 55% of the Canadian population, 85% of manufacturing output on just 2% of the land surface. Agricultural land located near high population areas is insurance against food shortage, high prices, transportation costs, change in temperature or precipitation. Canada has 4 million hectares of cities and roads -only 0.4%of total- but most of it is in the Quebec-Windsor corridor where the country's prime agricultural land occurs (Friend and Rapport, 1991). Quebec has not experienced the urban-fringe problem the way Ontario has because of its strict agricultural zoning laws and relatively slow economic growth. (Bill 90 - La loi sur la protection agricole, Vaillancourt, 1985).

loss of land in this area becomes significant . This corridor also has the highest capability and surface area for corn, soy, beans, fruits in Canada (Appendix A.3, A.4.). In Québec particularly, "the encroachment of urban and industrial developments is on the best agricultural lands. The best soil zones, those suited to the widest diversity of crops in the best climatic area, have already been lost to agriculture. This is the zone extending from Saint-Eustache to Terrebone and including Montreal, Ile Jesus (Laval) and Ile Bizard (Lajoie, 1975: 44)". Any cropland reserves, where they exist, are located in marginal areas with respect to fertility, climate, markets or infrastructure. Practically all of the land with substantial cropping capability is already in use or will be in use within the next decade. Once these remaining lands have been brought into production, there will be no more stocks to offset permanent losses in land productivity due to soil degradation (Agriculture Canada, 1985: 15). In the five year period 1981-1986, 55,000 ha of land in Canada was converted to urban use of which 59% fell into classes 1-3. (Environment Canada, 1989). In the preceding period 1976-1981, 100,000 ha was converted, one half of which was prime land. (Agricultural Institute of Canada, 1986).

2.5.1 Land Inventories, Measurement and Classification Systems:

To construct the wealth account as outlined earlier in this chapter, a land inventory that filled the following criteria was needed. Units in the inventory, however classified, had to be georeferenced at a site level in order to be linked to market transactions. The units or hectares had to be in classes or groupings that made sense and that were easily managed. Finally, the groupings had to reflect productivity, both actual and potential.

2.5.1.1 Soil Land Inventory in Québec:

The Soil Series Classification is an inventory that is mapped at the 1:50 000 scale (Appendix A.5). It meets the site-specific criteria, but not the other two.

First, the groupings of soil classes would mean handling hundreds of classifications and secondly, these classes can not be related directly to productivity without further work. They would have to be manipulated into a cardinally ranked productivity index or some manner of rating, requiring expertise in pedology.

2.5.1.2 Census:

Census hectares, as recorded on the Census survey, can be considered a type of inventory (Appendix A.1). For intercensal years, hectares in each category are adjusted by looking at the change trends from the past two Census tabulations and annualizing them. Once the next survey's results are added, there is a backwards 4 year adjustment. Hectares in actual production are reported, but potential farm/pasture land is not included in these tabulations. Both the land usage, (i.e.) crops, pasture, summerfallow, and the type of production, (i.e.) wheat, tame hay, potatoes, berries, is captured (Appendix A.2). These categories can be linked to productivity with some assumptions, however, these variables cannot be georeferenced except at the census small area level due to confidentiality restraints.

2.5.1.3. Soil Landscapes

The soil landscapes project (Agriculture Canada, 1992, seen in Appendix A.12), was designed to provide consistent information across Canada, to assess productivity on a large scale, and to enable a variety of other linkages between soil data and other types of data. Each polygon in the landscape is described by a set of 26 attributes including drainage, slope, topsoil depth, parent material etc. The scale of this project was 1: 1 000 000, making its use or relevance difficult for a linkage to site level transaction prices. The attributes portray a comprehensive profile of the soil polygon, but these classifications can not readily be used by the economist in a meaningful inventory.

2.5.1.4 The Canada Land Inventory Classes and Limitation Subclasses: The Canada Land Inventory has eight classes, seven of which are ordinally ranked for suitability for agriculture. Appendix A.6 gives a description of the CLI classes and limitations and Table 2.5 shows the hectares in each class. The CLI is mapped at a small enough scale that it is useful at a site level and can be compared to soil maps for accuracy (Appendix A.5 and Appendix A.7). It can be overlaid to specific plots, and has a manageable number of groupings which are directly related to its potential for agriculture and productivity. It was chosen as the best measure of stocks as it reflected land in actual use and potential for agriculture. The CLI and soil mapping projects were vast undertakings and the sentiment in institutions now is that such detailed and expensive inventories will never be undertaken again (Dumanski, 1991; Shields, 1994; Cossette, 1995; Wood, 1996).

Table 2.5 Land Classes in Québec

Land inventory in Quebec	Hectares(000's)
1	59.56
2	942.16
3	1346.48
4	2795.04
5	1615.8
6	8.76
7	21581.44
0	1252.28
TOTAL	**29601**
TOTAL SURFACE AREA IN QUEBEC	**135,683**

SOURCE: adapted from Lajoie (1975).

CHAPTER THREE: METHODS

In this section the steps needed to develop an NRA for farm land in Quebec are described. First, implicit prices per unit for each class of land in the CLI must be identified. These prices will be multiplied by the units in the inventory to yield a total value, and thus the wealth account.

$$\$\mathit{Value\ of\ Class_i\ land} = \frac{\$\ \mathit{implicit\ price}}{1\ \mathit{hectare\ class_i}} \times \mathit{no.\ hectares\ class_i}$$

for i = 1..n

Then the total value of agricultural land in Quebec can be written as:

$$\mathit{Total\ Value} = \Sigma_i\ [(\frac{P_i}{H_i}) \times (X_i\ H_i)] = P_i\ X_i$$

where
- i = 1...n land classes
- P = imputed price of land class per unit 1...n
- H = hectare of land class 1...n
- X = number of hectares in inventory class 1..n

A hedonic pricing model was used to estimate the prices of the land classes. The final model was accepted after screening with diagnostic tests for: variable and functional form specification, significance of individual variables, fit of equation, multicollinearity and heteroskedasticity. Estimated coefficients from this model were used as the prices for the resource valuation, leading into the NRA.

3.1 VARIABLE SPECIFICATION

Several approaches were taken in selecting the variables for the implicit price model. Variables that have consistently emerged as being significant for different markets and locations in other research were included and measured for this study (Table 3.1). In addition, other variables were included, based upon *a priori* knowledge of farmland markets in the study area. Once these steps had been taken and the variables measured, only those having significant t-statistics and low pair-wise correlations were kept in the final specifications.

3.1.1 Data Sources:

Data for many of the specified variables was recorded from 237 farm land transactions dated between 1989 and 1992 and furnished by the Office du Crédit Agricole du Québec (OCAQ)[1]. The market area, within 150 km of Montréal, comprises the St-Lawrence lowlands and the foothills of the Laurentian and Appalachian mountains. Criteria were imposed against the pool of transaction records that were available from the OCAQ: the transaction had to have a complete set of data for all variables under investigation (no missing variables); only farms that had at least 10 cultivated hectares were sought; all non arms length transactions and forced sales were eliminated; and at least 85% of the land in the parcel had to have an agricultural use (cultivated or pasture). This was to avoid those properties where the land use was primarily for sugarbush or woodlot.

The OCAQ files (Appendix A.8) contained all the price data, lot and cadastral numbers, number of hectares, circumstances of sale, and sometimes included production type, land condition, and soil type. From the lot number and the parish name, the parcels could then be located on cadastral maps. In some of the county archives, the cadastral maps were on transparent film that overlaid the topographical maps of the same scale. In other cases, transparent grid paper and opisometers were employed to transpose the coordinates and dimensions from the cadastral maps on to the other types of maps to collect the

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1 The Office du Credit Agricole du Quebec (OCAQ) changed its name in 1994 to the Societe de Financement Agricole (SFA).

Table 3.1. Comparison of HPMs Used in Farm Land Markets

Authors	Variables	# of sales used	R_2 adj.	Functional Form
Danielson (1986)	price per acre, size, distance to city, % cultivated (as a proxy for productivity), peanut allotment, tobacco allotment, county population density, housing change, dummies for roads, water, industry, housing.	383	0.28	Justified use of semi-log functional form based upon the literature. Used a transcendental function.
Coelli et al. (1991)	area, price per hectare, rain, dummy for water scheme, building value, dummy home, distance from town, pasture quality, water quality, fence quality, proportions of heavy medium or light soil.	129	0.67-0.71	Log-log tested with Ramsey Reset.
Ervin and Mill (1985)	size, sale date, bldg value/acre, % tilled, soil product index, slope, % in erosion, % terraced, soil loss, dummy for subsidy eligibility, house characteristics, distance town, distance market.	ND	0.63	Linear- assumed when no curvilinear graphical evidence.
King, Sinden (1988)	price per hectare, size, slope, dummy river, wheat yield/acre, % arable, cost of conservation/hectare	50	0.69	Log-linear and semi-log. proceeded to second stage of HPM.
Miranowski, Hammes (1984)	topsoil depth, RKLS, pH, county average farmland price per hectare minus buildings and improvements.	94	0.33-0.51	Linear after testing Box-Cox
Pardew, Shane, Yanagida (1986)	parcel price, size, distance from mountains, dummy trees, dummy roads, tax rate, dummy sewer	72	0.47	Log-linear-proceeded to second stage.
Shonkwiler, Reynolds (1986)	price per acre, % wood, distance from Gulf, proportion cultivated, month of sale, dist to airport and interstate, size	189	0.70	transcendental function-a variation on the HPM.

Gardner, Barrows (1985)	price per acre, improvements, contract, % down, interest rate, term, price index, county, dist town, community centre, tobacco acres, proportion contoured, Land Capability Class, erosion phase, slope.	158	0.92	Linear chosen because coefficients from alternatives were consistent
Warmann, et al (1985)	price per acre, total acres, building value, productivity points, demographic characteristics, percent tract in pasture, grass, crop, road conditions, distance to town, precipitation	ND	0.30	Step-wise regression. Not an HPM.
Garrod and Willis (1992)	price, percentage woodland, river, orchard or parkland, wetland, view, view of cables, housing variables, districts, community, demographics	2000	0.76	Semi-log after trying Box - Cox linear and quadratic transformations
Messonier and Luzar (1990)	lease costs, road, cabin, quail, ratio of deer, insurance, squirrel	3 areas with 162, 137, 25	0.55 - 0.67	Linear Box-Cox transformation

ND- not disclosed by authors

variables pertaining to that cadastral lot. Through this method, known as overlaying, the following variables were recorded: water access, distances from towns, cities, creeks, road conditions and slopes, soil types, precipitation, degree days, CLI class etc. A description of some of maps, variables and sources can be found in Appendix A.9 and others are listed in Table 3.2.

The dependant variable **RAWL** is the raw land transaction price provided by the OCAQ. In many cases, **RAWL** was the actual sales price if land was the only good exchanging hands. In other cases where quota, equipment or buildings were included in the sale, **PAID** was the total price and **RAWL** was the value for the land alone as determined by the appraiser. Both the dependant and independent variables were indexed to a base year of 1990 using a land and building index (Statistics Canada, 1994) which in non-Census years is based upon a land value index from the Farm Credit Corporation (Farm Credit Corporation, 1994).

The independent variables can be grouped into three categories commonly used in HPM studies: productivity, location, and consumption characteristics (Pardew, Shane, Yanagida, 1986; King and Sinden, 1988; Coelli, 1991). These were briefly described in Chapter 2 and variables are listed by these groups in Table 3.2. A database was assembled, gathering almost all information possible associated with a farm parcel without interviewing the farmer or testing on site.

Productivity variables:

These variables can be categorized as any attributes that are intrinsic to the physical land asset or that affect its productivity. These may be attributes like fertility measurements, yield, soil type and structure, precipitation or slope.

For this study, productivity was measured using Canada Land Inventory Classes. The CLI classes range from 1 through 7 for mineral soils and there is a separate

Table 3.2. Recorded Variables - Expected Sign, Mean Value and Source of Variables

Not all variables made it into the final specification, however they are described here.

VARIABLE	DESCRIPTION	MEAN VALUE	Expec	Sourc	Unit
	DEPENDANT VARIABLES				
RAWL	Raw value of land without buildings, etc.	88,460	+	1	$
PAID	Total paid for parcel	135,140	+	1	$
RNPH	RAWL divided by THECT	1910	+	1	$
	PRODUCTIVITY VARIABLES				
CLIH1	Hectares in class 1***	2.5%	+	2	ha
CLIH2	Hectares in class 2	50%	+	2	ha
CLIH12	Hectares in class 1 and 2	52.5%	+	2	ha
CLIH3	Hectares in class 3	19.8%	+	2	ha
CLIH123	Hectares in class 1, 2 and 3	72.3%	+	2	ha
CLIH4	Hectares in class 4	15.9%	+	2	ha
CLIH5	Hectares in class 5	2.27%	+	2	ha
CLIH7	Hectares in class 7	2.67%	+	2	ha
CLIH57	Hectares in class 5 and 7	4.94%	+	2	ha
CLIHO	Hectares in organic soil	6.77%	+	2	ha
LIMR	Soil capability limitation -shallow	3.6%	-	2	1,0
LIMS	Soil capability limitation - poor fertility	10%	-	2	1,0
LIMW	Soil capability limitation - excess water	87%	-	2	1,0
PPN	May-Sept average rainfall	17.37	+	4	in
CREEK	Dummy variable - creek	70%	?	3	1,0
RIV	Dummy variable - river	8%	+	3	1,0
LAKE	Dummy variable - lake	10%	+	3	1,0
ACCESS	Dummy RIV or LAKE	20%	+	3	1,0
CHU	Corn heat units	2750	+	4	chu
DD	Degree days	3183	+	4	dd
SLOPE	Difference between. high and low points	4.88	-	3	m
	LOCATION VARIABLES				
DIST	Distance to local town	3.85	-	3	km
DISM	Distance to city - Montreal	55.4	-	3	km

VARIABLE	DESCRIPTION	MEAN VALUE	Expec	Sourc	Unit
REGION1	Vaudreuil-Soulanges	10%	?	3	1,0
REGION2	Shore north of Laval	15%	?	3	1,0
REGION3	Chateauguay Valley	41%	?	3	1,0
REGION4	Richelieu - St. Hyacinthe	34%	?	3	1,0
	CONSUMPTION VARIABLES				
THECT	Total hectares on parcel	41.35	+	1	ha
GRAV	Dummy variable - gravel road	10%	-	3	1,0
PAVE	Dummy variable - paved road	60%	?	3	1,0
HWAY	Dummy variable - highway	30%	+	3	1,0
DRHECT	Hectares drained on parcel	21.94	+	1	ha
PDR	Proportion of parcel drained	52%	+	1	%
DRVAL	Value of drainage	14,683	+	1	$
CULT	Hectares of parcel cultivated	34.75	+	1	ha
PAST	Hectares of parcel in pasture	1.4	-	1	ha
WOOD	Hectares of parcel wooded	4.9	-	1	ha
PWOOD	Proportion of parcel wooded	9.8%	-	1	%
SUGAR	Hectares of parcel sugarbush	0.24	-	1	ha
CROP	Value of crop inventory	760	+	1	$
NONF	Value of nonfield inventory	8868	+	1	$
ANIM	Value of animals	3373	+	1	$
TOOL	Value of tools/equipment	5005	+	1	$
QUOT	Value of quota	11271	+	1	$
BLDG	Value of buildings	25694	+	1	$

Not all of these variables will not be included in the model specification, but were all recorded separately on the transaction files or on the maps.

SOURCE:1. Farm transaction records from 1988-1991 in 15 counties in the St-Lawrence lowlands from the Office du Crédit Agricole du Québec (1991).

2. Canada Land Inventory Capability for Agriculture. (Energy, Mines and Resources, 1975). Scale 1:250,000.

3. Topographical and cadastral maps (Minister of Energy Mines and Resources, 1984). Scale 1:20 000.

4. Climatological maps (Ministère de l'Agriculture du Quebec, 1977; Ministère des Transports du Quebec, 1981), stabilization insurance data (Régie de l'Assurance, 1994) .

5. Soil survey maps at 1:55,000 (Ministère de l'Agriculture du Quebec, 1950; Minister of Energy, Mines and Resources, 1982).

class 0 for organic soils. Class 1 is the premium land category and is found in Canada, in four places: the St. Lawrence lowlands, the Niagara Peninsula, a relatively small pocket in the Prairies and lower mainland B.C. (Okanagan Valley). Classes 1-3 encompass most of Canada's cropping potential including fruits and vegetables, legumes, cereals and cash crops. Classes 4-5 have many topographical or climatic limitations but still have crop capabilities (with improvements), animal carrying capacity for pasture and some areas have healthy grass and legume hay production. Classes 6 and 7 have severe limitations and can only support a few perennial crops. All of Canada's land with agricultural potential has been mapped for mineral soils. Organic soils appear under class 0 whether they are rich black peat and muck soils or poorly oxidized bog. "Only an extremely small proportion of the organic soils are improved and used for agriculture. A significant tract of these soils is used for vegetable crops in the Sainte-Clothilde area, south of Montreal, but the area used for field crops is negligible (Lajoie, 1975: 35)". The CLI variables were measured in hectares. **CLIH1** through **CLIH7** measures the number of hectares of class 1 through class 7 appearing on a given property. Note that no variable appears for **CLIH6**. This is because there was no class 6 land in the area where the market data was collected and class 6 land is almost negligible in Québec accounting for only 0.03% of the surface area (Lajoie, 1975: 48). Similarly **CLIHO** measures the number of hectares of organic soils on the property. The grouping together of a wide range of organic soils under **CLIHO** was not thought to be a problem for the soils in the market area, because the organic soils of the Chateauguay Valley and Mirabel area are of similar quality and evolution.

It was hypothesized that these variables would have positive coefficients in descending magnitude from **CLIH1** down to **CLIH7**. The coefficient for **CLIHO** was also thought to be positive. It was also apparent *ex ante* that the estimated value of the top quality organic soils south of Montreal would not be representative of all organic soils in the study area. Precautions were taken with this class to ensure proper interpretation of results. This is discussed further in Chapter 4.

Limitations (**LIMR, LIMS, LIMW**) of the productive capacity of the soil capability classes were measured in dummy variable format (Appendix A.6). With each CLI land class found on a map polygon, and represented by a number, there is often a subclass (limitation) appearing as a letter subscript next to the soil code. The proportion of the soil class out of a total of ten appears as the superscript:

$$2_w{}^7 3_p{}^3$$

This would mean that land appearing within this mapped polygon was 70% CLI class 2 **(CLIH2)** with an excess moisture limitation **(LIMW)** and 30% CLI class 3 **(CLIH3)** with stoniness **(LIMP)**. Instead of specifying each land class as a variable with every possible combination of limitations, (i.e.) 3rs, 2w, 4xpst, 4w, the land class given by numbers 1 through 7 (or 0 for organic soils) was specified in hectares and the limitations appear as dummy variables equal to one if they were found to be present on the CLI land category and zero otherwise. As there is no distinction to severity of each limitation, the binary dummy is the most appropriate measure. For instance, **LIMW** indicates that the subscript W was found on the soil type of a farm parcel, meaning that this soil type had excess moisture.

Other factors that relate to productivity are climate and topographical limitations. There are excellent soils in some places but if the winter weather is too harsh or the access difficult, then these areas are less desirable. Precipitation **(PPN)** was a significant variable found in many HPM studies for farm land. The May-September average precipitation in inches per month was believed to be the best measure of water availability during the growing season, although spring run-off and protection from snow cover are also important. The **PPN**, a proxy for level of soil moisture was expected to have a positive coefficient as found with comparable studies in the literature. In addition to precipitation, the connection to a source of water was specified in 4 separate dummy variables as having river frontage (**RIV**=1,0 otherwise) on the property, lake frontage (**LAKE**=1,0 otherwise), a series of creeks (**CREEK**=1,0 otherwise) or access (**ACCESS**), which meant that 1 was recorded for presence of **RIV** or **LAKE** or **CREEK.**

For each transaction plot, the length of the growing season and the temperatures reached during the season were recorded. The measures used were degree days (**DD**) and Corn Heat Units (**CHU**) respectively. As these increase in magnitude, they become more beneficial, reducing the likelihood of frost damage and broadening the variety of crops that can be grown. In the St. Lawrence lowlands there are many regions with microclimates as noted in the Régie de l'Assurance data (1994). Within 10 miles of each other, the CHUs recorded can vary by 200 or even 300 units. This is particularly important in Québec, because this will determine where a number of crops can be grown; corn, soybeans etc. Both **DD** and **CHU** are expected to have positive coefficients.

The slope of each farm parcel (**SLOPE**) was measured as the value of the difference in meters between the highest point above sea level on the farm property and the lowest point above sea level. **SLOPE** was expected to return a negative coefficient because of difficulties encountered with cultivation on adverse topography and it was thought that **SLOPE** may reflect the potential for run-off and erosivity.

Locational variables:

The locational variables are considered to be those characteristics of a farm parcel that are geocentric. Locational factors of a parcel can be linked to urban pressures and are uncoupled from productivity. The effects of these factors can mask the effects from the other two categories, but the reverse is also true, depending upon the land use. Repeated here for emphasis, in Québec, at the time the transactions took place, farm land was protected under law, so that the only possible end use was for agriculture; no residential or industrial uses were permitted.

The distance in kilometres (**DIST**) from the farm parcel to the nearest town with services, was measured in kilometres of road travel. **DIST** was found through topographical maps at a scale of 1:20 000 (MEMR, 1984). The distance from Montreal (**DISM**), the closest major metropolitan centre in the market area, was measured in aerial kilometres to the point arbitrarily chosen as the intersection of highways 15 and 40 on Montreal Island.

Four distinct regions were recognized in the study data. These variables were specified after having done some preliminary modelling with the distance variables. They are included as locational characteristics, though they could be considered as having some consumption qualities as well. They are thought to capture many factors relating to urban pressure, proximity to off-farm work, residential amenities, resale value etc. They were modelled as dummy variables and one of the four was omitted in the model to avoid singularity. The omitted variable would be implicitly captured in the constant term. **REGION1** is the Vaudreuil-Soulanges area west of Montreal. Typically this area has a high rural commuter population, many horse owners and high property taxes relative to other agricultural areas. The signs of the coefficients for the regional variables were unknown *a priori* however, one could predict that this region would outrank the others in terms of amenities and urban pressure factors. **REGION2** is known in the Montreal area as the 'North Shore' (of the St-Lawrence). This area is cooler and becomes more hilly than the other regions in the study as one moves North. It fills a pocket between congested Laval suburbs and industrial parks and mountainous resort areas of the Laurentians. The Chateauguay Valley area, **REGION3**, is a long established agricultural area with many six and seventh generation farms. The region is characterized by its many dairy operations and corn production. It occupies the stretch of land west of the Richelieu River and south of the St. Lawrence and includes the belt of rich organic soils that form a fruit and vegetable growing region about 15 miles south of the Island of Montreal. Although many parishes in **REGION3** fall within a short drive of Montreal's many bridges, the 'Loi sur la protection agricole' (Vaillancourt, 1985) has guarded these parishes from residential and industrial use, although not necessarily from other urban pressures. **REGION4** is the area east of the Richelieu River and south of the St. Lawrence including the St-Hyacinthe plains. Localized climates occur here, with **CHUs** in the 2700-3000 range making this region the best dairy and corn belt in Québec. These flats span quite a distance between the lowlands proper, and the Appalachian mountains. These regions are depicted in Appendix A.10.

Consumption variables:
This last category of variables includes residential amenities, and factors that affect resale. There is an equivocal line between location factors and consumption factors. The important thing to recognize though, is that there are various effects that contribute to parcel prices, some of which have little to do with productivity.

The total number of hectares in a farm parcel including the building site and forested or uncultivated land was specified as **THECT**. **DRHECT** was defined as the total number of drained hectares on a farm parcel. Other factors relating to the surface area of the parcel were the number of hectares that were cultivated (**CULT**), the number of hectares that were in managed pasture (**PAST**), the number of hectares that were forested (**WOOD**), and the number of hectares that were in maple sugar bush (**SUGAR**). **CULT** was thought to be positively related to the dependant variable, while **PAST** and **WOOD** were expected to be negatively related, and there was no clear expectations for **SUGAR**.

Road conditions were determined using the topographic maps where access was shown to be either gravel road (**GRAV**), paved road (**PAVE**) or provincial highway (**HWAY**). The cadastral system in Quebec follows the seigneurial system that was established by the French. Many farm parcels in Québec have provincial highway and paved road frontage because of the shape of the farm parcels. Often a farm is less than 1/8th of a mile wide but a mile deep. Farm houses and buildings tend to be very close to the road and in close proximity to neighbours.

The dollar value of buildings (**BLDG**), animals (**ANIM**), quota (**QUOTA**), equipment (**TOOL**), non-farm inventory (**NONF**), standing or stored crop (**CROP**) and drainage value (**DRVAL**), were included in some model specifications where the total transfer price, **PAID**, was the dependant variable. These values were estimated by the appraiser of the property, except for quota whose trading price is known through monthly auctions and equipment whose value was recorded from a standard fair market value guidebook. In many instances, the seller was willing to divide the farm enterprise and sell the quota and livestock separately. It is expected that the appraiser, buyer and seller would have full information on the price of the individual components and the price of a package of them.

The HPM was specified as:

$P(Z_i)$ = f (vectors of land class variables such as $CLIH2_i$, $CLIH3_i$, $CLIH4_i$,
vectors of other productivity variables such as PPN_i, $SLOPE_i$,
vectors of location variables such as $REGION_i$,
vectors of consumption variables such as PAV_i,
error $term_i$).

where $P(Z_i)$ = market price

The final model specification is discussed in Chapter 4 and shown in Table 4.1.

3.1.2 Consequences of Variable Misspecification:

Misspecification of variables occurs in three ways: First, if insignificant variables are included in the equation, the resulting adjusted R^2 can be lower. The t-statistics for these variables will be low and their standard errors high. The equation will not be sensitive to their absence if they are dropped. A second type of misspecification takes place when significant variables are overlooked either because the researcher is unaware of their importance or is aware but unable to measure or estimate a proxy for the effect. The coefficient estimates may be biased if these variables are correlated to the variables that are used in the estimating equation. A third way this problem can occur is when variables that theory suggests should be part of the model are improperly measured. In this case, a variable that is a significant explanatory variable may be dismissed because of poor results or results that are unstable.

3.2 SPECIFICATION OF FUNCTIONAL FORM:

The functional form debate is given more space and time in the literature than any other of the considerations when using HPM. This is perhaps because no single functional form for farm land has been indicated by hedonic price theory. Earlier hedonic studies almost exclusively used the simple linear functional form (Messonier and Luzar, 1990). Not only is there a paucity of theory for determining suitable functional forms but there is also little guidance as to the criteria to use in selecting a functional form.

Some researchers feel that if underlying functional relationships are not known (recall that the HPF reveals nothing about underlying structures) and there is little theory on which to formulate functional form, the linear form should be used unless there is strong evidence that it is inappropriate (Studenmund, 1987). A linear functional form yields constant prices even for different levels of a characteristic. Miranowski and Hammes (1984) noted that HPM is based upon a reduced form equation without a theoretically derived functional form, and is sensitive to specification. These authors used a linear form but attempted several Box-Cox transformations before choosing the final specification. Gardner and Barrows (1985: 945) used tests of the coefficients from a linear, log-log and semilog specification, to guide them in their decisions on functional form. "The coefficient estimates ..from the [alternate forms] are highly consistent, suggesting that a Box-Cox procedure was unnecessary" (Ibid: 945), thus the linear HPF was chosen. Ervin and Mill (1985) used a linear form when the variables they plotted revealed no apparent visual curvilinear forms. They also argued that a linear functional form was assumed because all sales in a given time frame were used, and not just a sample. This reasoning is flawed. Using the entire population will unquestionably yield the identity, but this identity can not be assumed to be linear without testing any alternatives. "The practice of assuming a linear specification without testing any alternative specification is not unique to hedonic studies but the assumption could be most unrealistic as it implies the implicit prices of the attributes (the first partial derivatives) are constants and thus independent of the quantity of an attribute the good possesses" (Coelli et. al.,1991: 6). Garrod and Willis (1992: 66) also argue against the choice of a linear form, stating buyers can not repackage and arbitrage land parcels. They expect non-linearity, because attributes cannot be treated as discrete items from which one can pick and mix. This point can be argued: if a buyer cannot maximize his or her utility because the attributes are fixed and the number and selection of packages very limited, then non-linearity may be expected. Conversely, if there *are* a large number of packages available with a wide range of combinations and levels of attributes, assumptions still cannot be made without further evidence.

Regardless of whether the functional form is linear or non-linear, Garrod and Willis (1992) advocate the testing of alternative forms. They advise against an *a priori* choice based upon other research as is seen in Danielson (1986), Messonier and Luzar (1990). For example, Danielson (1986) chose a semi-log form based upon similar studies without first testing data. Messonier and Luzar (1990) decided to use a linear Box-Cox transformation, citing that even under misspecification, the Box-Cox or flexible form that best fits the data, is superior to other forms.

In the cases where Rosen's second stage (Rosen, 1974) was employed (Pardew, et al., 1986; King and Sinden, 1988) the log-linear and semi-log forms were used in the first stage. Two-stage estimation can not be used with linear forms because the HPF collapses onto the implicit price function when the HPF is linear. Progression to the second stage would have been impossible if a linear form was selected. Pardew et. al.(1986) did not attempt to test functional forms but based their choice of a log-linear on other authors findings.

Studenmund (1987) argues that those functional forms chosen on the foundation of theory are far superior than those chosen on the grounds of fit. He also makes the point that adjusted R^2 should never be compared between alternative specifications, when the comparison is between dependant variables that are transformed. One way of evaluating alternatives is to apply maximum-likelihood ratios[2] or the Ramsey Reset test. This might avoid a subjective assessment of comparing adjusted R^2, levels of significance between two or more forms. Coelli et al (1991) used a log-log model after looking at the alternatives through the use of the Ramsey Reset test.

Cropper et al (1988) suggest simplicity and flexibility (like linear or linear Box-Cox) should be the driving forces in model selection while Garrod and Willis (1992) take a comprehensive and pragmatic approach, looking at adjusted R^2 and highest number of significant variables for all of the forms. Beginning with

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2 The BOX command in SHAZAM (White et al, 1993) performs a line search for parameters that maximize the likelihood.

the simplest linear forms, they abandoned them in favour of non-linear forms, found to be an improvement. They felt this investigation was not comprehensive enough so a Box-Cox quadratic transformation was attempted. A multicollinearity problem was discovered with the second order terms and there was a concern that in the presence of variable mispecification, the quadratic form is more susceptible to large errors than any other form. Finally, a linear Box-Cox transformation pointed to the semi-log form when line parameters were searched.

Correct functional form is crucial for interpretation or forecasting, and can become a severe problem when the coefficients of the explanatory variables are applied to data outside the sample range. Given these considerations, several functional forms were used to estimate the hedonic price coefficients: linear, log-log, semi-log and the Box-Cox transformation. This is discussed further in the results of Chapter 4. It was not expected that autocorrelation would be a problem, however incorrect functional form may lead to autocorrelated errors. Thus, the Durbin-Watson test statistic was used both as a test for autocorrelation and for functional form (Tarassoff, 1993).

Once the variables had been selected, recorded and entered into a database, OLS regression analysis was performed to estimate values for the coefficients. Results were then diagnosed for the presence of multicollinearity and heteroskedasticity, two violations of the classical assumptions under the OLS model (Table 3.3).

Table 3.3. Assumptions for the Classical Ordinary Least Squares (OLS) Method

The Classical Assumptions:	**Violation**
Linear in coefficients and error term	
Error has a zero mean (population)	
Independent variables are uncorrelated to the error term	
Error terms are independent of each other	Autocorrelation
Variance of the errors is constant (random) unweighted	Heteroscedasticity
No independent variable is a (perfect) linear function of other explanatory variables.	Multicollinearity
Error term (u) is normally distributed.	

SOURCE: adapted from Studenmund (1987:61).

3.2.1. Consequences of Incorrect Functional Form:

Many functional forms may fit the data in the sample range. Using the functional form with the best fit over the sample is not an entirely sound basis for selecting a functional form, especially if the results will be applied beyond the sample range. Non linear functional forms, by definition, change their slopes. If one considers the possible divergence between linear and non-linear forms, colossal forecasting errors can be made if one form is chosen mistakenly. Biased and inconsistent estimated parameters can ensue with the improper functional form.

Cropper et al (1988) experimented with each type of functional form. The forms were first tested in a perfect information environment, then were misspecified through omission of some variables. The purpose was to examine the performance of the different forms affected by specification error and errors in measurement of variables. The quadratic and the Box-Cox quadratic fared poorly; some estimates of the marginal bids were over or underestimated by as much as 600%. The simple linear and linear Box-Cox emerged as the best, with respect to both types of errors. In one scenario where there was perfect information, it was posited the quadratic functional form was the correct form. When mispecification was introduced, the two linear forms still outperformed the quadratic ones even when the true model was quadratic. The semi-log and log-log were somewhat in between in those situations where mispecification was known or likely to exist.

3.3 MULTICOLLINEARITY:

Multicollinearity does not bias estimators but it does mask the individual effects of each regressor. The first test to detect collinearity was to use a pair-wise correlation (zero order) matrix to sift out any problematic variables. The zero order matrix deals with collinear relationships involving two variables but multicollinearity (collinear relationships with more than 2 variables) is somewhat harder to deal with since it is more difficult to detect and correct, where complicated interdependencies are occurring. Variables affected by multicollinearity can be dropped from the specification but often this action biases the specification and undermines the objectives of the study. In this instance, variables are often left as is, with the understanding that the uncorrected models are sensitive to change in specification (Studenmund, 1987; Coelli et al, 1991).

Most studies that were reviewed do not discuss and perhaps did not encounter multicollinearity or heteroskedasticity. The reason for the lack of mention is not known. Garrod (1992) observed that multicollinearity is conveniently ignored in the literature, but conceded that this wasn't grievous unless quadratic forms had been used. The quadratic form uses the coefficients several times, thus heightening the interrelationships, where they exist.

3.4. HETEROSKEDASTICITY

Heteroskedasticity is a common problem in cross-sectional data. It is often discovered where there is a large variation between the smallest and the largest of one or several variables (Z), especially if the variable is spatial in nature or pertains to size. The first diagnostic used to detect heteroskedasticity was a plot of residuals of the various models against each of the explanatory variables. Results, discussed further in Chapter 4, were confirmed by running a Park test. There is also a diagnostic option in SHAZAM (White et al, 1993) that runs 7 different chi-square tests for heteroskedasticity including Harvey, Glejser and Arch tests. These testing procedures are outlined in Studenmund (1987), Judge (1988), and Gujarati (1988) along with criticisms.

3.5. CONSTRUCTION OF THE WEALTH ACCOUNTS: OPENING INVENTORY

The approach for accounting for the farm land resource was outlined in Chapter 2 and will be followed here. A 'Beginning Farm Land Inventory' was constructed for 1976 because it was a Census year and coincided closely with the Canada Land Inventory publication (Lajoie, 1975). The basis for the opening inventory was the CLI as described in Section 2.5 and Table 2.5. ***All land*** in Southern Québec was rated for its agricultural potential, so current farm land was included, unimproved land with potential, plus land unsuitable for agriculture. The latter category of land was deemed to be superfluous for an inventory that was to reflect the agricultural land resource. Adjustments were made to this base inventory particularly to classes 7 and 0. One criticism of the CLI is that class 0 does not distinguish between types of organic soils. Organic soils in the St. Lawrence Lowlands that are well oxidized and formed and that are capable of supporting lucrative fruit and vegetable operations, are not representative of organic soil found in the north. There are many adverse conditions with organic soils in Grand Lac Victoria for example, that precludes its use for field crops or horticulture (Lajoie, 1975). Much of the class of organic land, except that which had potential for agricultural use was excluded. Similarly results for CLIH7 were only extended to those tracts of class 7 lands falling within or adjacent to current agricultural areas. Often class 7 in these regions is intrinsically mixed with class 5 land, lending it to limited use. The majority of class 7 land has no use whatsoever for cultivation or domestic animal carrying capacity. These adjustments were made on the basis of visual and digital interpretation of soil maps (MAPAQ, 1950; EMR, 1982), CLI maps (EMR, 1975), crop production potential maps (Dumanski, 1983), discussion found in Lajoie (1975), and personal communication (Cossette, 1995; Shields, 1994). The results of adjustments from Appendix A6 can be seen in a comparison between the CLI inventory (Lajoie, 1975), the opening inventory for this study and the Census hectares in production, reported in 1976 in Table 3.4.

There were many class 4 and 5 lands that were not in production at the time of the opening inventory, nor does satellite photography reveal their use today. These lands around Senneterre and Rouyn-Noranda have the capability to support pasture, hay and some field crops (potatoes and spring wheat) if considerable improvements are made (Agriculture Canada, 1983; Lajoie, 1975). They are included in the resource base for the opening inventory. It is unlikely that many of these hectares are recorded in the Census of Agriculture (Appendix A.2, Table 3.4).

3.6. ADJUSTMENTS BETWEEN OPENING (1976) AND CLOSING INVENTORIES (1991):

The 'Closing Inventory' was constructed for 1991, also being a Census year. It was built upon the opening inventory as described. There has not been a comprehensive review of the Canada Land Inventory since its establishment to take stock of any changes, so adjustments were made to the inventory using several of the following methods.

Table 3.4. Comparison between CLI, Opening Inventory and 1976 Census

(Thousands of Hectares)

<table>
<tr><th>CLASS</th><th>A
CLI as per
Lajoie, 1975</th><th>B
Opening
Inventory 1976</th><th>C
Census of
Agriculture, 1976</th><th>Linking CLI classes
to Census
categories</th></tr>
<tr><td>1</td><td>59.56</td><td>59.56</td><td rowspan="4">1867.95</td><td rowspan="4">most likely to be 'hectares in crop' and 'summerfallow'</td></tr>
<tr><td>2</td><td>936.56</td><td>936.56</td></tr>
<tr><td>3</td><td>1313.88</td><td>1313.88</td></tr>
<tr><td>0</td><td>1252.28</td><td>153.16</td></tr>
<tr><td>4</td><td>2795.04</td><td>2493.96</td><td>470.31</td><td>most likely to be 'hectares in crop', 'summerfallow' and 'improved pasture'</td></tr>
<tr><td>5</td><td>1615.80</td><td>1272.64</td><td rowspan="2">1670.68</td><td rowspan="2">most likely to be 'improved pasture' and 'other'</td></tr>
<tr><td>7</td><td>21581.44</td><td>352.00</td></tr>
<tr><td>TOTAL</td><td>29492.00</td><td>6581.76</td><td>4008.95</td><td></td></tr>
</table>

Source: CLI- Lajoie (1975), Opening Inventory, as per adjustments described, Census of Agriculture - Statistics Canada (1992). * Note that there is a substantial difference between columns B and C especially in class 4 land. As mentioned earlier in the chapter, this land may not currently be in production. Also in earlier Census including 1976, unimproved pasture was not measured in the survey.

Table 3.5. Hectares of Land Lost Due to Urbanization:

Québec, 1966-1991 Classes 1-3, All rural land (Ha)

<table>
<tr><th>YEARS</th><th>66-71*</th><th>71-76*</th><th>76-81*</th><th>81-86*</th><th>86-91**</th></tr>
<tr><td>Prime land, classes 1-3</td><td>8 409</td><td>5 486</td><td>7 346</td><td>3 671</td><td>15 061</td></tr>
<tr><td>classes 4-7</td><td>7 223</td><td>5596</td><td>10 263</td><td>2593</td><td>na</td></tr>
<tr><td>All Rural land</td><td>15 632</td><td>11 082</td><td>17 609</td><td>6 264</td><td>15 061</td></tr>
<tr><td></td><td colspan="2">NA- losses occurred before opening inventory</td><td colspan="3">These hectares will be deleted from the inventory.</td></tr>
</table>

Source: * Environment Canada (1989). **Statistics Canada (1996) Different methodologies were used for the 1966-1986 period and the 1986-1991 period. The CMAs of Montreal and Québec city only are included in this figure. The branch that performed the earlier work no longer exists.

3.6.1. Urbanization:

The first adjustment was for losses of agricultural land due to urbanization. While urbanized lands still have value, often higher than the agricultural value, they are no longer considered part of the productive resource base, as the transformation is irreversible. Table 3.5 shows multiperiod losses of land spanning several censuses. These urbanized hectares will be subtracted from the opening inventory and will be considered as a loss in the wealth account and as an adjustment to inventory in the income accounts. Note that the monetized 'adjustment to inventory' value, could shift either because of changes in the units or because of changes in prices. The accounts should clearly separate physical units and prices.

3.6.2. Abandoned Land:

The second set of adjustments made to the inventory resulted from abandoned agricultural land. The abandoned hectares seen in Table 3.6 were determined from a MAPAQ project on fallow land using satellite images (Carignan, 1985). From 1989 to 1991, Landsat imagery was completed for the province of Quebec (Appendix A.11). The results were used to geo-reference the locations of abandoned formerly cultivated land where perennial vegetation or shrubs have started to grow. With the locations of these lands known, it can be determined upon which land classes they fall. These idle hectares are not lost from the resource base as are urbanized hectares. With improvements or investment, they can become productive again. For this reason, they will not be subtracted outright from the inventory, but will instead appear as a shift between classes. For example, if 100 hectares of class 4 has been abandoned and grown over for several years with brush and bush, the 100 hectares are subtracted from class 4 and added to class 5, which reflects the unimproved state of the land.

Table 3.6 Hectares of Land Lost to Abandonment

CLI class	Abandoned overgrown hectares
class 1	2472
class 2	24265
class 3	31010
class 4	66054
class 5	36450
class 7	8976
class 0	4157
TOTAL	173384

Source: Carignan (1995), overlaid to Lajoie (1975)

3.6.3. Census Cropping Patterns

The Census of Agriculture is also a source of information in determining changing cropping patterns and hectares in farming. In Appendix A.2 a net loss in hectares on farms is apparent. This can be misleading: there is no explanation for the loss, so all that can be concluded is that fewer hectares are being farmed. The cause could be: loss to urbanization; abandonment - land that was marginal for cropping (class 4 or 5) and has been left idle in favour of land that can support higher value crops or higher yields; land has been so badly degraded or eroded that production is no longer possible or corrective measures are too costly; parcels have been subdivided and fields so small, that larger operations do not purchase them when they become available and finally there are fewer farms but more and more individuals purchasing 'farmettes' who do not report farm incomes. In light of this wide range of possibilities, it would be presumptuous to assume that there is a loss of potential or a permanent loss of hectares. Because the nature of the changes is not known, nor the specific classes which they affect, nor the location of the changes, cropping patterns as reflected in the Census were not used to adjust the stock account. The ending inventory is based upon the described adjustments and is shown in Table 3.7.

Table 3.7. Closing Inventory, 1991.
(Hectares)

Class	Opening Inventory, 1976	Minus Urbanized Land, 1976-1991	Adjusted for Abandoned Land, 1976-1991†	Shift in Class	Closing Inventory, 1991
Class 1	59,560	26,078	2,472	-2,472	2,226,175
Class 2	936,560		24,265	-24,265	
Class 3	1,313,880		31,010	-31,010	
Class 4	2,493,960		66,054	-66,054	2,427,906
Class 5	1,272,640	12,856	36,450	+127,958	1,739,742
Class 6	na		na		
Class 7	352,000		8,976		
Class 0	153,160	na	4,157	-4,157	149,003
Total	6,581,760	38,934	173,384	0	6,542,826

SOURCE: Census of Agriculture (1991) Cat. 95-335, 95-336; Cosette (1995); Agriculture Canada (1985); Environment Canada (1989). Caron (1994), Carignan(1991), Lajoie(1975)

† Urbanized land was considered a loss to the inventory

†† Abandoned land was subtracted from the productive classes (class 1-4 and class 0). No adjustment was made to land in classes 5-7, as these classes had severe limitations to start with. The number of hectares subtracted from classes 1-4 and class 0 were added to the pool of lower productivity lands in the adjacent column.

CHAPTER FOUR: RESULTS

All variables described in Chapter 3 were included in preliminary OLS models. As the empirical work progressed, some variables were eliminated or reformulated, as dictated by various tests and diagnostics. Heteroskedasticity posed an OLS violation that was simple to detect and remedy. Multicollinearity presented more of a challenge, both in detecting the sources and finding solutions. The final model is shown in Table 4.1 and the first two sections of this chapter describe the regressions and individual variable results in detail. The chapter culminates with the construction of a wealth account for Québec farm land.

4.1. Linear Functional Form

Final choice of functional form was based upon a combination of procedures taken from Cropper et. al. (1988), Garrod and Willis (1992), Studenmund (1987), and Miranowski and Hammes (1984). Several functional forms were tested for their suitability to estimate the hedonic price coefficients. These included: linear, log-log, semi-log and the Box-Cox transformation. Of these, the linear model produced superior results, outperforming the other specifications in each of the following areas: joint F tests, adjusted R^2's, and significance (t-statistics) of equation parameters.

The Durbin Watson statistic was generated for each linear regression. The resulting test statistics were between 1.7 and 1.98, so for even the worst cases, DW was within the inconclusive region ($d_l < DW < d_u$). While not a test for functional form, an incorrect functional form can give the appearance of the presence of serial correlation. Thus, the DW statistic could not offer confirmation of correct functional form, but nor did it manifest any problems. These results, in combination with the other evidence as described above, were indicative that the linear form was appropriate for the farmland market under investigation.

Table 4.1. Final Specification WLS Model

SHAZAM COMMAND: 237 OLS RAWLIND = CLIH123 CLIH4 CLIH57 CLIHO REGION1 REGION34 LSLOPE PWOOD/ RSTST HET WEIGHT =THECT

R-SQUARE = 0.8055

ADJUSTED R-SQUARE = 0.7987

DURBIN-WATSON 1.8060

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO
CLIH23	2463.2	90.57	27.20
CLIH4	2320.8	188.7	12.30
CLIH57	920.73	477.6	1.928
CLIHO	1557.9	388.5	4.010
REGION1	68056	10640	6.395
REGION34	41805	7751	5.393
LSLOPE	-7243.7	2935	-2.468
PWOOD	-91313	44820	-2.037
CONSTANT	-22310	8635	-2.584

4.2. OLS and WLS Results

Heteroskedasticity and Corrective Measures:

Residuals from the first series of OLS models were plotted against selected explanatory variables. The resulting graphs gave reason to believe that heteroskedasticity was affecting all of the models, as deterministic patterns in the residuals were clearly visible. Results were confirmed by running a Park test (Studenmund, 1987: 254). Residuals from the OLS estimation (e_i in equation 4.1) were used in a log-linear regression (equation 4.2) where a 'proportionality factor' (Z) is regressed on to the log of squared residuals. The coefficient from Z_i is tested for significance with a t-test. If Z_i is significant in explaining $\ln(e_i^2)$, this is evidence of heteroskedasticity .

$$e_i = Y_i - \hat{\beta}_0 - \hat{\beta}_{1i} - \hat{\beta}_2 X_{2i} \qquad \text{equation 4.1.}$$

$$\ln(e_i^2) = \alpha_0 + \alpha_1 \ln Z_i + u_i \qquad \text{equation 4.2.}$$

where e = the residual from the ith observation
Z = the proportionality factor i.e. hectares, that may be causing heteroskedasticity,
u = classical (homoskedastic) error term.

The SHAZAM econometric software (White, 1993), also has seven chi-square diagnostic options for heteroskedasticity, including Harvey, Glejser and Arch tests. These tests along with critical analyses are outlined in Studenmund (1987), Gujarati (1988), Judge (1988). All of these tests are performed concurrently to the OLS regressions. All gave directional evidence of heteroskedasticity. Heteroskedasticity was so strongly evident from the visual interpretation and Park test, that further testing for detection was felt unnecessary. These tests were useful later however, in determining if the violations had been remedied.

An attempt was made to transform the variables and model on to a per hectare basis to correct the model. This type of reformulation is commonly suggested in land studies, studies with spatial data, and studies with a wide range in the variables (Studenmund, 1987). **RAWL** was divided by **THECT** to yield a price per hectare as the dependant variable. The land classes were then expressed as proportion of coverage, rather than by hectares found on the property. This corrective approach proved to be fruitless, as the problem of singularity seemed to emerge. Despite dropping a class(es) to avoid this problem, all the coefficients for the land classes became insignificant and unstable and adjusted R^2 dropped below 0.30. Another way to amend this OLS violation is to use the Weighted Least Squares (WLS) model. This model requires the identification of an appropriate proportionality factor (Z) and dividing throughout by this factor. The factor (Z) is usually one that has a wide variation between the smallest and largest recorded measurement. **THECT** was thought to be germane and was the (Z) factor used in the Park test. SHAZAM uses the square root of the proportionality variable (Z) as the weighting factor, as opposed to the square of the variable. Either method has the same effect upon results. The OLS specifications affected by heteroscedasticity were then re-specified as WLS equations with THECT used as the proportionality factor. With this adjustment, the tests for heteroskedasticity were performed again; in all tests the null hypothesis that the variance of the error terms was constant (random) could not be rejected.

Multicollinearity:

Multicollinearity was the biggest challenge faced during the regression phase of this research. Gardner and Barrows (1985) encountered difficulties that were identical in nature, and even in variables, to this study. Land capability classes, similar to the CLI were included in their model. They also recorded cultivated acres, forest and pasture. This in effect, causes duplication and introduces multicollinearity into those models where both land classes and coverage variables are specified. It is quite logical to expect that what grows on top of the soil is related to what is in the root zone. In the Gardner study, one of the land classes was highly correlated with 'forest' and thus 'forest' was dropped because they reasoned it was implicity included. 'Pasture' was then excluded to avoid singularity amongst 'cultivated', 'pasture' and 'forest'. 'Cultivated' would interfere with the land classes which were suitable for cultivation, and the constant term would be intertwined with the land classes suitable for 'pasture'. All three variables would in effect be double counted since they were all measured in acres. In Québec for instance, WOOD tends to be found on the poorer quality non-arable land. There is very little class 1-3 land left in agricultural zones in Québec that has any tree cover on it.

The similarities between the Gardner study and this study were recognized more so when the empirical work got underway. Pair-wise correlation coefficients between **CULT, PAST, WOOD, DRHECT** and **SUGAR** and the **CLI** variables were examined. **WOOD** had a positive relationship with classes 4, 5, 7 and 0, and a negative relation to classes 1 and 2. Conversely **CULT** and **DRHECT** had a negative link with the poorer classes and positive one to classes 1 and 2. Presumably this is because it makes the most sense to pay for improvements on the best land. Correspondingly, these variables were examined for their performance in WLS models. When **WOOD** was added to the specification, its negative value drew away from the poorer land class and positively biased them and double counted. Conversely, when any of the drainage variables (**DRVAL, DRHECT**) were added to the specifications their positive parameters drew away from the prime land classes, most of which are tile drained, and negatively biased them. The obvious problems were revealed, and indicated that these variables should not be introduced into specifications with **CLI** variables and vice versa. Either the land coverage approach could be used or the **CLI** explanatory variables but not both. Since the **CLI** variables were the key measures in this study, the land coverage variables, except for **WOOD** and **DRHECT**, were dropped from further specifications.

WOOD was not eliminated outright because some high t-statistics were evidenced with wood coverage (**WOOD**) and drainage (**DRHECT**). A small experiment was executed to assess the importance of the two factors: residuals from regressions where **WOOD** and **DRHECT** had been excluded were saved as a variable and then omitted variables were regressed upon these error terms. The ones related to wood coverage consistently gave adjusted R^2's of ~ 0.15 while the variables relating to drainage returned adjusted R^2's of ~ 0.20. These adjusted R^2's indicate that the variables had a role in explaining the variation in land prices. The equations appear misspecified without one or both of them, adjusted R^2's were lower and heteroskedasticity more significant, yet when they were included in the specifications they biased the coefficients of **CLIH2** and **CLIH5** (Table 4.2). This was addressed by specifying **DRHECT** as **PDR**- the percentage of the parcel with drainage, but even the effects of **PDR** upon the other variables became such a difficulty that this variable was dropped altogether. Likewise, **WOOD** was reformulated as **PWOOD.** It was retained the final specification.

A final consideration, was examination of **CLIH2** and **CLIH3**. These lands were almost always found on the same farm or in the same soil polygon. This was one example of multicollinearity whereby the variables involved were vital to the study and could not be dropped without biasing the estimators and undermining the objectives of the study. The t-statistics of these two variables were consistently greater than 10 and the **CLIH3** coefficient was stable under a variety of specifications, so the correlation was overlooked. This was done with the understanding that models uncorrected for 'mild' multicollinearity will be somewhat sensitive to change in specification. Later these variables were grouped under one new variable **CLIH123,** as the differences in premiums being assigned to the top 3 land classes were negligible.

Individual Variable Results:

For the following discussion, **RAWL** was used as the dependant variable. Equations were regressed using WLS to correct for heteroskedasticity. In all regressions with the linear functional form, adjusted R^2 ranged from 0.70 to 0.86 and F tests were significant for each equation. These results are in accordance with expectations for cross-sectional data. The estimated coefficients were significant at the 1% level in almost every instance. The coefficients were generally of the expected sign, whether or not they made it into the final specification. The exception was PPN which is discussed later in this chapter. The value of coefficients from the final specification (Table 4.1), were the per unit values that were ultimately used with the land inventory to construct a wealth account.

Canada Land Inventory Variables:

CLIH1 was quickly dropped at the onset and included with **CLIH2**. There wasn't a large difference in the premiums being assigned to the top two classes, but **CLIH1** had insignificant t-ratios when it was classed alone. Class 1 land only accounts for 2.2% of the surface area and 2.5% of the hectares traded in the market place in this study. Later, Classes 1, 2 and 3 would all be grouped together, for reasons previously discussed. In most specifications **CLIH2** and **CLIH3** had premiums that were between $50-$100/hectare apart except when **WOOD** or **DRHECT** was included and then **CLIH2** was highly sensitive. **CLIH6** does not appear because there is only a minimal amount of this land in the entire province (3/100ths of one percent) and none in the study area. As the testing of models proceeded, the final specification of the CLI variables was **CLIH123**,

CLIH4, **CLIH57** and **CLIH0**. Grouping the variables in this manner, solved the problems of multicollinearity previously discussed and the improved the t-ratios in the CLIH57 grouping. The **CLIH2** and **CLIH3**, **CLIH4** and **CLIH0** returned very high t-ratios and stable coefficients. Implicit prices were calculated for each of the land classes as can be seen in Table 4.1 (retained model) and in Table 4.2.

All of the land variables had the expected signs. In the final model, all of the land classes had an implicit price that corresponds with economic theory, with higher productivity land classes being valued at higher levels than the lower classes i.e. **CLIH123** > **CLIH4** > **CLIH57**. The results are consistent with the hypothesis that market prices recognize productivity, however, they did not distinguish between the top three classes, commonly called 'prime land', nor did they distinguish between class 5 and class 7 often found mixed in a polygon.

The coefficient for **CLIH0** was stable and it had a highly significant t-ratio, however this class is problematic because of the way in which it is classified in the CLI. Values for the other classes can be applied beyond the market area, because the units in the universe of inventory of class 1, are *relatively* homogeneous and have comparative capabilities and limitations. However, the units in the Class 0 inventory can cover such a wide range of soils, that an implicit value cannot be easily transferred beyond the study area or even within it. This is discussed in Section 3.5 during construction of the opening inventory. Census data measuring the hectares of the crops this muck soil is most likely to support were compared with the other types of maps and overlay methods to arrive at an opening inventory which took this into consideration.

Limitation subclasses:

All CLI limitation subclasses, except **LIMW**, did not prove to be significant in any attempted models, in spite of the fact that these types of limitations *do affect* productivity. One reason the limitations were not found to be significant, can be

Table 4.2 Individual CLI Results

(Note that shaded rows are the way variable was specified in the final model Table 4.1.)

VARIABLE	T-RATIO	COEFFICIENT	DIAGNOSIS
CLIH1	poor	unstable between $ 2100 and $2800	small % of hectares in study, insignificant
CLIH2	excellent	variable between $ 2 100 (with PDR) and $2 550 (with WOOD)	coefficient mildly sensitive to specification, particularly drainage - eliminate PDR and group classes 1,2,3.
CLIH3	excellent	steady around $2400	no problems
CLIH4	excellent at 12.30	steady around $ 2 320	no problems
CLIH5	poor	unstable between $ 1 200 (with PWOOD) and $ 2 200 (with PDR)	coefficient extremely sensitive to the specification particularly PDR- eliminate PDR and group class 5 and 7 together.
CLIH7	poor	variable between $500 and $ 800	insignificant
CLIH0	excellent at 4.010	stable around $ 1 557	no problems
CLIH123	excellent at 27.20	stable around $ 2 463.20	no problems
CLIH57	good at 1.928	stable around $ 920.73	no problems

There was a trade-off between a CLIH5 value that was thought to be too high and a CLIH2 value that was thought to be too low each time PDR was used. It can be seen what effects PWOOD and PDR have upon some of the coefficients.

attributed in part to the way the CLI was designed. **LIMW** (excess water) was present on almost all of the class 2 land in Southwest Quebec, and on 87 % of all parcels, yet there are no varying degrees of wetness indicated. This limitation is mapped on the soil polygons as a dummy variable and was included this way in the model. This could be one of the reasons that most of the soil limitations showed up as insignificant. **LIMW** was omitted in later specifications as part of the attempt to avoid the effects of multicollinearity: although it was a dummy variable it was correlated to and/or may have double counted as **CLIH123**, **DRHECT**, and **DRVAL.**

Slope:

The slope measure was as accurate as the scale of the map. Contours that are spaced a certain elevation height apart can miss the effects of gullying, or erosion and give the appearance of a gentle slope. **SLOPE** was insignificant but appeared in some specifications, including the final model, as **LSLOPE;** this was the natural log of the slope variable. **SLOPE** was the only variable that was significant when transformed logarithmically. Its t-statistic (-2.468) and coefficient value (-7243.7) met expectations.

Distance and Regional Variables:

DIST (from a town) proved to be insignificant for the farmland market in Southwest Quebec. Most parcels in the study have a small town with services, an average distance of 3.85 km away (Table 3.2). The rural population included in this research, do not face the isolation from services found in other agricultural regions in North America. **DISM** (from Montreal) had conflicting results. **DISM** was measured as aerial distance from a point in the centre of Montreal island. Some areas (North shore) are close to the city centre as the crow flies, but are quite a commuting distance away as a result of the location of bridges. Other areas are a further distance away, but are still considered suburbs and have many desirable neighbourhood amenities (St-Lazare).

After preliminary OLS regressions and inconsistent results, **DISM** was replaced by the location variables **REGION1**, **REGION2**, **REGION3**, **REGION4**. A community dummy was thought to capture more than the linear measure. The value of their estimated coefficients were then congruous with expectations and t-ratios were in the 1% range of significance. On an average size farm, the difference between a parcel in **REGION1** and one in **REGION2** was about $50,000 based upon location *ceteris paribus*. **REGION1** parcels were about $20,000 - $30,000 higher than parcels in **REGION3** and **REGION4**. The latter two were grouped together as **REGION34** because there was no significant statistical difference between their estimated implicit prices. In the final specification **REGION1** had a $68,056 premium attached to it and **REGION34** had a $ 41,805 premium. With a constant term of -$22,310 and **REGION2** dropped to avoid singularity, it can be concluded that if one went shopping for a parcel of land with identical productivity in the 4 regions, **REGION1** would be the most expensive place at about $27,000 more expensive than **REGION34** and **REGION2** is the cheapest, its lower value reflected in the constant.

With the introduction of the region variables i.e. **REGION1**, new considerations arose. **DISM** was a fairly continuous variable measured in km, but the region variables were discrete. Farm parcels were forced into discrete groupings. For some variables such as **DD**, this new grouping became highly correlated to **DD**, as all the **DD** values within certain areas were homogenous. For example in **REGION2**, all farm parcels had the same **PPN, DD** and **CHU** values. Subsequently, **PPN, DD** and **CHU** were no longer selected for inclusion, despite having been significant in some models. There was insufficient variation of the climatological factors within a region and it was felt their effects were being double counted or collinear under the regional parameters and skewing results.

Some questions needed to be answered at this point, namely:

1) Were there regional effects beyond the identified climatological variables (**CHU, DD**) and distance associated with each of these REGION variables ?

2) If there were other effects, were they specified in other variables causing double counting and/or correlation ?

3) Would **REGION** be capturing other effects that were not measured and included in initial specifications ?

Shonkwiler and Reynolds (1986) found that geographic areas and distances were significant and counted for many non-agricultural effects where an alternate use variable was not included. In this study an alternate use variable was not included because Québec's agricultural zoning law. However, **REGION** may have included some effects of *end use*, within the context of the agricultural zoning. The OCAQ transactions used in this study did not have the type of production recorded on a majority of the files, thus a production variable was not specified.

There is no contesting the fact that the 'Loi sur la protection agricole' helped decelerate the conversion of land to alternative uses (Vaillancourt, 1985). However, there is evidence that this law has not been successful in protecting agricultural land from urban pressure or other non-agricultural effects on its price. The regional variables capture this pressure amongst other factors, in their parameter estimates. For appraisers and indeed anyone measuring land values, these values assigned to communities or regions are very important and vary greatly. The **REGION** results highlight the importance for understanding and isolating regional premiums that can't be explained by land and building values.

Water availability:

PPN was supposed to have a positive sign but turned out to have a negative coefficient in models where it was significant, (i.e.) a marginal implicit price of -$

12,689.00 for each additional inch of May-September precipitation, with a t-ratio of -2.2. This showed that there were no benefits of having more **PPN** in the market area. As stated in chapter 3, precipitation levels were recorded for each of the land parcels because it was thought to have had a positive effect. In retrospect, the St. Lawrence lowlands fall in Canada's temperate humid zone so drought is not the problem that it may be in other study areas in the literature. Along the same reasoning, **RIV**, **LAKE**, **CREEK** and **ACCESS** were insignificant in each attempted run. Because of the insignificance of these variables and because of the multicollinearity problems with **PPN,** none of the water access variables made it into the final specifications.

Roads:

Other variables that proved to be insignificant included the measures for road conditions: **HWAY**, **PAVE,GRAV**. In reviewing the distribution and occurrence of these variables, 60% of all the properties were found to be on paved roads, 30% on provincial highways and only 10% on graded gravel roads. No properties were found on dirt roads (Table 3.2). Road conditions had no significant correlation to distance from Montreal (**DISM**) or to the **REGION** variables. This contrasts with some studies where there is a direct relationship between road quality and distance from urban amenities. The insignificance may also have occurred because of negligible differences in the quality of paved roads versus rural provincial highways.

Land coverage:

As described in the multicollinearity discussion, all land coverage variables were dropped except **PWOOD**, a reformulation of **WOOD**. **PWOOD** had a parameter value of -91313. This means that if a parcel was 100% covered in woods it would detract $ 93,313.00 from the price. This is not as meaningful as the variable **WOOD** which was measured in hectares instead of proportions, but the **WOOD** variable biased the other variables too severely.

Auxiliary Results:

The following observations were felt to be of some interest, however they were not placed under the rigorous scrutiny or diagnostic tests as were the results in the previous section. They are directional only, but highlight some important aspects of the possibilities of the HPM. The variables mentioned below are chattels, improvements, buildings or equipment that were sold along with the farm land parcels in some instances. They were measured in dollar values as found on the OCAQ transactions. They were not used in any of final models. In some initial models when **PAID** (total transaction price) was used as the dependant variable instead of **RAWL** (raw land price) the variables **DRVAL, NONF, ANIM, TOOL, QUOT, BLDG** were specified. Even though none of these models made the final selection it was worthwhile to note that for each unit (dollar) that **DRVAL** was appraised at, the capitalization into the implicit marginal price turned out to be between $1.50 and $2.00 (150-200%). Implicit prices for **QUOT** and **TOOL** were not much different, dollar for dollar, than their appraised values at around $1.01-$1.03 (101-103%). **BLDG** and **NONF** had considerably lower implicit marginal prices at $ 0.25-$ 0.50 (25-50%). This could mean that for every dollar invested in drainage and improvements, a return of $1.50 was capitalized into the selling price. Equipment and quota were apparently capitalized at fair market price, while buildings seemed to be undervalued or improperly depreciated when appraised. This type of information is very valuable to those buying and selling properties or to those considering adding improvements. These results, which were secondary to the main research, re-emphasize the use of HPM as a cost-benefit tool.

Based upon the results as described in this chapter, there is empirical econometric evidence that ***farmland prices do account for different levels in productivity***. The hypothesis of the implicit price portion of this research can be ***accepted***.

4.3. THE WEALTH ACCOUNT

The coefficients from the equation that was chosen to explain variation in the farm land market yielded the estimated implicit prices. The implicit prices for the land classes were multiplied by the inventory of each land class to arrive at the monetized wealth account (Table 4.3). The various adjustments to the inventory as described in Chapter Three, were also multiplied by the estimated price from the HPM to generate the dollar losses or class adjustments to the wealth value over a 15 year period, yielding the physical accounts (Table 4.4) and the monetized account (Table 4.5).

Once the value for the 1991 ending land inventory was found, it was subtracted from the 1976 wealth value to show the dollar amount of agricultural land that had been urbanized, or that was abandoned as degraded or marginal land. This amounts to around $260 million dollars of which $76 million is a capital loss and of which $184 million reflects decrease in land quality. This amount is a conservative estimate of loss and damages because it does not include estimates of deteriorated or degraded land, except if the land has been abandoned. While the losses appear relatively small, 95% of the charges are against classes 1 through 4 which represent the main crop growing base. It is important to maintain separate physical and wealth accounts. This allows a clear indication of the source of changes: whether hectares have been lost or values have changed or both. Victor (1990a: 19) concurs saying "it is possible for the real price or the net price of the resource to rise over time at the same rate as (or faster than) the rate of decrease in the physical stock of the resource with the result that the value of the resource remaining would stay constant (or rise) until there was none left". The separation of the physical and monetized, would carefully track the phenomena mentioned here.

This comprehensive wealth value of $ 10,152,091,000 was recorded in the 1991

Table 4.3 Valuation of the Opening Inventory

Inventory-Quebec CLI classes	Hectares in the Opening Land Inventory	Estimated Implicit Price per Hectare	Total Value
1	59,560	2463.20	$146,708,190.00
2	936,560	2463.20	$2,306,934,590.00
3	1,313,880	2463.20	$3,236,349,220.00
4	*2,493,960	493,960 @ 2320.80, 2,000,000 @ 920.73	$2,987,842,370.00
5	1,272,640	920.73	$1,171,757,800.00
7	352,000	920.73	$324,096,960.00
0	153,160	1557.90	$238,607,960.00
ESTIMATED VALUE OF WEALTH ACCOUNT = $ 10,412,297,000.00			

*For valuation purposes, 2000 ha of class 4 land were placed into the class 5 estimated price. It was felt that all class 4 land in the area where transactions were recorded, had many improvements and the class 5 value would be more appropriate to transfer to unimproved areas (Rouyn-Noranda) that have potential to come into production with improvements.

Table 4.4 The Physical Accounts and Closing Inventory

Quebec CLI classes	Beginning Hectares 1975	Subtotal	Urbanized (Ha)	Abandoned (Ha)	Loss (gain) to land class (Ha)	Ending Hectares 1991
1	59,560			*2,472		
2	936,560	2,310,000	26, 078	*24,265	83,825	2,226,175
3	1,313,880			*31,010		
4	2,493,960	2,493,960		*66,054	66,054	2,427,906
5	1, 272,640	1,624,640	12,856	36,450	(127,958) *shift from classes 1-4 and 0. - 12,856	1,739,742
7	352,000			8,976		
0	153,160	153,160		*4,157	4,157	149,003
TOTAL	6,581,760	6,581,760	38,934	173,384	net loss	6,542,826

Table 4.5 Valuation of the Closing Farm Land Inventory

Quebec CLI classes	Predicted Implicit Price	Beginning Value 1975 (in 1991 dollars) (000's dollars)	Urbanized Wealth Losses* (000's dollars)	Abandoned Land Adjustments (000's dollars)	Wealth Loss (000's dollars)	Ending Value 1991 (000's dollars)
1		146,708		(6,089)	(206,477)	
2	2463.2	2,306,934	(64,235)	(59,769)		5,483,514
3		3,236,349		(76,383)		
4	2320.8	2,987,842		(153,298)	(153,293)	2,834,544 2 million @ 920.73 and 427,906 @ 2320.8
5		1,171,757		117,814	105,977	1,601,830
7	920.73	324,096	(11,836)	no change		
0	1557.9	238,607		(6,476)	(6,476)	232,131
TOTAL		10,412,297	(76,072)	(184,201)	260,269	10,152,019
TOTAL ESTIMATED VALUE OF THE LAND INVENTORY = $10,152,019,000						

Source: Environment Canada (1989)

*Note: The estimated price of CLIH123 was used for the prime land and the class 57 price was used for the rest of the rural land. Since rural land has not been broken down into categories, using the higher class 4 price may over estimate the losses.

Balance Sheet of the Agricultural Sector. This new figure would appear as a 'shock' to accounts the first time it was included. A parallel set of accounts, similar to Table 4.6 could be maintained to avoid this, or the figure could be annualized, much the way Statistics Canada handles Census data currently. For the agricultural resource this 'shock' or addition to wealth would be a one time adjustment, because the inventory includes all current and potential land. It is not akin to the mining industry, where reserves may suddenly be discovered, therefore introducing shocks on a regular basis. Repetto (1989) and Victor (1990b) argue against including adjustments to inventory in the income accounts and advocate reflecting them only as additions or losses in the wealth account. This is for fear that large discoveries will inflate current income in any given year. This is a valid point for the mineral, gas and oil industries, but not for agriculture. The losses and corresponding decrease in value will be charged against income as capital losses for urbanized land, and inventory adjustments for change in quality. The loss figures span three census periods for 15 years. Data is not available for annual inventories, so changes and losses were assumed to be divided equally over the 15 year time frame. This amounts to an annual charge of around $5 million in capital loss (urbanization) and $12.3 million as a downwards adjustment to inventory value (shifts in classes). The average annual charges were then inserted into the income accounts yielding the results found in Table 4.7.

There is a difference between the wealth account value of land and the Statistics Canada value of $ 5.7 billion dollars. Chapter 2 outlined the differences in price estimation and measurement of hectares so this was to be expected. The Statistics Canada figure is derived from an aggregate opinion of value of all farm real estate which is broken down into components by Statistics Canada. This figure is not determined from an inventory times price method. A second point of differentiation would be the number of hectares reflected in the two values. As discussed during construction of the opening inventory and as demonstrated in

Appendix A.2, the NRA deals with over 6.5 million hectares and the SNA deals with a figure of less than 3.5 million hectares in 1991. The census hectares showed a loss of 0.5 million hectares between 1976 and 1991, but this is not necessarily a loss of potential and no conclusions can be drawn from this figure.

Table 4.6 Balance Sheet of the Agricultural Sector, Québec, 1991

as at December 31, 1991 ('000 of dollars)

	Quebec	Amount of Adjustment	Quebec - Adjusted
Current Assets	1,206,833		1,206,833
cash, bonds, savings	277,312		277,312
accts. receivable	116,972		116,972
inventories	812,549		812,549
-poultry, mkt. livestock	291,269		291,269
-crops	273,392		273,392
-inputs	247,888		247,888
Household Contents	112,322		112,322
Quota	2,922,206		2,922,206
Breeding Livestock	1,149,345		1,149,345
Machinery	2,278,879		2,278,879
autos	34,834		34,834
trucks	188,590		188,590
other	2,055,455		2,055,455
Farm Real Estate	6,739,313	12,492,058	12,492,058
land	4,399,274	10,152,019	10,152,019
service buildings	2,152,836		2,152,836
homes	187,203		187,203
TOTAL ASSETS	14,408,898	20,161,643	20,161,643
Current Liabilities	327,529		327,529
Long-term Liabilities	2,792,940		2,792,940
TOTAL LIABILITIES	3,120,469		3,120,469
EQUITY	11,288,429	**17,041,174**	17,041,174

SOURCE: STATISTICS CANADA Catalogue No 21-603E. Although there are more recent data than this, 1991 was chosen for consistency so that 3 census periods 1976-1991 could be covered.

Table 4.7 Net Farm Income- 1991

('000s of dollars)

	Quebec	Amount of Adjustment	Quebec-Adjusted
+ Total cash receipts	3,829,862		3,829,862
- Oper. expenses after rebates	2,834,992		2,834,992
= Net Cash Income	994,870		994,870
+ Income in kind	59,219		59,219
- Depreciation charges	343,969	(5,071)	349,040
= Realized net income	710,120		705,049
+ Value of inventory change	(18,155)	(12,280)	(30,435)
= Total net income	691,965		674,614

Source: Statistics Canada (1994a)

CHAPTER FIVE: CONCLUSION

5.1. SUMMARY OF FINDINGS

Clearly the hypotheses posed in Chapter 1 can be accepted. Farm land prices account for differences in productivity as demonstrated through the HPM and implicit marginal price estimation. When monetized wealth accounts were constructed for the 1976 and 1991 periods, changes between these two periods yielded measures of capital loss and depreciation. When incorporated into the income (flow) accounts, Québec agricultural industrial output was negatively affected, thus confirming the hypothesis that output is currently overestimated in the SNA. This research dealt with only a few identified sources of land depletion or depreciation, namely urbanization and abandonment. If all depreciation were to be included from studies with on site measurement of damages and records of diminished fertility, the losses would have been even higher.

The coefficients in the HPM showed that there was a significant premium placed on classes 1-3 and on class 4. Prices *did account* for differences in productivity by differentiating the highly productive classes (1-3, 0 and 4) from the poorer classes (5 or 7). No variation in price was detected between classes 1, 2 and 3. Either the farm land market does not account for differences in productivity in this cultivated, high-performance land; or the land in classes 1 through 3 have had significant investments and improvements (crowning, tile drainage) that make them indistinguishable; or the CLI class definition did not accurately reflect differences in productive levels.

The regional variables in the HPM proved to interesting. Despite legislated protection against urban encroachment, it seems that farm land cannot be isolated from urban pressures. More and more farms have off-farm income, or are almost completely supported by off-farm income, making farming areas that are close to career centres (urban shadow) highly desirable. The productive ability of the farm to generate income for those farming full-time has to compete with the proximity of the location to provide off-farm income; this competition is happening on land zoned only for agriculture, thus farms as a residential commodity are on the rise. The regional variables were thought to have captured the effects of urban pressure, distance to Montreal, and some climatological factors like precipitation, and CHUs. More work with these types of regional premiums would form an interesting base for future research. It is possible that the regional variables captured characteristics beyond those mentioned here that could aid in explaining price variation.

The $ 260 million assigned as capital loss against the land resource seems relatively small. The important thing to note though, is that much of the urbanization has taken place on the best lands with the highest capabilities. This is not so much a concern when borders are open and trades are free. The reduced ability to be self sufficient becomes more important though under different world circumstances, like world shortages of food, crises or war. The wealth account assigned a much higher value to the farm land resource than that in the Statistics Canada Balance Sheet (1994a). The computing methods were different for determining prices (empirical objective method versus opinion of value), so there is some difference in price per unit. The biggest difference though, arises from the number of units that were valued in the inventory. The comprehensive CLI was designed to record all land that had capability for agriculture, whether it was being exploited or not. The Census only records land actually on farms reporting an income from farming. Since the Census definition of a farm is based on income and not on land holdings, many rural properties are excluded, as are areas with untapped potential.

Establishment of the monetized wealth account was the main thrust of this research. Erosion or degradation of the land asset was not measured on site or adjusted for in the wealth account, except to the extent that abandoned land accounted for this. The research presented here would be complemented by studies which had their basis in on-farm sampling for the purposes of measuring degradation. Furthermore, adding an Input-Output type model could demonstrate how the agricultural industry is both a source of and sink for pollutants. The flow of pollutants or topsoil into waterways or other properties could be factored into NRAs. An accounting for restructuring activities like drainage of wetland for agriculture and causeways in tidal areas, would complement the NRA intelligence further still. These additional steps would assist in establishing a pluralistic, comprehensive set of NRAs for Quebec agricultural land.

5.2. THE CLI, LAND USE RESEARCH AND GIS

Land monitoring projects, land use projects and resource information will come to depend more on the use of satellite photography, once available only to the Department of National Defense. These images are now accessible and are used for SOE reporting, by crop insurance companies, NGOs etc. Although costly, it provides a better benchmark, literally a better view, and less measurement error for grand scale projects. Technology, particularly GIS software has become increasingly important in land studies. Manual overlays of maps and information as was done by Garrod (1992) and for this study will soon be unheard of. Earlier versions of GIS software are now available freely over the Internet.

Unless there is some dramatic reversal, there is no expectation in the various government departments that the likes of the CLI or Soil Series inventory will ever be repeated. The possibility that changing soil capabilities will be mapped out and surveyed country-wide with hundreds of thousands of samples seems remote. There is a lack of continuity in land monitoring programs in Canada.

The Lands Directorate (the agency that created the CLI), the Land-Use Change Program, the resources available to maintain the Canadian Geographic Information Systems (CGIS) are all casualties of funding cuts and shifting agendas. The SOE branch still uses the CGIS to compile its reports, but there is no funding available to keep this digital databank accessible to other users, even within the government, thus no possibility of obtaining special runs or queries upon the data.

It would be a monumentous task to develop an alternative improved inventory to the CLI. It is easy to create a classification system, but difficult to build one with (a) meaningful and discrete units reflecting productive value and (b) one that can be linked to survey data, census and market prices, without on farm testing of soil attributes and productivity. The CLI and Soil Series were mapped and tested on such a small scale, that they allowed linkages through the maps. Although the CLI presents some difficulties, it was the best solution as it fit all the criteria needed for this study. Ideally, more work could be done to provide geographic linkages to recent, detailed inventories of degradation measures (MAPAQ, 1988). If these types of studies could be linked to the plot level and the findings ranked quantitatively, or in some productivity function, then they could be valued. If these two improvements were made, such an inventory would be a complement to, and an improvement upon, the CLI.

5.3. EFFECTS OF NRA RESULTS:

Natural capital and man-made capital are still thought of as substitutes, especially in this knowledge-based generation. Whether they are complements or substitutes, may not be known until threshold zones are reached, if these zones are even recognized. Then decision makers will either rapidly restrict economic activity with this resource or scramble to compensate with new technologies. If enough food around the world continues to be grown on a shrinking and lower quality land base, then the substitution argument will win. If food supply becomes a world crisis and technology cannot keep pace, then a more sombre point will be proven. Decision makers need to understand how far different forms of capital can be exchanged before welfare becomes affected. They cannot do this without the proper tools.

Granted, it is costly to maintain information on the natural resource base. Some think we cannot afford not to. Victor (1990b) pointed out that rising prices can compensate for losses in sheer units and thus maintain total value, whilst the resource is disappearing. Others state that once prices for natural resources have risen due to scarcity, they will account for higher costs of extraction (Hamilton, 1991), and for the costs of information discovery (Gardner and Barrows, 1985). In that scenario, there is no market failure, but there may be a failure of the SNA to account for and to provide sufficient warnings about imminent thresholds and irreversible damage; there may also be a failure to reflect rates of changing productivity. In Québec agriculture, if one were to look at the balance sheet over the last several years, a steady increase in the land asset base would be seen. There would be no indication of the loss of prime lands to urbanization, to abandonment or degradation; only a total value that is by no means transparent to the true activities.

This type of research project is pertinent in the wake of recent strides towards sustainable development. Without the right indicators, policy attempts to change can be misguided, or may not be taking place at all. Corrected accounting paradigms have many applications. They can provide users with an idea of investment levels needed to maintain current levels of production; conservation dollars can more accurately match damages and areas of greatest need; decision-makers can be alerted to otherwise hidden losses, extent of damage, changes, scarcity, and rising prices. Perhaps most importantly, they can dispel the illusion that one can trade-off degradation for prosperity (Repetto, 1989).

With depreciation measures, governments and private industry can have an idea of just how much income to reinvest into the resource base to attain a truly sustainable income (El Serafy, 1989). It should be noted that many companies dealing with primary commodities practice this reinvestment already to protect their own economic interests.

Hamilton contemplates NRAs and asks the question, will adjusted measures be used ? GDP is certainly the dominant indicator presently which works well when unemployment and inflation are the primary socio-economic problems. "When deterioration of the environment becomes the major socio-economic problem, then perhaps measures of net product and total wealth will find their place" (Ibid 1991:9).

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- 10 -

STEP 16 – Please answer the following questions about the market value of land and buildings on this holding.

- Do not include the value of any land and buildings rented or leased to others

	Present market value (dollars only)
166 What is the estimate of the present market value of land and buildings that are: – owned	480 .00
– rented or leased from governments or others	481 .00

STEP 17 – Please answer the following questions about farm machinery and equipment located on this holding.

- Report all farm machinery and equipment used in this farm business and located on this holding on June 4, 1991, regardless of ownership.
- Include all farm machinery and equipment located on this holding: – with shared ownership – with a long-term lease.
- For this step, "Present market value" refers to the amount a machine or piece of equipment would bring at an auction sale in your district.

	Number: 2 wheel drive	Number: 4 wheel drive	Present market value (dollars only)
167 Tractors: – under 20 p.t.o. hp (15 kW) (include garden tractors)	500	501	502 .00
– 20-39 p.t.o. hp. (15-29 kW)	503	504	505 .00
– 40-99 p.t.o. hp. (29-74 kW)	506	507	508 .00
– 100-149 p.t.o. hp. (75-111 kW)	509	510	511 .00
– over 149 p.t.o. hp. (111 kW)	512	513	514 .00

	Number	Present market value (dollars only)
168. Farm trucks: – pick-ups and cargo vans	515	516 .00
– other trucks	517	518 .00
169. Cars (include all passenger vehicles used in the farm business)	519	520 .00
170. Grain combines: – self-propelled	521	522 .00
– pull type	523	524 .00
171 Swathers (include self-propelled and pull type)	525	526 .00
172. Mower conditioners	527	528 .00
173 Balers: – making bales less than 200 lbs (90 kg)	529	530 .00
– making bales 200 lbs (90 kg) or more	531	532 .00
174 Forage harvesters	533	534 .00
175 Cultivation, tillage and seeding equipment		535 .00
176 All other farm machinery and equipment (include materials handling and processing equipment (elevators, wagons, manure spreaders, dryers, augers, grinder-mixers, etc.), harvesting equipment (rakes, pickers, etc.), spraying and irrigation equipment, workshop and office equipment, etc.)		536 .00
177 TOTAL present market value of all farm machinery and equipment (Total of values reported in questions 167 to 176)		537 .00

178. Is a personal computer used on this holding in the management of the farm business? 538 ◯ No 539 ◯ Yes

OFFICE USE

540 541 542 543 544 545

Source: Statistics Canada Catalogue 96-107

APPENDIX A1b: 1991 CENSUS OF AGRICULTURE SURVEY

- 8 -

BERRIES AND GRAPES (grown for sale)

- Report the area to the nearest tenth. e.g. 5 : 7/10

	Area harvested or to be harvested in 1991	Total area under cultivation in 1991
60 Strawberries	240	241
61. Raspberries	242	243
62. Grapes	244	245
63 Blueberries (cultivated high and low bush, and low bush grown or managed)	246	247
64. Cranberries	248	249
65 Other cultivated berries (e.g. saskatoons, loganberries, currants, etc.) Specify ______	250	251
66 TOTAL area of berries and grapes under cultivation		252

VEGETABLES (grown for sale)

- Do not include greenhouse products. These should be reported in STEP 10, page 7
- Report the area to the nearest tenth. e.g. 1 : 5/10

	Area		Area		Area
67 Sweet corn	270	77 Carrots	280	87 Squash and pumpkins (include zucchini)	290
68. Tomatoes	271	78 Rutabagas (turnips)	281	88. Rhubarb	291
69 Cucumbers and gherkins	272	79. Beets	282	89 Asparagus, producing	292
70 Green peas (Report dry field peas in question 34.)	273	80. Radishes	283	90. Asparagus, not producing	293
71 Green or wax beans	274	81 Dry onions	284	91 Other vegetables (e.g. bok choy, melons, etc.) Specify ______	294
72 Cabbage (Report Chinese cabbage below)	275	82 Green or bunching onions, shallots	285	______	295
73 Chinese cabbage	276	83. Celery	286		
74 Cauliflower	277	84 Lettuce	287		
75 Broccoli	278	85 Spinach	288		
76 Brussels sprouts	279	86 Peppers	289	92. TOTAL area of vegetables (Total of questions 67 to 91)	296

STEP 7 - Are any nursery products or sod grown for sale? → 310 ◯ No - Skip to STEP 8; 311 ◯ Yes

- Include total area under cultivation.

	Area
93 TOTAL area of nursery products (include area of cut flowers, bulbs, shrubs, trees, vines, ornamentals, etc. grown out-of-doors)	312
94 TOTAL area of sod grown for sale	313

STEP 8 - Please answer the following questions about the use of the land on this holding

	Area
95 Sum of all the areas reported for field crops, fruits, vegetables, nursery products and sod (Total of questions 50, 58, 66, 92, 93 and 94)	320
96 Summerfallow (Report idle land that has not been worked or sprayed more than one year in question 99.)	321
97 Improved land for pasture or grazing (Improved by seeding, draining, irrigating, fertilizing, brush or weed control. Do not include areas to be harvested for hay, silage or seed.)	322
98 Unimproved land for pasture, grazing or hay (Include native pasture, native hay, rangeland, grazable bush, etc.)	323
99. All other land (Include land on which farm buildings, barnyards, lanes, home gardens, greenhouses and mushroom houses are located; improved idle land; woodlots; Christmas tree lots; sugarbush; tree windbreaks, bogs, marshes, sloughs, etc.)	324
100 TOTAL land area (Total of questions 95 to 99) (This total should equal the total area of the holding reported in question 19, page 1.)	325

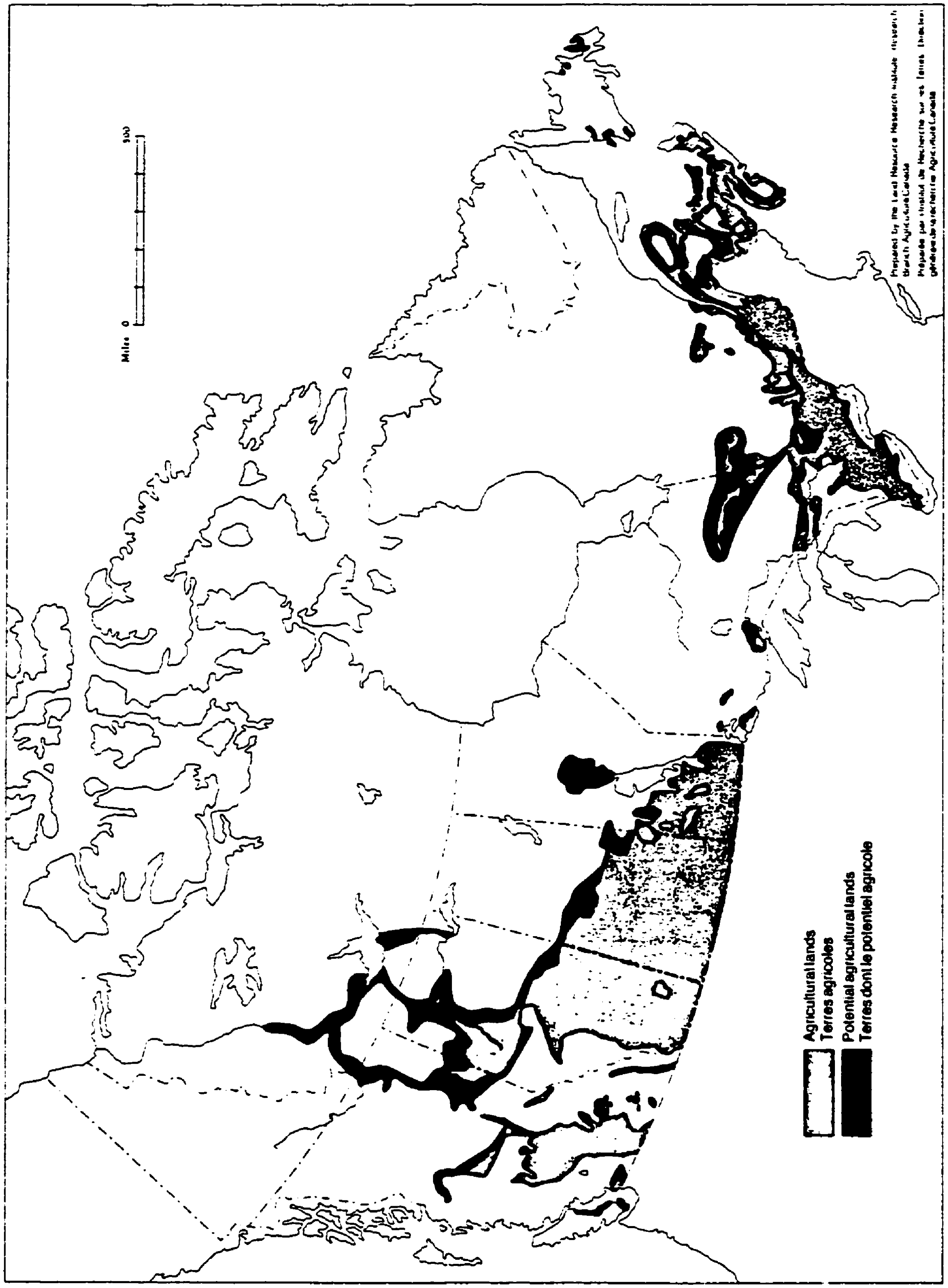
Source: Statistics Canada Catalogue 96-107

APPENDIX A2: CHANGE IN FARMLAND - CENSUS OF AGRICULTURE, 1976-1991

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Total land area	3.4E+08			335521920			
Total farms reporting	51587	48144	41448	38076	-13511	-26%	
Total area of farms	4008945	3779169	3638801	3429610	-579335	-14%	
Area in crops	1847507	1756038	1744396	1638453	-209054	-11%	1234
Sumerfallow	20441	53077	31803	14712	-5729	-28%	1234
Improved Pasture	470314	443559	301133	270924	-199390	-42%	12345
Other Land	1670683	1526606	1561470	1505520	-165163	-10%	567
[illegible] crops							
Oats	225236	150099	84222	96348	-128888	-57%	1234
Barley	18898	105962	175363	157387	138489	733%	1234
Grain Corn	62593	165446	234360	293758	231165	369%	1234
Corn Silage	103574	84391	61251	31756	-71818	-69%	1234
Soybeans	240	1439	4395	25271	25031	10430%	1234
Potatoes	17410	17172	17269	17515	105	1%	1234
Tobacco	3827	3568	3413	2107	-1720	-45%	1234
Berries and Grapes	2598	4494	6105	12520	9922	382%	1234
Tree Fruits	10820	8755	9015	9102	-1718	-16%	1234
Vegetables	33722	32544	32804	36575	2853	8%	0

Source: Statistics Canada Catalogue 96-107

APPENDIX A3: LOCATION OF CANADA'S AGRICULTURAL LANDS



Source: Agriculture Canada, 1985:4.

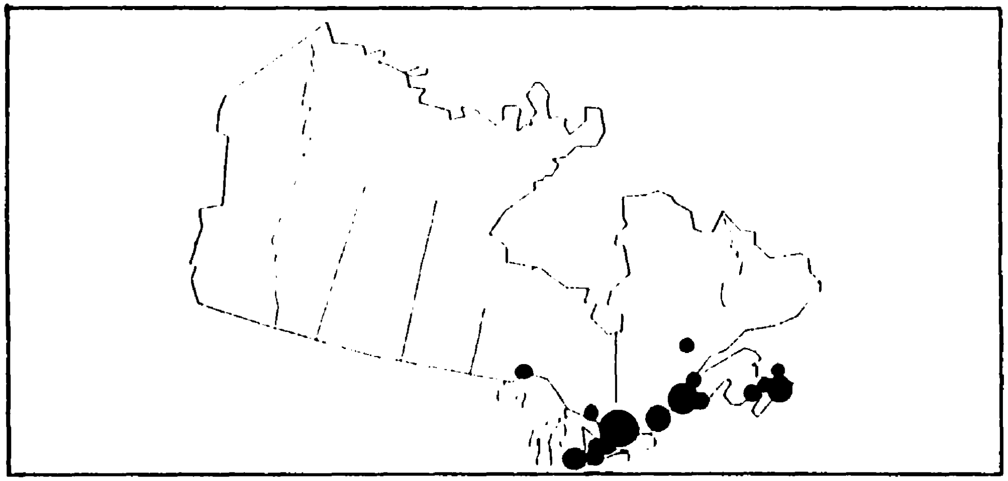


Figure A.1 Census Metropolitan areas- The Quebec Windsor Axis.

When comparing these four maps, it is easy to see that the areas under the most urban pressure are also the areas with the greatest agricultural potential. Note that only the eastern provinces were highlighted in this map series. For soybeans in particular, there are no other areas in Canada with the capability to grow this crop. Also, this corridor of land bears the highest levels of sulphur deposition in Canada.

Source: Adapted from Agriculture Canada (1983).

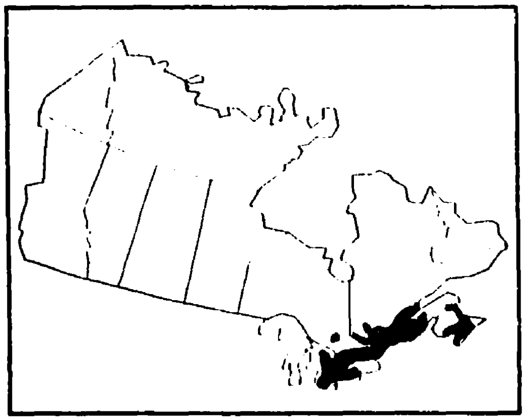


Fig A.2 Areas most suited for corn.

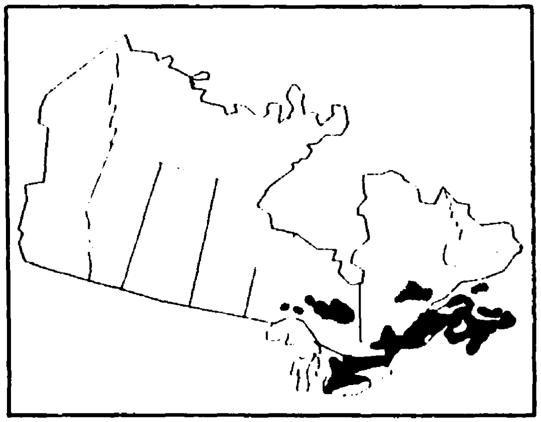


Fig A.3 Areas most suited for potatoes

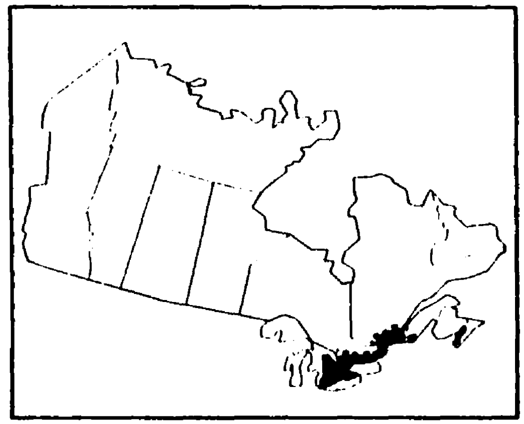
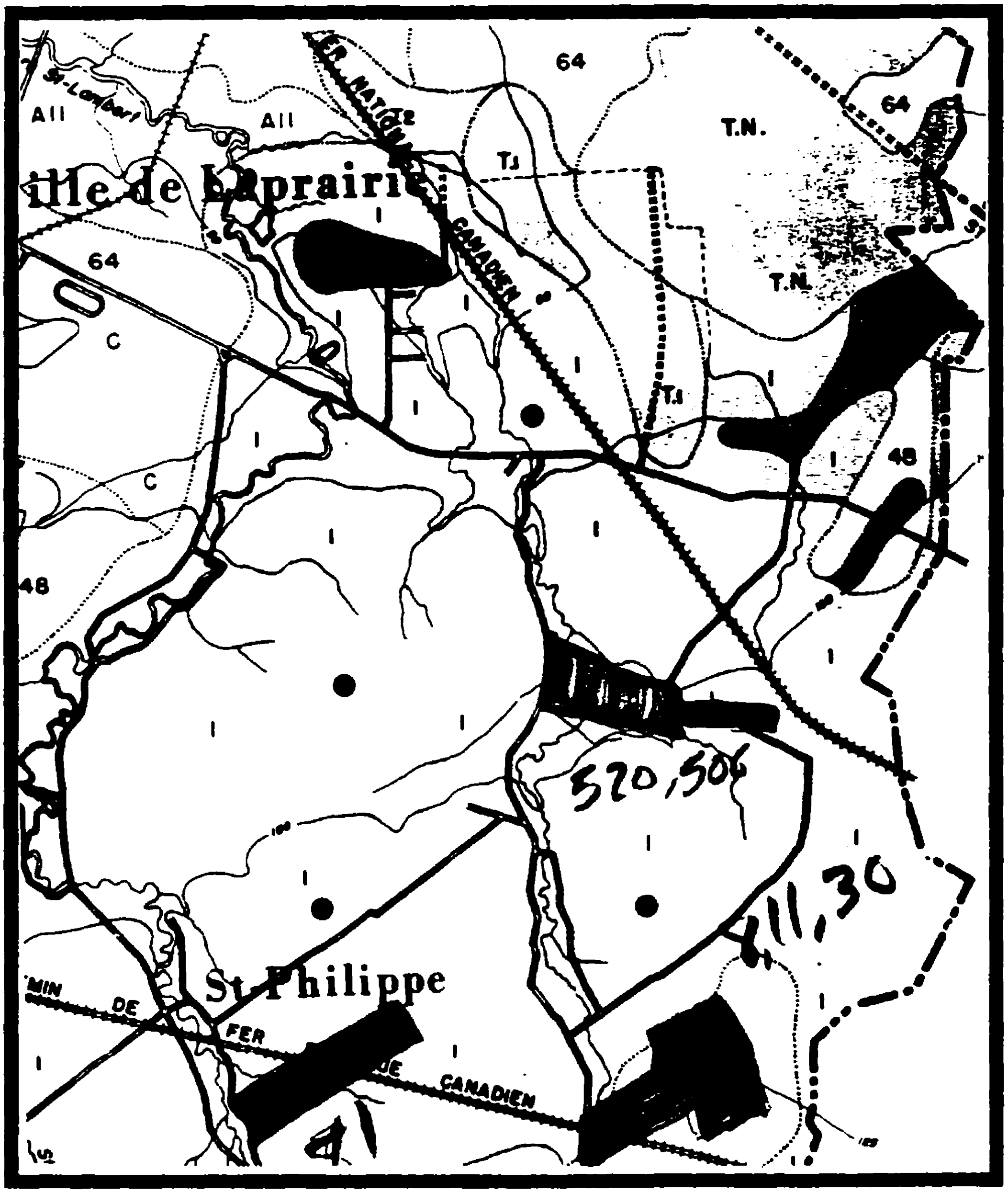


Fig A.4 Areas most suited for soybeans.

APPENDIX A5: SOIL SERIES MAP



Source: Energy, Mines and Resources, 1982

APPENDIX A.6a THE CANADA LAND INVENTORY CLASSES

Classes are categorized as seven groups of mineral soils and one group of organic soils. Each class has many different types of soil needing different management and treatment. 'The classs are based on intensity, rather than kind, of limitations for agriculture.' (legend, Soil Capability for Agriculture, Canada Land Inventory,scale 1: 1 000 000, Lajoie, 1975).

CLASSES	DESCRIPTION
CLASS 1	Soils in this class have no significant limitations to use for crops.
CLASS 2	Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.
CLASS 3	Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices.
CLASS 4	Soils in this class have severe limitations that restrict the range of crops or require special conservation practices or both.
CLASS 5	Soils in this class have very severe limitations that restrict their capability to producing perennial forage crops, but improvement practices are feasible.
CLASS 6	Soils in this class are capable of producing perennial crops only, and improvement practices are not feasible.
CLASS 7	Soils in this class have no capability for crop use or permanent pasture.
CLASS 0	Organic Soils (not placed in capability classes)

Source: legend from maps included as insertion to Lajoie, 1975.

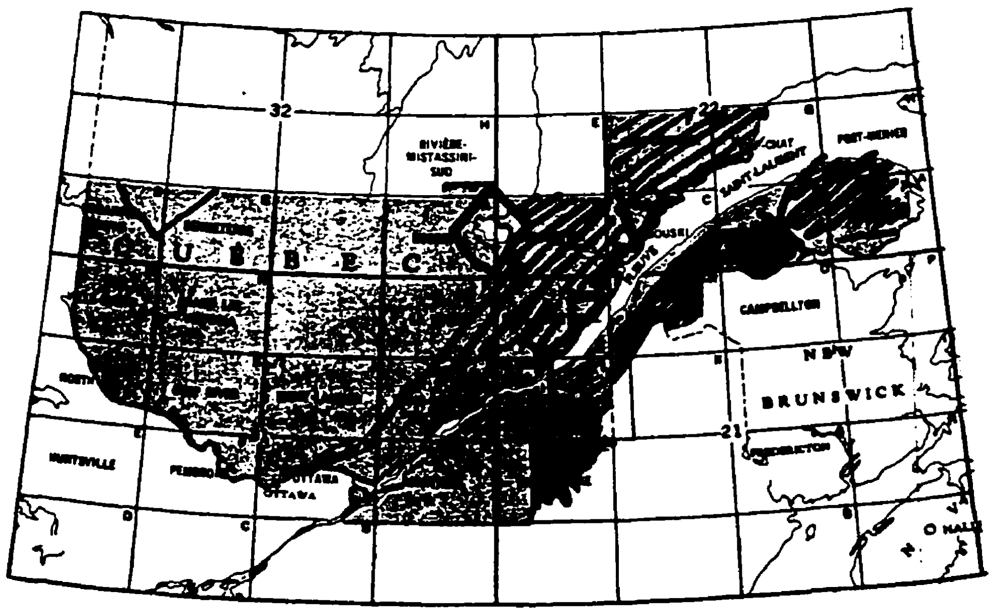
APPENDIX A.6b THE CANADA LAND INVENTORY- LIMITATION SUBCLASSES

LIMITATION SUBCLASSES	
A	droughtiness or aridity as a result of climate
D	undesirable soil structure and or low permeability
E	past damage from erosion
F	low natural fertility
H	adverse climate as a result of cold temperatures
I	periodic inundation by streams and lakes
M	deficient soil moisture
N	salinity
P	stoniness
R	shallowness to bedrock
S	a combination of two or more of the subclasses D, F, M and N
T	adverse relief because of steepness or pattern of slopes
V	a pattern of wet (W) and moisture deficient (M) soils very intimately associated
W	excessive soil moisture
X	an accumulation of two or more adverse characteristics that individually would not affect the class rating.

Source: legend from maps included as insertion to Lajoie, 1975.

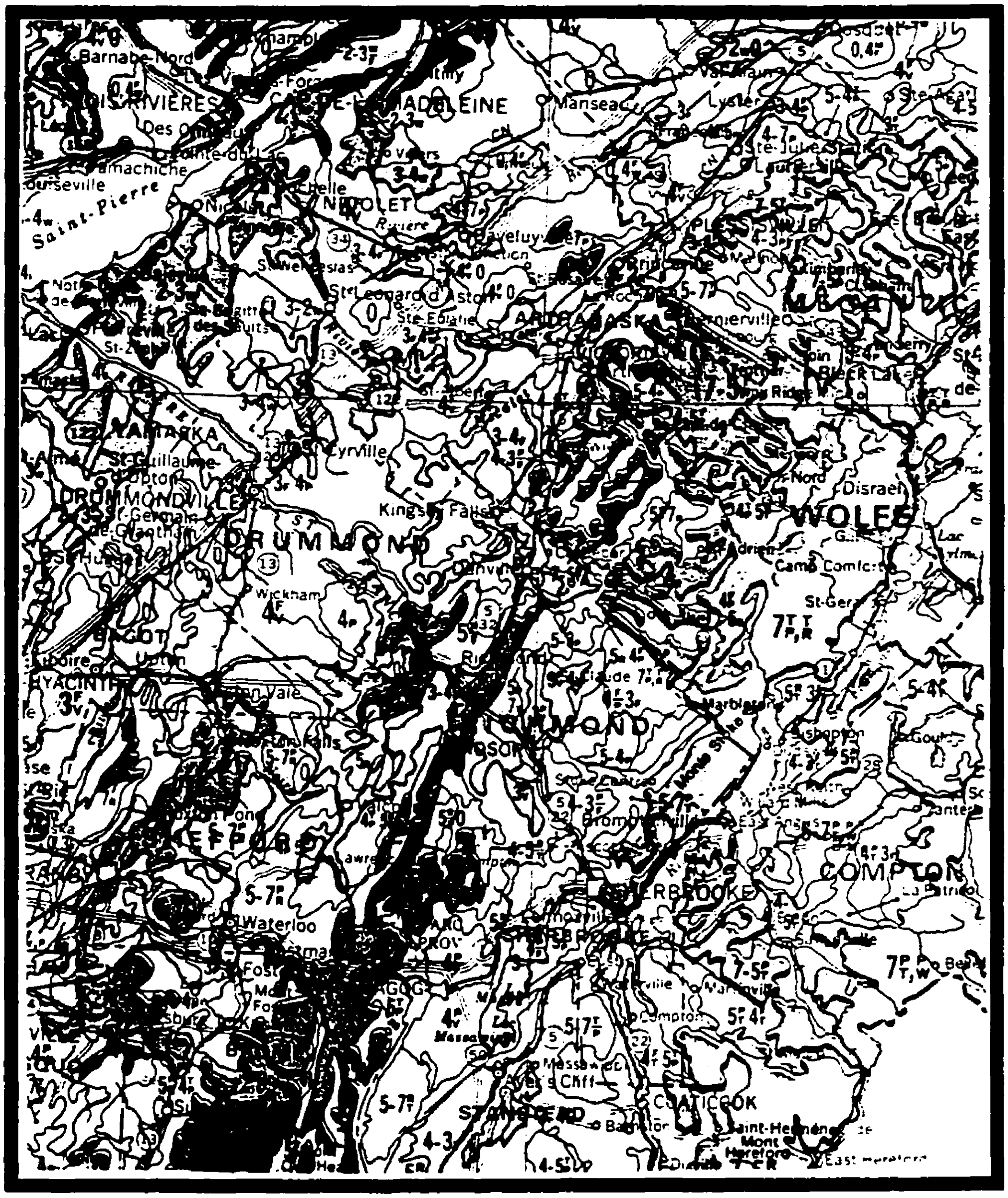
APPENDIX 6c: DISTRIBUTION OF THE OPENING INVENTORY, 1976

MAP	class 1	class 2	class 3	class 4	class 5	class 6	class 7	class 0	Total
									Hectares
Madelaine			6.16	4.32	0.92	8.76			**20.16**
Sherbrooke			53.52	201.6	207.6		100	6.72	**569.4**
Quebec		52.64	174.3	492.4	286.8		112	24	**1142.08**
Baie St-Paul	0.92	2.36	32.52	60.2	23.56				**119.56**
Edmunston			22.92	151.8	45.2				**219.96**
Cambellton		4.76	8.04	7.12					**19.92**
Gaspe	45.44	61.8	13.96	22.56				2.4	**146.16**
Matane		69.2	104.4	35.08	71.4				**280.12**
Rimouski		1.32	57.4	67.2	113.7				**239.6**
Chicoutimi		45.88	53.36	81	25.96				**206.2**
Port Meunier	1.04	21.68	45.2	70.08	10.32				**148.32**
Ottawa	1.64	75.56	91.04	95.16	25.8		80	15.04	**384.24**
Montreal	10.52	397.6	318.8	488.4	174.5		60	58.8	**1508.64**
Trois-Rivieres		161.4	98.6	329.2	65.52			46.2	**700.84**
Mont-Laurier		0.8	78.8	99.44	19.04				**198.08**
Ville Maire			28.8	88	62				**178.8**
Roberval		33.24	44.88	66.24	11.36				**155.72**
Senneterre			6.52	40	92.2				**138.72**
Rouyn			71.08	87.84	36.8				**195.72**
Riv. Mastissini		8.36	3.56	6.36					**18.28**
Total with adju	**59.56**	**936.6**	**1314**	**2494**	**1273**	**8.76**	**352**	**153.2**	**6590.52**



Source: Adapted from Lajoie (1975). Methods as described in Chapter 3.5.

APPENDIX 7: CANADA LAND INVENTORY MAP



Source: Lajoie, 1975. Note that this scale is 1: 1 000 000 and the scale used for overlaying was 1: 250 000

APPENDIX 8a: SAMPLE OCAQ TRANSACTION

(194)

Office du crédit agricole du Québec

VENTE COMPARABLE

NO CIVIQUE	GENRE D'ENTREPRISE	CODE	INDEX
47 St-Patrice	maraîchère	5	[redacted]

DATE DE VENTE: PA nov. 90 MUNICIPALITÉ: Sherrington COMTÉ MUNICIPAL: Napierville

[redacted] St-Patrice de Sherrington
LOTS - RANG - CANTON OU PAROISSE

VENDEUR: [redacted] OCCUPATION:

ACQUÉREUR [redacted] OCCUPATION [redacted]

ACHAT POUR ÉTABLISSEMENT ☑ AGRANDISSEMENT ☐ FINS NON AGRICOLES ☐

ANALYSE DU PRIX DE VENTE

REVENU BRUT DE L'ENTREPRISE:	1	PRIX TOTAL PAYÉ: 70 000	2

DESCRIPTION	VALEUR MARCHANDE		
ANIMAUX:			
OUTILLAGE:			
RÉCOLTES:			3
QUOTAS:			
AUTRES:			
VALEUR RÉSIDUELLE À L'IMMEUBLE = (2 − 3):		70 000	4

ANALYSE DU TERRAIN

DESCRIPTION	SUPERFICIE ha	VALEUR $/ha
TOTALE:	25,6 ha	
CULTIVÉE:	23,5	2 100
PAT. NAT.:		
BOISÉ:	2,1	
VERGERS ______ ARBRES		
ÉRABLIÈRES ______ ENTAIL		

TYPE DE SOL: 5 ha terre noire 4 - 5 pieds

TOPOGRAPHIE

RENDEMENT TB ☐ BO ☒ MY ☐ FA ☐

PLUS-VALUE DUE AU DRAINAGE SOUTERRAIN 0 ha $/ha

ANALYSE DU PRIX DE L'IMMEUBLE

BOISÉ, ÉRABLIÈRE, PAT. NAT., VERGER, ETC.		5
TERRE CULTIVÉE BÂTIE (4-5)		6
VALEUR MARCHANDE DE LA TERRE NUE	50 000	7
CONTRIBUTION DES BÂTISSES (6-7)	20 000	8
COÛT DE REMPLACEMENT DÉPRÉCIÉ (C.R.D.)	17 000	9
% DE CONTRIBUTION DES BÂTISSES (8÷9) × 100	117	10

ANALYSE DE LA CONTRIBUTION DES BÂTISSES

	C.R.D.	CONTRIBUTION	%	
MAISON				11
AUTRES BÂTISSES				12
IMMEUBLES PAR DESTINATION				13

COMPLÉTÉ PAR: [redacted] DATE: 6/19/90

APPENDIX 8b: SAMPLE OCAQ TRANSACTION

(221)

Office du crédit agricole du Québec

VENTE COMPARABLE

CIVIQUE	GENRE D'ENTREPRISE	CODE	INDEX
	grandes cultures	1 1	[redacted]

DATE DE VENTE P.A. 09-89 MUNICIPALITÉ [redacted] COMTÉ MUNICIPAL Richelieu

LOTS - RANG - CANTON OU PAROISSE: P 461, P460, P459, P458, P457, P456, P455, P454, P349, P362, P363, P364, P366 P367, P370, P371, P372, P373 P374, P375, P376, P377, P379

VENDEUR [redacted] OCCUPATION agriculteur

ACQUÉREUR [redacted] OCCUPATION agriculteurs

ACHAT POUR ÉTABLISSEMENT ☐ AGRANDISSEMENT ☒ FINS NON AGRICOLES ☐

ANALYSE DU PRIX DE VENTE

REVENU BRUT DE L'ENTREPRISE		1	PRIX TOTAL PAYÉ	380 000	2
DESCRIPTION	**VALEUR MARCHANDE**				
ANIMAUX					
OUTILLAGE					
RÉCOLTES					3
QUOTAS					
AUTRES					
VALEUR RÉSIDUELLE À L'IMMEUBLE = (2 - 3)				380 000	4

ANALYSE DU TERRAIN

DESCRIPTION	SUPERFICIE ha	VALEUR $/ha
TOTALE	123	2 970
CULTIVÉE		
PAT. NAT.		
BOISÉ		
VERGERS ____ ARBRES		
ÉRABLIÈRES ____ ENTAIL		
TYPE DE SOL	loam sableux & argileux	
TOPOGRAPHIE	plane	
[illegible] TB ☒ BT ☐ MY ☐ FA ☐		

ANALYSE DU PRIX DE L'IMMEUBLE

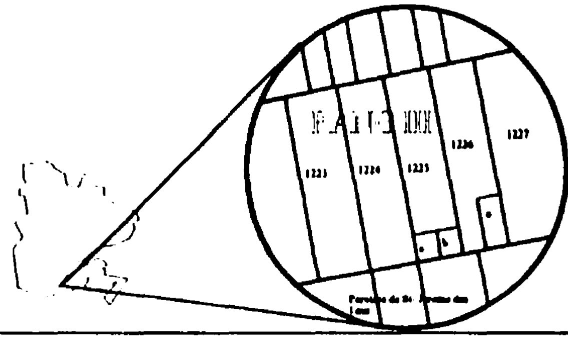
BOISÉ, ÉRABLIÈRE, PAT. NAT., VERGER, ETC.		5
TERRE CULTIVÉE BÂTIE = (4-5)		6
VALEUR MARCHANDE DE LA TERRE NUE	350 000	7
CONTRIBUTION DES BÂTISSES = (6-7)		8
COÛT DE REMPLACEMENT DÉPRÉCIÉ (C.R.D.)		9
% DE CONTRIBUTION DES BÂTISSES = (8/9) × 100		10

ANALYSE DE LA CONTRIBUTION DES BÂTISSES

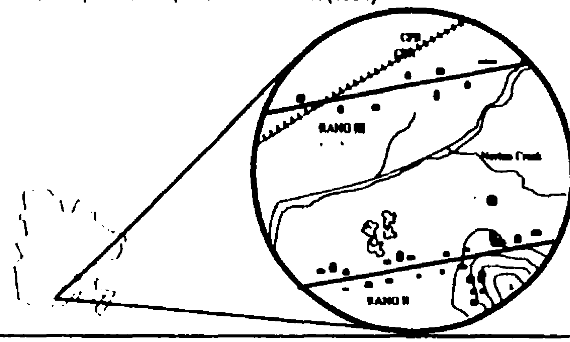
	C.R.D.	CONTRIBUTION	%	
MAISON				11
AUTRES BÂTISSES				12
IMMEUBLES PAR DESTINATION				13

[redacted]

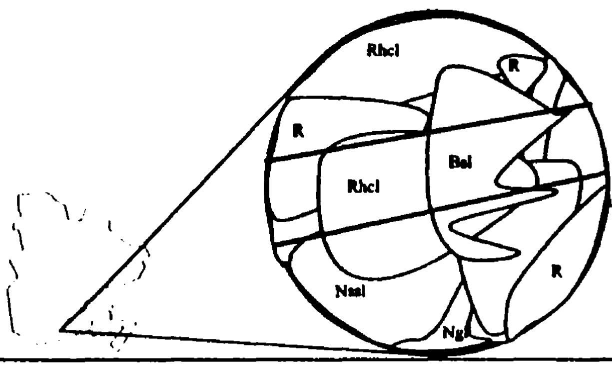
Cadastral Maps were used to locate property from the lot numbers on the sales transaction. The shape and precise location of the property was needed to overlay on to the other maps to record the independant variables.
Scale 1: 10,000 or 1: 20,000. Source: MER (1984)



In step two, road conditions, water access, distance from town, and slope was recorded from the topographical maps. In some archives, the cadastral map was a transparent overlay of this map. In other cases, the cadastral map had to be photocopied on acetate grid sheets,to compare between the different maps.
Scale 1:10,000 or 1:20,000. Source: MER (1984)

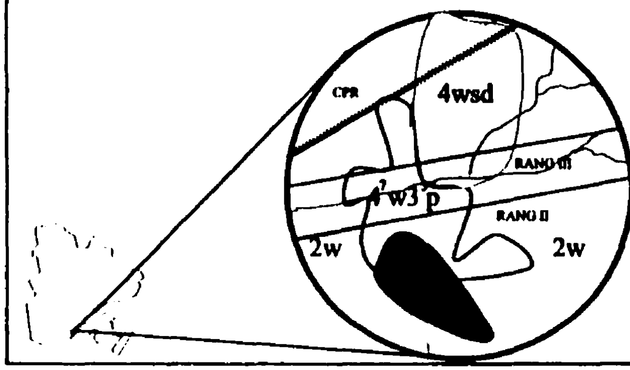


In step three, the transparent overlays from step one were placed over photocopied enlargements of the soil maps. This was achieved by solving for 1/10000 = x/55000. The result was the percentage enlargement needed to overlay the maps perfectly. The letters stand for the soil type ie) Rhcl = Ste-Rosalie heavy clay loam.
Scale 1:55,000 Source: MAPAQ (1950) and MER (1982)

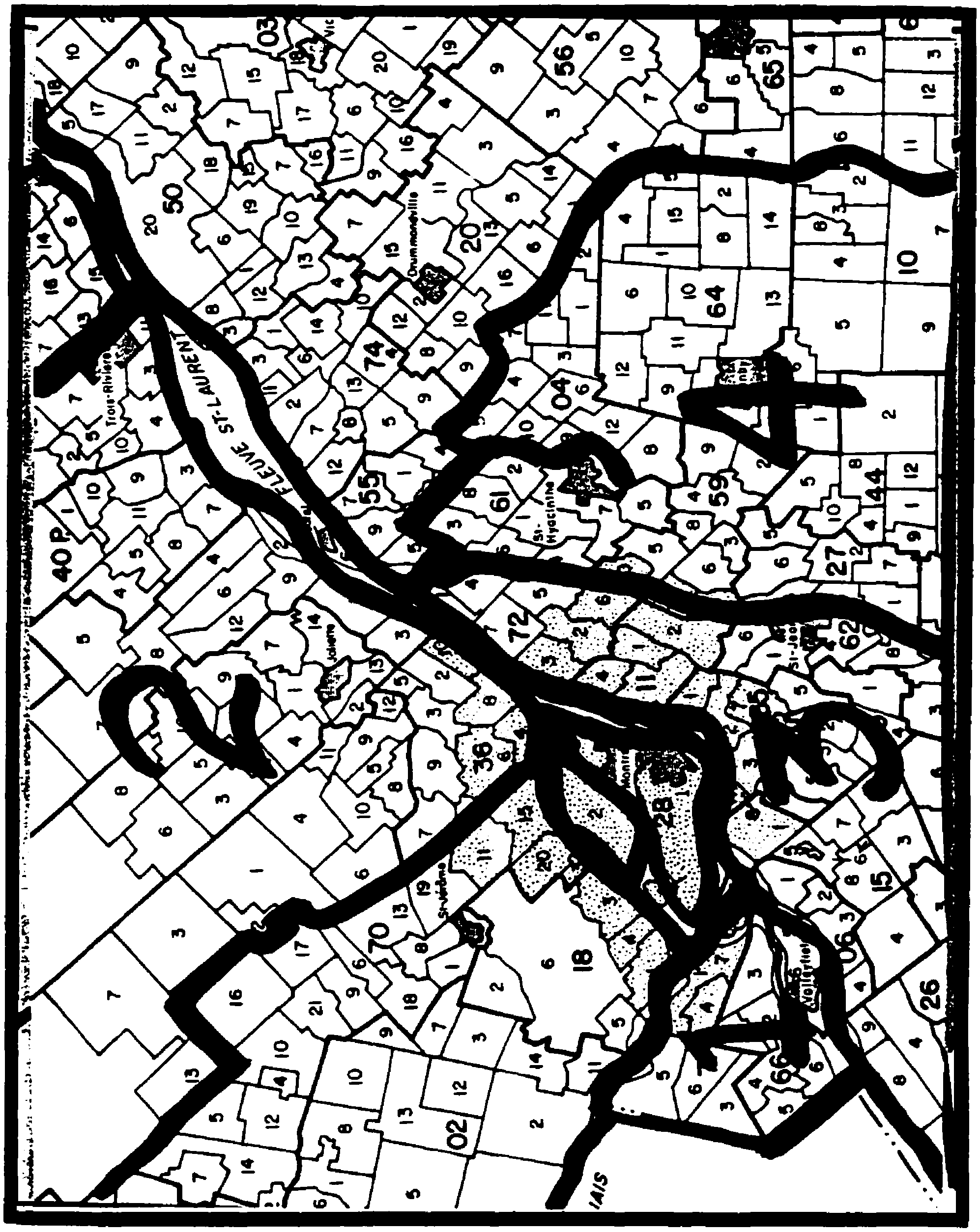


The fourth step of the variables gathered at plot level was to record the Canada Land Inventory classes. The number gives the CLI class, the superscript, if any, shows the percentage and the letters give the limitations of the subclasses.

Scale 1:250,000 Source: EMR (1975)



APPENDIX 10: THE FOUR REGIONAL VARIABLES IN THE MARKET AREA



APPENDIX 11: ABANDONED HECTARES - RESULTS FROM SATELLITE IMAGERY

Agricultural Region-	Agricultural land (Ha) 1. (1981)	Agricultural land (Ha) 2.(1991)	Abandoned Land 3.			Proportion abandoned (%)
			perennial (Ha)	shrub (Ha)	both	
1	241 281	199 242	6 253	10 628	16 881	6.99
2	232 858	194 916	10 202	14 320	24 522	10.53
3	184 965	117 621	12 568	17 915	30 483	16.48
4	279 092	229 245	12 146	12 948	25 094	8.99
5	216 056	155 699	5 418	13 754	19 173	8.87
6	277 466	237 028	4 169	5 248	9418	3.39
7	274 911	239 341	6 807	7 227	14 034	5.1
8	174 957	120 186	-------	-------	-------	-------
9	128 071	84 322	-------	-------	-------	-------
10	167 005	147 421	4 392	6 321	10 653	6.38
11	98 434	80 196	-------	-------	10 000	-------
12	158 424	118 874	3 936	9 185	13 122	8.28
Québec	2 433 526	1 924 091	68 835	97 549	173 384	7.89

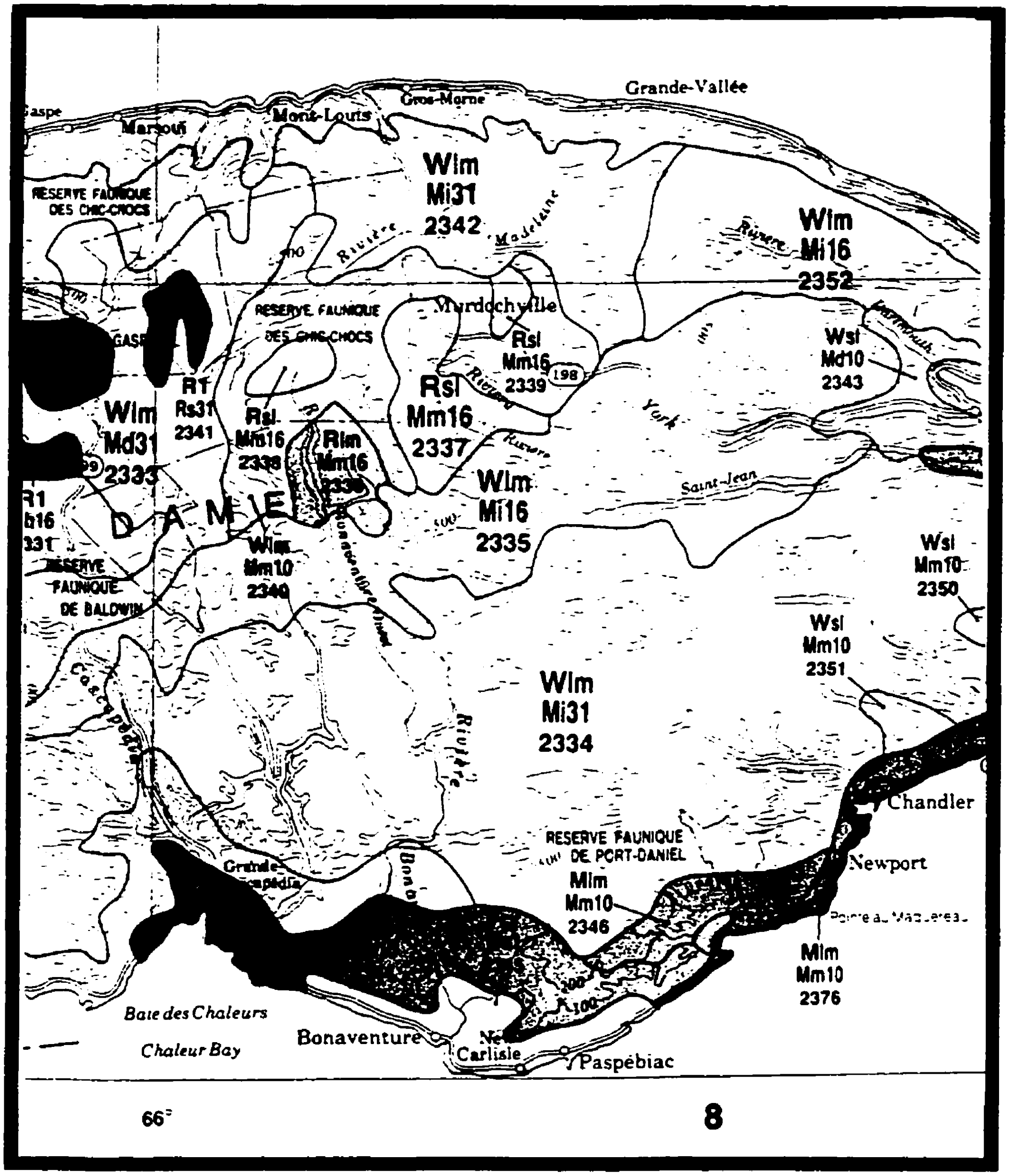
SOURCE: Adapted and translated from a MAPAQ special compilation <<Results from the Interpretation of Satellite Images >>(translation)., Division for Environment and Sustainable Devt. (1991).

1, based upon use of GEOextra software with producer information.

2, adapted from Caron (1994) from a special run from Statistics Canada (Carignan, 1995).

3, from Landsat Satellite photograph interpretation, 1991. Land abandoned and overgrown with at least 50% herbaceous/arbustive growth. Percentages in relation to the 8 calculated regions only.

APPENDIX12: SOIL LANDSCAPES



Source: Agriculture Canada, (1992). Scale is 1: 1 000 000

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6"

APPLIED IMAGE . Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989