The University of Calgary

AN EVALUATION OF ALBERTA SOIL SURVEYS FOR CONSERVATION PLANNING

BY

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A Masters Degree Project submitted to the Faculty of Environmental Design in partial fulfillment of the requirements for the degree of Master of Environmental Design (Environmental Science)

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FACULTY OF ENVIRONMENTAL DESIGN

The undersigned certify that they have read and recommend to the Faculty of Environmental Design for acceptance, a Master's Degree Project entitled: **"An Evaluation of Alberta Soil Surveys for Conservation Planning"** submitted by Mr. William L. Nikiforuk in partial fulfillment of the requirements for the degree of Master of Environmental Design.

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ABSTRACT

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Increased awareness of soil conservation and land degradation problems have caused many landowners to re-evaluate their current land use and farming practices. Consequently, the demand for farm conservation plans resulted in an increase in the use of soil survey information. A review of soil survey, soil conservation and farm conservation planning in Alberta was conducted to document and evaluate the adequacy of soils information available in soil survey reports and maps for farm conservation planning. Farm conservation planners were given a questionnaire to evaluate their soil information requirements and level of understanding of soil survey information.

Results of the literature review suggest that soil surveys produced prior to 1945 provide inadequate soils information for on-farm and municipal scale conservation planning. Reports produced after 1945 are adequate for municipal conservation planning, but do not provide the detail necessary for on-farm conservation planning. The results of the questionnaire indicate that, although farm conservation planners have difficulty interpreting certain technical data, they have a clear idea of their data needs and for algorithms necessary for interpreting the data.

Analyses of the results leads to the conclusion that effective use of soil survey information requires a variety of products and delivery methods. These include the production of standardized soil survey reports and maps, increased education and training in soil survey methods, and the use of electronic and interactive computer technology as alternatives to hard copy reports and maps. Further studies must also be conducted to develop quantitative algorithms for some forms of land degradation so that collection of soils data specific to these algorithms can be facilitated.

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1.0 INTRODUCTION

Land degradation on the prairies is a persistent problem that has been well documented (Wyatt, Macgregor-Smith, Newton and Gillies 1932; Neatby 1940; Nesbitt 1950; Coote 1983; Standing Senate Committee on Agriculture, Fisheries and Forestry 1984; Science Council of Canada 1986; Toogood 1989). It results in a reduction of a farmers ability to sustain current levels of food and fibre production and increases their costs. In an effort to decrease land degradation many Alberta farmers are evaluating current land use and farming practices. This is evidenced by the formation and existence of over 45 conservation interest groups (Alberta Agriculture 1992b; Hermans 1992; Meents pers. comm. 1992). One organization, specifically Conservation 2000, accounts for 37 of the total groups and has between 600 and 750 members (Meents pers. comm. 1992). Farm conservation planning is one of the programs used by farmers to decrease land degradation. Farm conservation plans are developed for farmers with the assistance of conservation planners (agricultural fieldmen, district agriculturalists and consultants) and are recognized as the first step in reducing land degradation.

Soils data are one of the types of information needed to compile farm conservation plans. The principal sources of soils information are soil survey reports and maps prepared by the Alberta Research Council, Agriculture Canada and the University of Alberta. This project was initiated to evaluate the adequacy of existing soil survey reports and maps for conservation planning.

1.1 Background

Approximately 80 percent of Canada's agricultural lands are located within the prairie provinces. The total area of improved land available for crop production is estimated at 34.1 million hectares (Science Council of Canada 1986) which differs from the Agriculture Canada (1981) estimate of 37.7 million hectares. This difference may be due to an interpretation of what improved land is. In Alberta the total area available for crop production is 12.5 million hectares (Agriculture Canada 1981). Of this total, approximately 1.8 million hectares have been eroded, 0.4 million hectares are affected by secondary salinity and 1.7 million hectares are affected by acidity (Anderson and Knapik 1984). The area affected by all forms of degradation is projected to increase by approximately 1.6 million hectares by 2008 if degradation continues at current rates (Table 1).

Table 1. Estimated current and future land degradation of improved lands in Alberta (millions of hectares) (Anderson and Knapik 1984)

	Year	
Type of land degradation	1984	2008
Secondary soil salinity	0.4	0.47
Erosion	1.8	2.2
Acidity	1.7	2.8
Total	3.9	5.47

The Science Council of Canada (1986) estimated that land degradation costs the prairie provinces one billion dollars annually (off and on-farm costs). This estimate is predicted to increase to 2.7 billion dollars annually by 2006. It is imperative that measures be employed to stabilize or reverse the trends of increasing on and off-farm costs of land degradation. These costs may be alleviated through increases in research and transfer of new and existing technology and agricultural programs to the farm level (Alberta Agriculture and Agriculture Canada 1989, 1991). On-farm and municipal conservation planning are two processes that can demonstrate ways to decrease the cost and amount of land degradation. Although both methods are relatively new in Alberta, they have been proven effective in decreasing the on and off-farm costs of and amounts of land degradation in other geographical areas (Soil and Water Conservation Society 1990). For example, the Soil and Water Conservation Society (1990) reported a 90 percent reduction in the amount of erosion after planned soil conserving cover was used in erodible fields in the United States.

Conservation planning is defined as a "structured resource planning process that is flexible to meet the needs of the user to protect, preserve and enhance the soil and water resources, thus, insuring the long term, sustainable production of food and fibre" (Alberta Agriculture 1990). The farm conservation planning process involves the compilation of a detailed inventory of existing soil and land resources, the evaluation of farm management capabilities and the derivation of alternative methods for controlling degradation of land (Alberta Agriculture 1990). The information generally required to compile farm conservation plans includes inventories of soils, vegetation, water, climate, farm equipment and so on (Table 2). That is, an inventory of the resources available for production of commodities on a farm. One goal of the farm conservation planning process is to produce a soil conservation plan.

Table 2. Comparison of resource information required for farm conservation planning (Alberta and United States)

Resource information required for conservation planning	
Alberta (Olds College and Alberta Agriculture 1989)	United States (USDA 1984)
- land use	- land use
- ownership and land tenure data	- ownership
- geology and groundwater	- geology - groundwater supply - mineral location
- topography	- topography
- hydrology - water management - water well location - dugout location	- community sanitation and water supply - water impoundments - potential water impoundment sites - drainage area - flood plains - irrigation water supply - wetlands (population, agriculture, plant materials, water quality, recreation inventory and potential, climatic data)
- soils data - wind erosion (observation, calculation and predictions) - water erosion (observation, calculation and predictions) - salinity (observation, calculation and predictions)	- soil data, interpretations and potential
- nonpoint source pollution	- pollution sources - sediment sources
Other information required includes: - climate and weather data - municipal assessment records - machinery (equipment) - cropping history - tillage practices - insect infestation - weed problems)	Other information required includes: - plant cover - special purpose districts - fish and wildlife habitat potential - natural , scenic, historic, archaeological and other cultural resources - natural areas for scientific study - unique landforms - environmental quality - developmental sites - transportation and utility - location of threatened or endangered species

The principal source of soils data used by farm conservation planners is the soil survey report and map. Soil surveys in Alberta were initiated approximately 70 years ago. The soils information presented in the initial soils reports and maps was indicative of what was known about soil classification and genesis. Early soils reports and maps contained non-technical and easily understandable language (Wyatt and Newton 1925; Wyatt, Newton and Mather 1930). They later became technically complex and scientific terms replaced simple language (Reeder and Odynsky 1965; Howitt 1988; Walker, Brierley and Coen 1991). Since the initiation of soil mapping, soils maps and reports have been compiled at different map scales, using different mapping concepts, a variety of classification systems and on a variety of presentation media (Wyatt and Newton 1925; Wyatt, Newton, Bowser and Odynsky 1941; Lindsay, Odynsky, Peters and Bowser 1968; Macyk, Greenlee and Veauvy 1985; Howitt 1988).

The soils maps and reports provide users with chemical and physical descriptions of soils and information on the distribution and interpretation of soils (Table 3). MacMillan (1985) conducted a survey that identified and described the data requirements of users of soil and land information in Alberta. He found that most respondents knew what soils information was required to make their decisions and they preferred this type of information in a relatively unprocessed form. That is, they wanted "raw" data in tabular form rather than interpreted information. He concluded that to meet this demand, published soil and land maps should contain and describe as many data elements as possible. MacMillan's study implied that farm conservation planners know what soils information is needed to compile farm conservation plans; they require only a portion of all the information that is presented in a soil survey report; and they should be capable of extracting this information from soil survey reports to compile farm plans.

Many users of soil survey information are technically competent, however, some have little or no technical background in soil survey methods or terminology (Valentine, Naughton and Navai 1981; Souster and Peters 1991). As a result, some soil survey information is not understood and therefore not effectively used (Sombroek and van de Weg 1980; Valentine et al. 1981; Anderson, Skarie and Adams 1982; Valentine 1983). This is contrary to the objective of soil survey which is to provide understandable, accurate and precise information to people who need to understand and use soils as they occur in the landscape (Brown 1985b). However, satisfying the needs of users who do not have technical soils backgrounds contradicts the needs of technically competent users, who have suggested that more data and technical information be included in soil survey reports.

Bicki (1991) stated that it is neither possible nor desirable to express all soil survey information in non-technical language. Therefore, a balance must be created between the needs of these two user groups. Enough technical language must be replaced with non-technical language to satisfy both user groups.

Table 3. Soils information available in Alberta soil survey reports 1925 to 1992

Physical and landscape properties	Chemical properties	Interpretations
- drainage	- % nitrogen	- organic matter loss*
- consistence	- % phosphorous	- soil salinity*
- classification	- % calcium	- irrigation*
- series	- % magnesium	- summerfallow*
- horizon thickness and type	- calcium carbonate content	- wind erosion (extent, severity and control)
- structure	- exchangeable cations	- agriculture capability
- texture	- soluble salts	- available water supplies
- soil color	- % sand	- soil management and conservation
- landform description	- % silt	- engineering
- stoniness	- % clay	- forestry
- slope (percent)	- water holding capacity	- deep plowing and ripping suitability
- agroclimatic zone	- organic carbon	- water erosion (susceptibility)
	- cation exchange capacity (CEC)	
	- electrical conductivity (EC)	
	- base saturation	
	- soluble cations	
	- bulk density	

* in the Soil Survey of the Macleod sheet (Wyatt and Newton 1925)

A review of examples of farm conservation plans suggests that some conservation planners have difficulty understanding data as presented in soil survey reports and interpreting and translating it for the farmer. The tendency is to present all available soils information in a farm conservation plan rather than reporting the data necessary for farmers to make management decisions. The plans illustrate that soil survey maps and reports are not being effectively used by some conservation planners. Brown (1985b) stated that the optimal or effective use of the soils information is achieved only if a user (conservation planner) comprehends all the parts of the soil survey report. The first step in the process of achieving the goal of effective use of soil surveys in conservation planning is to identify the soil information needs of the farm conservation planners. Their needs and requirements will be used to assess the adequacy of current soil survey products and in the potential development of alternative soil survey products.

A review of the soil information needs of conservation planners and an evaluation of the adequacy of soil survey maps and reports for conservation planning is necessary if the goal of reducing the amount of land degradation is to be achieved. Changes to soil maps and reports are necessary if they do not provide proper or adequate information for the users. In order for soil survey maps and reports to be effectively used, methods of soil survey delivery should be considered that reduce the misunderstanding of soils information by conservation planners and address their information needs.

1.2 Goals

The goals of this project are to:

1. Determine if soil surveys adequately meet the information needs of farm conservation planners
2. Enhance and improve farm conservation planning, through effective use of soil survey products by farm conservation planners, so that there is a reduction in the amount of soil and land degradation

1.3 Objectives

The objectives of the study are to:

1. Determine the soils information required for compilation of farm conservation plans
2. Define the on-farm and municipal conservation planning process
3. Make recommendations for modifying soil survey reports so that farm conservation planning and other user needs are addressed
4. Evaluate the competency and qualifications of soil conservation planners to compile soil conservation plans

1.4 Methodology

The study had three distinct components (Figure 1):

1. Literature review
2. Questionnaire of conservation planners who use soil survey reports
3. Evaluation of the adequacy of soil survey reports for farm conservation planning based on the literature review and the questionnaire

The literature review examined the history of soil conservation in Alberta, the farm conservation planning process and the soil information requirements of farm conservation planners in Alberta, the history of soil survey in Alberta and what soils information can be obtained from soil survey reports. These three sections provided background on how soil conservation evolved, how farm conservation plans are compiled, why soils information is required to compile a farm conservation plan, who was responsible for collection of soils information and why soils information is perplexing to conservation planners who are required to use it.

In conjunction with the literature review a questionnaire was developed and used to:

1. Ascertain the soils information requirements of conservation planners as documented in the literature
2. Determine the soils comprehension level of conservation planners
3. Determine the preferred soil map scales and products of conservation planners

The questionnaire was targeted at soil conservation planners in Alberta and was conducted via telephone. Lists of personnel employed as agricultural fieldmen, district agriculturalists, soil conservation technologists, soil conservation regional specialists and public lands specialists were obtained from Alberta Agriculture and Alberta Forestry, Lands and Wildlife. In addition, participants from the private sector employed as consultants were considered as part of the farm conservation planning population. Names of consultants conducting soil conservation plans were obtained from Alberta Agriculture. Approximately 200 individuals constituted the total population. Participants were selected from areas in the province where land degradation was considered a problem. Attempts were made to contact about 80 individuals (with a variety of educational backgrounds) and 53 participated in the questionnaire. Usually, participation was a function of availability at the time of telephone contact.

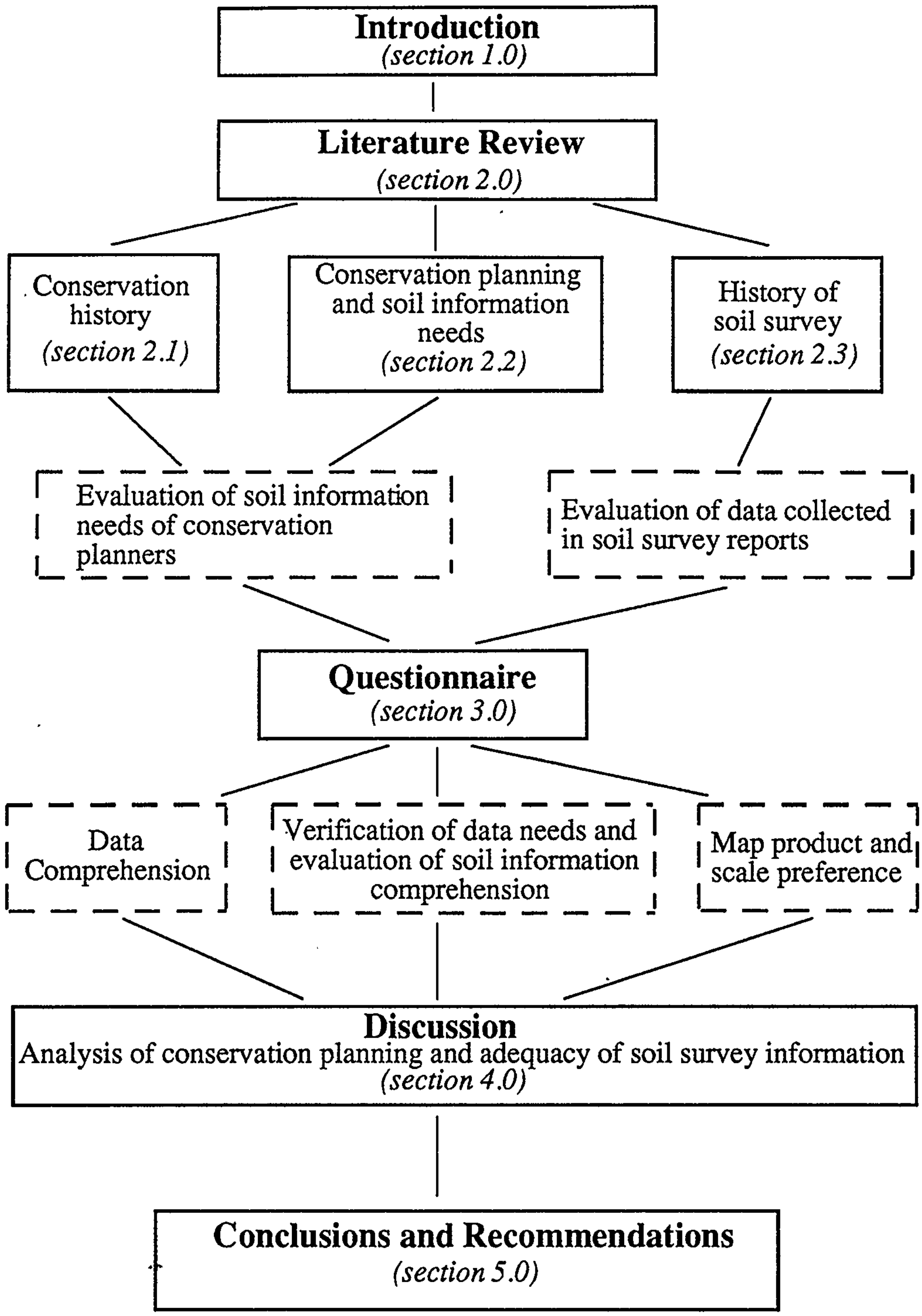


Figure 1. Methodology

The questionnaire had four sections. The first section provided information on the soils backgrounds of the respondents. The second section dealt with technical and interpretive data that could be obtained from soil survey maps and reports. Respondents were asked, through telephone inquiry, to evaluate the usefulness (utility) of each piece of soils information for conservation planning purposes. The third section dealt with the way soil maps are presented in reports. The respondents were asked to rank map products for on-farm and municipal planning. The last section dealt with soil map scale. The respondents were asked to rank the utility of different map scales for on-farm and municipal conservation planning. In addition to ranking map scale and map product preferences, respondents were asked to provide reasons for their primary choices.

Data, obtained from the questionnaire, were compiled, analyzed and used with information from the literature review to evaluate the adequacy of soil survey reports and maps to derive recommendations for alternative methods of soil survey product presentation.

The discussion section presented:

1. An evaluation of the adequacy of soils information as presented in soil survey reports and maps for farm conservation planning
2. Suggestions for alternatives to currently produced soil survey reports and maps
3. Suggestions for improvements to the current farm conservation planning process

Recommendations were made which address the adequacy of soil survey reports, technical background of planners and directions for future soil survey mapping and reports. Implications of the recommendations were discussed and finally, an overview was provided of the possible solutions proposed for addressing the soil survey information needs of conservation planners.

The appendices contain information on the location of Experimental Farms in Canada, a copy of the questionnaire that was administered to conservation planners, an outline of the Canadian system of soil classification and a glossary of terms. Definitions for some terms are provided in the glossary. These terms are typed in bold face in the report .

2.0 LITERATURE REVIEW

The purpose of the literature review was to provide background information on:

1. How soil conservation evolved and how its evolution affected the type of soils information required for conservation planning
2. The procedures used for on-farm and municipal conservation planning
3. The soils information requirements of conservation planners in Alberta
4. The history of soil survey in Alberta, the products of soil surveys and the content of soil survey maps and reports

2.1 Soil Conservation History

In 1857 Captain John Palliser defined an area (the Palliser Triangle) where, due to low precipitation, agriculture would be hazardous (Archibald 1938; Gray 1967). The area was described to extend from 100 to 114 degrees longitude at its base and 52 degrees latitude at its apex. However, Gray (1967) stated that Palliser's assessment was only partly correct since there was land within the Triangle that could easily support agriculture. None-the-less, settlement of the area occurred. The main reason for settlement was protectionism. That is, it was necessary to have a strong population base in the prairie provinces for Canada to remain viable as a nation. Consequently, expansion occurred into many areas which were only marginally suited for agriculture and susceptible to land degradation if improperly managed.

Dr. Angus MacKay, in his Experimental Farm Reports of 1887 to 1889, emphasized that early settlers on the Canadian prairies faced risks from frost, drought and high winds (Archibald 1939). Some of these threats were overcome through technological advance. For example, the threat of frost was minimized with the development of early ripening varieties of cereals and garden crops. The threat of drought was partially overcome in 1886 when summerfallowing was discovered as a means of conserving soil moisture (Spector 1983). The advent of summerfallow contributed to the expansion of agriculture into drier portions of the prairies because crops could safely be grown without the threat of drought. Although it was an effective means of conserving soil moisture and controlling weeds, it proved to be the catalyst for wind erosion (Hopkins, Barnes, Palmer and Chepil 1935). Wind erosion was evident in 1890 in Manitoba (Archibald 1939), in 1897 in Saskatchewan (Hopkins et al. 1935) and in 1910 in Alberta (Gray 1967). Efforts to control wind erosion started in 1917 in the Monarch area of Alberta (Hopkins et al. 1935; Gray 1967). The techniques first utilized by farmers were strip farming and maintenance of standing stubble.

In 1886, the Dominion Experimental Farms System was established. The Experimental Farms undertook work with soils, crops and animals that would best serve the settled and unsettled areas of Western Canada (Archibald 1939; Gray 1967). The objectives of the Experimental Farms were to answer all agricultural questions that farmers had (Gray 1967). The Farms were directed by the federal government in Ottawa but were located in different areas and had different activities. Initially, five farms were established and located at Ottawa (Ontario), Nappan (Nova Scotia), Brandon (Manitoba), Indian Head (Saskatchewan) and Agassiz (British Columbia) (Anstey 1986). An additional eleven stations were established between 1906 and 1935 (PFRA 1983). The establishment of the Farms was significant in that they proved to be an effective vehicle for delivery of soil conservation technology to the farming community.

Alberta's first official endeavor to cope with drought and the land utilization problem was the Special Areas Act in 1927 (Longman 1939; Alberta Institute of Agrologists (AIA) 1961). The purpose of the Act was to improve rural social conditions by improving the economic return from lands within such areas. The Act was designed and intended to mend the mistakes of the land settlement policy which placed settlers on marginal lands (Longman 1939). The Act involved depopulation, disorganization of municipalities and school districts, enlargement of land holdings, transfer of land in arrears of taxes to the Crown, and the establishment of an authority to administer the new policies within the affected region (AIA 1961). The area covered under the legislation included 3.6 million hectares (Longman 1939).

In 1935, the PFRA and Agricultural Improvement Associations were formed by the Canadian government and the Soil Drifting Control Act was passed in Alberta. The Soil Drifting Control Act (eventually became the Soil Conservation Act) evolved as a result of soil erosion which took place during the 1920s and early 1930s and was the first of its kind enacted in Canada. At the request of a government committee, legislation was introduced, to punish those who permitted their soil to drift by neglecting to follow the best known preventative measures. The bill was passed but not before the penalty clause was 'substantially reduced' (AIA 1961). At present, penalties range from 20 to 200 dollars or up to 30 days imprisonment for any person who fails to comply to the legislation (Alberta Government 1988). To date, there have been no criminal convictions as result of the enforcement of the Act (AIA 1961; VanderPluym pers. comm. 1991).

Agricultural Improvement Associations (AIAs) were formed in response to the drought conditions on the prairies (Shirriff 1939). The AIAs were a cooperative venture between farmers and the government. The objectives of the AIAs were to learn and apply new methods of agriculture with the hope that the prairie drought area could be made habitable and profitable. The number of AIAs formed and membership totals have been documented by several authors (PFRA 1983; Brown 1985b; Anstey 1986). The estimates vary between 228 to 280 total AIAs and membership of 33,600 to 36,000 farmers. The PFRA, through the Experimental Farms Service, provided aid to the AIAs in the form of instruction on erosion control and financial assistance to cover administrative costs. The PFRA felt that it was imperative that every farmer adopt the management techniques of trash farming and strip cropping to reduce the impacts (on and off-farm) of wind erosion (Anstey 1986). The return of improved climatic and financial conditions after the Second World War caused a decline in participation in the associations. As a result, most associations ceased operations during this period.

The Prairie Farm Rehabilitation Act was passed to help alleviate the problems created by drought on the prairies through the rehabilitation of lands affected by drought and soil drifting (Archibald 1938; Gray 1967; Dumanski, Coote, Luciuk and Lok 1986). The passing of the Act enabled the formation of the Prairie Farm Rehabilitation Administration (PFRA) (PFRA 1983). The organization was allocated five million dollars for its first five years of operation (Gray 1967; Brown 1985a). The funds were used to develop new methods for controlling wind erosion, provide on farm demonstrations, increase the number of Experimental Farm substations, establish Reclamation sub-stations, establish and demonstrate the effectiveness of field shelterbelts, establish AIAs and demonstrate crop production under irrigation (Brown 1985a). The PFRA mandate became permanent in 1940 (Dumanski et al. 1986).

Initially, the PFRA did not have a large technical staff and acted as an administrative body responsible for some experimental work and providing financial assistance to farmers (Archibald 1938; Gray 1967). The organization relied upon the Experimental Farms system for the majority of its technical work. The financial commitment made to soil and water conservation research helped revitalize the Experimental Farms system. Until about 1935 there had been a lack of effective communication between the Experimental Farms and the farm population (Gray 1967). The lack of communication was alleviated through increased extension activity by the Farms and by creation of substations and reclamation stations. These stations (50 in total) were spread across the prairies and increased the opportunity for contact with the farming populace (Anstey 1986) (Appendix 1).

In 1938, three PFRA branches were created (Archibald 1938; Gray 1967). They were the Cultural, Land Utilization and Water Development Branches (Archibald 1938; Spence and Vallance 1939). The Cultural Branch included District Experiment Sub-station, Reclamation sub-station, grass seeding, tree planting (field shelterbelt), soils research, soil survey, soil drifting (methods to control), seed grains (seed production), economic survey, insect survey, aerial survey and new rust resistant grains programs. The Land Utilization Branch included the community pasture, reserve grazing area, staff organization, irrigation districts and feed and fodder relief inspection programs. The Water Development Branch included the dugout, small stock watering dam, small irrigation dam, community and municipal projects, financial assistance for small projects and larger water development project programs. In 1946 the Cultural Division was transferred to the Experimental Farm Service. The transfer brought PFRA's involvement in soil conservation to an end (PFRA 1983). However, the organizations activities in water conservation programs continued.

In 1945 the Agricultural Service Board Act was passed in Alberta. The Act provided financial assistance to municipalities to aid in carrying out projects that were of interest to municipalities and Alberta Agriculture. Soil conservation programs, like on-farm demonstrations, tree planting, water erosion control, reclamation of eroded lands and forage seed for soil reclamation and improvement, were supported by the Act (AIA 1961).

From 1945 to the early 1980s there were no significant soil conservation programs or initiatives. In the 1980s, an increase in public awareness with respect to land degradation issues brought soil conservation to the attention of the public (Fairbairn 1984, Standing Committee on Agriculture, Fisheries and Forestry 1984). The Alberta government formed the Conservation and Development Branch of Alberta Agriculture in 1983 to address concerns about land degradation in the province (Hermans 1992). Farm conservation planning in Alberta was initiated in 1987, as a component of the Disaster Assistance program (Vanderwel pers. comm. 1992). Conservation planning was also a component of the Canada-Alberta Soil Conservation Initiative (CASCI) program (Alberta Agriculture and Agriculture Canada 1989).

These government programs (as well as some privately funded programs) are offered to assist landowners in the implementation of farm conservation plans. The programs provide financial and technical assistance to landowners who wish to voluntarily retire highly erodible or environmentally sensitive lands from production or implement soil conservation techniques.

2.2 Soil Conservation Planning

Soil conservation planning is a component of soil conservation programs that are delivered by PFRA, Agriculture Canada, Alberta Agriculture and Ducks Unlimited (Alberta Agriculture 1987; Alberta Agriculture and Agriculture Canada 1989; Ducks Unlimited Canada 1989). The programs offer financial incentives to landowners for the retirement of lands that have been severely degraded or have potential for being degraded.

Alberta Agriculture (1990) defined conservation planning as:

> "a structured resource planning process that is flexible enough to meet the needs of the user to protect, preserve and enhance the soil and water resources, thus, insuring the long term sustainable production of food and fibre".

This definition is similar to that used by the United States Department of Agriculture (1984), who defined conservation planning as:

> "a plan of action that land users follow in managing soil, water and related plant and animal resources. It helps land users put these resources to the best use, whether for farming, ranching, forestry, housing, recreation, transportation or some combination of uses".

In Alberta, the goals of conservation planning are to understand soil, water, plant and animal resources so they can be managed in a sustainable manner within an integrated management system; and to provide the best land use recommendations for all uses (Alberta Agriculture 1990). However, unlike in the U.S.A., Alberta conservation plans do not usually provide non-agricultural land use recommendations.

The result of the conservation planning process is the development of a conservation plan. The plan is a document that provides a framework for the way in which landowners should manage and conserve land, soil and water resources. Technical and scientific support for conservation plans is provided by agriculture extension personnel and by scientists with specific areas of expertise. The two types of conservation plans developed in Alberta are on-farm and municipal conservation plans.

On-farm conservation planning details the resources on a parcel of land, identifies land degradation, provides an explanation of why land degradation is occurring and lists methods for controlling land degradation while maintaining farm production. On-farm plans are compiled at scales of 1:15 000 or larger. Ideally the on-farm conservation plan will assist the farmer to develop the best land use and production system for the farm (Alberta Agriculture 1990).

Municipal conservation planning describes the natural resources in a municipality or county and identifies the location, extent and severity of soil and water conservation problems (Barlott, Knapik and Voth 1990). The objective of the planning process is to formulate a plan of action, for a county or municipality, for addressing long and short term conservation problems and to prioritize conservation issues so that major conservation problems are addressed first. These plans are compiled at scales of 1:50 000 to 1:200 000 (Barlott et al. 1990).

2.2.1 On-Farm Conservation Planning - Process

"Conservation planning is most successful if conducted in a structured, stepwise approach" (Barlott et al. 1990). Alberta Agriculture (1990) identified the following ten steps in the on-farm conservation planning process:

1. Introduction and explanation - the farm conservation planning process is described and explained to a group of farmers
2. Acceptance - a farmer decides that a farm conservation plan would be beneficial to his or her farming operation. He or she will then solicit the local agricultural extension person to assist them in the compilation of a plan.
3. Objectives - the objectives of the conservation planning process are determined. The plan is altered to accommodate the concerns and needs of the farmer. For example if wind erosion is the main degradation concern, information relevant to determining the degree, extent and potential for wind erosion would be collected.
4. Information collection - information is gathered on the existing resources of the farm (soils, vegetation, wildlife, climate, equipment, and so on)
5. Recommendations - make recommendations on methods to control land degradation
6. Check - the information and recommendations are checked to ensure that they are correct, accurate and feasible

7. <u>Completion</u> - the plan is considered complete after Step 6 is completed
8. <u>Assessment</u> - assess the plan for completeness and determine if more information or action is required at the time the conservation plan is produced or will be required in the future
9. <u>Review</u> - conduct an annual review to assess if the implemented control measures have been effective in controlling land degradation
10. <u>Evaluation</u> - the plan is evaluated after more than two years to determine if control measures are effective for controlling land degradation in the long term

The farm conservation planner should maintain contact with the farmer or landowner throughout the ten step procedure outlined. At minimum, the conservation planner should make two visits to the farm or parcel of land. The first visit should involve a field check of the farm to assess and document the degree of degradation. The second visit should occur after the plan has been completed. During this visit, the plan should be presented and discussed with the farmer or landowner to ensure that the recommendations made are reasonable and feasible.

The on-farm conservation plan delivered to the farmer should have the following format (Alberta Agriculture 1990):

1. <u>Title page</u> - the title page should contain information on the legal land location, farmer's name, address and phone number, level of plan, the names of the authors of the plan and the date the plan was produced
2. <u>Introduction</u> - the first page should provide a list of the objectives of the plan, any cautionary notes or prefaces, title and date of publication of information used
3. <u>Inventory information</u> - an inventory of the resources on the farm should follow the information in the introduction (Table 2). Information should be compiled on aerial photographs with acetate overlays provided of soil survey information, land use and existing land degradation. A written summary of the data and interpretations should accompany the photographs and acetate overlays.
4. <u>Recommendations</u> - recommendations should be provided for all degradation issues
5. <u>Field forms</u> - the final section of the plan should contain forms (field record sheets) to help the farmer keep records of management practices used to

control degradation

Barlott et al. (1990) modified the ten step process outlined by Alberta Agriculture into an eight step process for municipal conservation planning as follows:

1. Initiation and commitment
2. Collection of resource information
3. Organization and interpretation of the information
4. Development of viable alternative solutions and objectives
5. Development of the action plan, projects and activities
6. Implementation of projects and activities
7. Monitoring and evaluation
8. Revision and update

The eight step process is almost identical to the ten step process outlined by Alberta Agriculture (1990). The advantage to using the process outlined by Barlott et al. (1990) is that their process allows for more farmer feedback and for planners to regularly update or modify their conservation plans.

2.2.2 Types of On-Farm Conservation Plans

Alberta Agriculture (1990) described two types of on-farm conservation plans in Alberta. Level 1 conservation plans are brief synopses of the soil resources on a farm, describing the extent and degree of land degradation that has occurred in the past and documenting whether land degradation is still occurring. The plan delivered to the landowner is an encyclopedia of existing resource information (soil, water, vegetation, land use, farm equipment and farm animals) that has been compiled for a parcel of land. A brief set of recommendations address the land degradation problems that are occurring on the parcel. This plan is delivered with the hope that the landowner will adopt some conservation measures and perhaps pursue the development of a more detailed Level 2 plan. The majority of farm conservation plans compiled in Alberta are Level 1 plans (Goddard pers. comm. 1992). The advantages of compiling Level 1 plans are (Alberta Agriculture 1990):

1. The landowner has a permanent record of the land resources and the effect that current management practices have upon land degradation
2. The landowner has an increased awareness of land degradation and the management practices required to alleviate the degradation problem

3. Contact between the landowner and conservation planner results in some soil conservation education occurring
4. The completion of the Level 1 plan may cause the landowner to pursue the compilation of a more detailed Level 2 plan

Level 2 conservation plans are detailed accounts of soil and related resources on a farm and the potential for degradation of the soils under existing farming practices. Existing resource information is collected and supplemented by the collection of additional (detailed) information. The additional information is collected via field inspection (for example, the sampling of soils) and visits to farmers. Detailed recommendations are made to the land owner for reducing or eliminating land degradation. The document also provides farmers the forms necessary for maintaining and updating records of management practices. This allows farmers to determine whether or not their management practices are effective in decreasing the amount of degradation on their land. Level 2 plans should not be initiated if a Level 1 plan has not been completed for a farm. The advantages of Level 2 plans include (Alberta Agriculture 1990):

1. They are more detailed than Level 1 plans
2. Soil interpretations are done with more detailed information
3. The involvement with farmers producing Level 2 plans allow conservation planners to learn more about the landowners farming operation
4. The plan provides a framework for conservation planning, monitoring and information for the completion of economic production models.

2.2.2.1 Soils Information Required for On-Farm Conservation Planning

Soils information is required to compile conservation plans so that recommendations can be made for minimizing or reducing land degradation. Land degradation issues include soil erosion, salinity, acidification, organic matter loss and compaction. The amount and kind of soils information required for conservation planning depends upon the type of conservation plan being compiled. Alberta Agriculture (1990) stated that, for on-farm conservation planning, soils found on a parcel of land must be identified and their basic properties documented. The basic soil properties required include profile characteristics such as topsoil depth and color, pH, stoniness, soil texture, type of subsoil, electrical conductivity and other information necessary to fulfill the requirements of the Wind Erosion Equation (WEE) and Universal Soil Loss Equation (USLE) (Alberta Agriculture 1990). Other necessary soils information includes location and distribution of soils, location of salinity, erosion and other "important soil properties" necessary for farmers to make management decisions (Alberta Agriculture 1990).

The soils information required for assessing the extent, degree and potential of land to degrade is listed in Table 4. For example, quantitative and qualitative assessment of the degree and extent of wind and water erosion of soils can be made if soil texture, slope length and steepness, organic matter content, landform description, soil structure, soil drainage, soil classification (soil series), distribution of soils, location and extent of erosion and stoniness information is provided. Some soils information can be used for more than

Table 4. Soils information required for land degradation assessment

	Type of land degradation					
Soil property or variable	Wind erosion	Water erosion	Soil salinity	Soil acidification	Organic matter loss	Soil compaction
Landform	x	x	x		x	
Slope length		x				
% slope	x	x	x			
Slope position (soils)			x		x	
Parent materials type	x	x	x	x		x
Distribution of soils	x	x	x	x	x	x
Stoniness		x				
Land use	x	x	x	x	x	x
Drainage	x	x	x			x
Color	x	x	x		x	
Soil series	x	x	x	x	x	x
Soil classification	x	x	x	x	x	x
Topsoil depth	x	x			x	
Type of subsoil			x			x
Soil structure	x	x				x
Texture	x	x	x	x		x
pH	x	x		x		
Electrical conductivity			x			
Exchangeable cations (cmol kg $^{-1}$)			x			x
Soluble cations (mmol l $^{-1}$)			x			x
% carbon					x	
CaC03 (eq.) %				x		
Cation exchange capacity			x	x	x	
Base saturation				x		

one type of degradation. For example, soil texture is important for assessing the potential for wind and water erosion, salinization, acidification and compaction of soils.

Quantitative or qualitative methods are used to derive estimates of land degradation. Quantitative methods, like the Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1965) and the Wind Erosion Equation (WEE) (Chepil and Woodruff 1963) are used to derive estimates of water and wind erosion. The information needed to fulfill the requirements of these equations may be obtained from existing data sources (soil survey reports) or collected in the field. Qualitative assessments (via field inspections) of land degradation are necessary because it is difficult to use algorithms to quantify some forms of degradation. Alberta Agriculture (1985, 1986, 1987, 1988) and Barlott et al. (1990) provided the methodology necessary for conducting visual assessments of the degree and extent of various types of degradation.

a) Water Erosion - Quantitative Assessment

The USLE is a quantitative method used to determine the water erosion potential of soils (Wischmeier and Smith 1965). It can be used to show farmers the effects that changes in farming practices have upon lowering soil erosion (Alberta Agriculture 1990). That is, implications of various farming practices can be demonstrated by changing the values of factors in the equations. The equation is also used to determine the contribution of individual factors to water erosion of soils and devise land use and management practices that would minimize soil loss. For example, the equation can be modified by replacing soil loss (A) with tolerable erosion level (T) to limit erosion loss to a predetermined level. In Alberta, Tajek, Pettapiece and Toogood (1985) suggested T values ranging from 1 to 6 tonnes per hectare depending upon soil type. The USLE combines six erosion factors into the following equation:

$$A = R_T K L S C P$$

where:

A = soil loss per unit area (average)
R_T = rainfall and snowmelt erosivity factor
K = soil erodibility factor
L = slope length
S = steepness factor
C = cropping-management factor
P = conservation practice factor

Tajek et al. (1985) computed soil loss potential (in tonnes/hectare/year) for Alberta soils (soil series and subgroups). Values for R, K, L, S and C variables were tabulated and used for determining the erosion potential of soils under various cropping practices. The P variable was not used in the calculation because practices such as contour tillage, mulching, terracing and so on were not in widespread use in Alberta in 1985. Tajek et al. (1985) suggested the following procedure for calculating A (potential soil loss) values:

1. Obtain the soil survey map for the area
2. Identify the soil series occurring on a given landscape and the length and steepness of slopes within the landscape (if the series is unknown, determine the texture and subgroup of the soil)
3. From the nomograph in Tajek et al. (1985) obtain the corresponding L, S value
4. Find the K value for the identified series. In the absence of soil series information, K values can be determined from a nomograph designed by Wischmeier, Johnson and Cross (1971). The soil properties required to determine K values are percent silt, percent sand, percent organic matter, type of soil structure and soil permeability
5. Determine the R_T factor using the isoerodent map
6. Select the C factor for the geographical area
7. Apply the values to the USLE and compute the potential soil loss.

b) Wind Erosion - Quantitative Assessment

Two wind erosion equations have been documented and used in Alberta. Alberta Agriculture (1985) used the WEE derived in the U.S.A. (Woodruff and Siddoway 1965). The WEE used by Alberta Agriculture (1985) is aimed at improving the understanding of factors which contribute to the understanding of wind erosion. The model uses five factors:

$$E = f(I\ K\ C\ L\ V)$$

where:

E = estimated soil loss (tonnes/hectare/year)

I = soil erodibility factor

K = soil surface roughness factor

C = climatic factor

L = unsheltered distance factor

V = vegetative factor

The I factor is the potential annual soil loss that would occur on level, smooth, bare and unprotected surfaces. It is a function of soil texture and structure. That is, soils with high clay contents tend to have more cloddy surfaces, therefore decreasing potential for soil erosion. Conversely, soils with high sand contents have single grained structure and have high potential for wind erosion.

The K factor is a measure of surface roughness caused by ridges and undulations on the soil surface. Ridged surfaces are less erosive than smooth surfaces.

The climatic factor (C) is derived from the average wind velocity and the precipitation and evaporation index for a geographic location. It is a function of soil moisture and wind speed. That is, wet soils are less susceptible to wind erosion and high wind speeds contribute to more erosive conditions on dry soils.

The unsheltered distance factor (L) is determined by subtracting the sheltered distance protected by a barrier on the windward side (height of barrier X 10) from the unsheltered distance across the field parallel to the direction of prevailing wind.

The vegetative cover factor (V) is the amount of crop residue left on the soil surface. Crop residue cover can be estimated by using the "rope" method. The method allows for easy estimation of percent residue cover that can be converted (using a nomograph) to amount of cover in kilograms/hectare. It entails dividing a rope into equal proportions, laying the rope perpendicular to the direction of tillage operation and observing at how many intervals a piece of trash occurs. Vegetative cover can also be estimated from residue production tables (Alberta Agriculture 1990).

Alberta Agriculture (1985) provided nomographs, tables and charts that allow farm conservation planners to estimate values for each of the above factors and determine the potential soil loss from farmed fields. This method is easier to use than the method described and used by Coote and Pettapiece (1989).

The second WEE used in Alberta was derived by Coote and Pettapiece (1989) was based on an unpublished model derived from Chepil (1945; 1956) and Chepil and Woodruff (1963). The model derived by Coote and Pettapiece (1989) is used for assessing the risk of wind erosion on bare, unprotected mineral soils during the months of April and May. The model combines six erosion factors into the following equation:

$$E = KC(V_*^2 - \gamma W^2)^{1.5}$$

where:

E = maximum instantaneous soil movement by wind (dimensionless)

K = surface roughness and aggregation factor (dimensionless)

C = factor representing soil resistance to movement by wind (dimensionless)

V_* = drag velocity of wind at the soil surface (cm/s)

γ = soil moisture shear resistance (dimensionless)

W = available moisture at the surface soil (m^3water/m^3soil)

Coote and Pettapiece (1989) estimated the K and C factors based upon the clay content of soils, V_* and W factors were calculated or interpolated from existing data sources and the gamma factor is a constant value for all soils. Coote and Pettapiece (1989) also provided values for estimates of wind erosion under different cropping practices. Based upon personal experience, this model is difficult to use and values for the factors are difficult to derive.

c) Water and Wind Erosion - Qualitative Assessment

The amount of water and wind erosion can be determined qualitatively using methods established by Alberta Agriculture (1985, 1986, 1988). These methods involve the visual inspection of erosion of soils on a parcel by parcel basis. Erosion assessment is made by traversing roads in an area and recording (on aerial photographs, topographic maps and field sheets) the location and severity of erosion (Alberta Agriculture 1985).

The severity of water and wind erosion is divided into four classes (Alberta Agriculture 1985). Indicators of water erosion include topsoil and subsoil mixing where the soil color in affected areas is different than in non-eroded areas, topsoil accumulation in toe slope and depression areas, and presence of rills or gullies. The visual indicators of wind erosion include topsoil and subsoil mixing, sandblasted emerging crops, accumulation of topsoil in ditches, depressions, along fences and vegetative barriers, appearance of subsoil on the surface of the land and a polished appearance of the land surface after an erosion event has taken place.

Three levels of visual surveys can be conducted to estimate and document the degree and extent of erosion and salinity (Alberta Agriculture 1985).

Level I surveys are preliminary and conducted in order to identify and quantify land degradation occurring within a municipality or county. These surveys are undertaken by local conservation specialists who either conduct field inspections or mail questionnaires to landowners who in turn conduct a visual assessment of degradation for the conservation specialist.

Level II surveys are initiated after areas that have been affected by erosion or salinity have been located. These surveys are detailed and record the extent and degree of present erosion and salinity on a parcel by parcel basis. Information is collected that allows for an assessment of the degree of degradation by the conservation specialist and provides the framework for subsequent planning of remedial action. These surveys are conducted by an agricultural fieldman, district agriculturalist or soils specialist, with assistance from the landowner.

Level III surveys are comprehensive and record the extent of past and current degradation and estimate potential for future degradation. The surveys are conducted by a skilled soils mapper with assistance from the landowner. The landowner provides a detailed description of his (or her) land management practices.

Soils information, required for compilation of these surveys, differs depending upon the level of detail required (Table 5). Level I surveys require regional data, whereas Level II and Level III surveys require site specific information.

d) Soil Salinity

The assessment of the degree and extent of salinity is based upon crop or vegetative growth on a parcel of land. In instances where there is no crop or vegetation, salts may be visible as white patches on the land surface. Alberta Agriculture (1985) divide salinity into five classes (Table 6).

In general assessments of salinity are made using existing data or by collection of additional data in the field. The surveys are conducted by traversing roads or fields by some mode of transport. Aerial photographs and soil analysis can be used to verify or supplement field inspections. For example, aerial photographs taken during the spring and fall can be used to supplement field inspections that are made when crop growth is not indicative of high levels of salinity. The soils information collected varies depending upon the level or intensity of survey (Table 5). Level I or municipal surveys require land use information,

Table 5. Soils information required at different levels of survey for erosion and salinity (Alberta Agriculture 1985)

	Water erosion			Wind erosion			Soil salinity		
Type of information	Level I	Level II	Level III	Level I	Level II	Level III	Level I	Level II	Level III*
Land use	x	x	x	x	x	x	x	x	
Soil deposition	x	x	x	x	x	x			
Presence of erosion or degradation	x	x	x	x	x	x	x	x	
Map unit			x			x			
Map sheet			x			x			
Soil zone			x			x			
Subgroup			x					x	
Type of parent material			x					x	
Texture of parent material			x						
Soil series								x	
Texture of topsoil and subsoil			x			x			
Structure of topsoil and subsoil			x						
Horizon thickness			x						
% slope			x						
Slope length			x						
Slope position							x		
pH						x			
$CaCO_3$ (eq) %						x			
Drainage							x		

* Intensive soil mapping is required.

Table 6. Salinity classification (Alberta Agriculture 1985)

Class	Degree of Salinity	EC (mS/cm)*	Description
1S	Negligible	0-2	Salinity affects negligible
2S	Slight	2-4	Yields of sensitive crops reduced
3S	Moderate	4-8	Yields of most crops reduced
4S	Severe	8-16	Only tolerant crops productive
5S	Extreme	>16	Only tolerant plants survive

* milli Seimens/centimeter

notation of the presence of saline areas, slope position of salinity and drainage. Level II (detailed on-farm surveys) require land use, notation of the presence of salinity, soil zone, subgroup and series information. Level III (comprehensive) on-farm surveys require "intensive soil mapping" (Alberta Agriculture 1985).

Alberta Agriculture (1992a) suggested that having a soil survey of the area enables a farm conservation planner to make inferences about hydrological processes that may contribute to salinity. Knowing the type of soil present provides information on whether the water movement is upward or downward. For example Luvic Gleysols (in depressions) indicate water recharge, whereas Orthic Gleysols (in depressions) indicate groundwater discharge. Useful soils information for salinity assessment includes depths to soluble salts, carbonates, soil color and depth to mottles.

Quantitative evaluation of the degree of salinity is made by the determination of electrical conductivity of soil samples in the laboratory (direct method) or with the use of an inductive electromagnetic soil conductivity meter (EM31 or EM38) to measure electrical conductivity (indirect method) (Alberta Agriculture 1988, 1992a).

e) Soil Acidification Assessment

Holowaychuk and Fessenden (1987) provided criteria for evaluation of the sensitivity of mineral soils to acidic inputs. The overall sensitivity rating of soils to acid deposition is based upon the sensitivity of soils to base loss, acidification and solubilization of aluminum. Ratings were based upon characteristics and properties of the topsoil layer (Ap horizon) (Table 7).

Sensitivity to base loss refers to the loss of basic cations from the soil. Base loss is caused by the displacement of basic cations (Ca^{+2}, Mg^{+2} and K^{+}) with H^{+} and the leaching of the displaced cations through the soil profile. Base loss is related to the cation exchange capacity (CEC) and pH of the soil. That is, the lower the pH and CEC, the more sensitive the soil is to base loss.

Sensitivity to acidification is a measure of the change in pH that a soil would experience relative to an addition of acid. It is a function of the cation exchange capacity (CEC) and the pH. Cation exchange capacity is a measure of the amount of exchangeable cations that a soil can adsorb and is related to the mineral and organic content of the soil. Therefore, in the absence of laboratory data, CEC can be estimated if soil texture and organic matter content are known. Soils with a high organic matter and clay content tend to have a high CEC, a high buffering capacity and a low sensitivity to acidification (Holowaychuk and Fessenden 1987). The pH influences the buffering capacity of the soils. Holowaychuk and Fessenden (1987) stated that soils with pH of 3.5 to 5.5 or 6.5 or greater are well buffered. Soils in the pH range 5.0 to 6.5 are less well buffered and consequently will be more susceptible to acidification.

Sensitivity to solubilization of aluminum is important because at high levels of concentration, aluminum is toxic to growth of some plant species. Generally, as pH decreases, aluminum toxicity increases.

More quantitative assessment of soil tolerance to acidic input can be obtained by application of the model derived by Bloom and Grigal (1985). The model is semi-empirical and was developed for the estimation of the long term effects of acidic deposition (Abboud and Turchenek 1990). Changes in soil reaction, base status and soluble aluminum (over time) can be predicted from the model. The soils information necessary for input into the model is CEC, base saturation and pH.

Table 7. Criteria for rating the sensitivity of mineral soils to acidification (Holowaychuk and Fessenden 1987)

CEC	pH	Sensitivity to:			Overall Sensitivity
		Base loss	Acidification	Aluminum solubilization	
< 6	< 4.6	H	L	H	H
	4.6 - 5.0	H	L	H	H
	5.1 - 5.5	H	M	H	H
	5.6 - 6.0	H	H	M	H
	6.1 - 6.5	H	H	L	H
	> 6.5	L	L	L	L
6 - 15	< 4.6	H	L	H	H
	4.6 - 5.0	M	L	H	M
	5.1 - 5.5	M	L - M	M	M
	5.6 - 6 0	M	L - M	L - M	M
	> 6.0	L	L	L	L
> 15	< 4.6	H	L	H	H
	4.6 - 5.0	M	L	H	M
	5.1 - 5.5	M	L	M	M
	5.6 - 6.0	L	L - M	L - M	L
	> 6.0	L	L	L	L

Legend: H = high M = medium L = low

e) Organic Matter Loss Assessment

Two methods of assessment of organic matter content of soils are used by Alberta Agriculture (1987). Quantitative assessment of organic matter is made in the laboratory using either the induction, dry combustion or wet combustion method. Each method provides data on the organic carbon content of a soil. In order to obtain organic matter content, the organic carbon content is multiplied by 1.724 (Alberta Agriculture 1987). Qualitative assessment of organic matter content is made in the field by observing topsoil thickness and soil color. Comparison of topsoil thickness in uncultivated versus cultivated fields provides an assessment of the amount of erosion that has occurred. Soil color provides an assessment of the quality and quantity of topsoil. It is one parameter used for the identification of soil horizons (estimation of quantity). That is, the lower the soil color **value** and **chroma**, the more organic matter it contains (estimation of quality).

f) Soil Compaction Assessment

The degree of soil compaction is dependent upon soil factors such as soil type, soil conditions, type of equipment used and traffic density (Cannon and Landsburg 1990; Naeth, White, Chanasyk, Macyk, Powter and Thacker 1991). The most understood and widely used physical property used by field extension personnel to assess compaction is bulk density (Naeth et al. 1991). Bulk density is a measure of the mass of dry soil per unit volume. It is measured by using radiation (neutron probes) or collecting core samples of a know volume (Cannon and Landsburg 1990; Naeth et al. 1991). Qualitative assessments of soil compaction can be made by classification of soils (to the series level), observation of soil structure and plant growth. Observable soil features that are indicative of compaction are the presence of plow pans or naturally formed soil horizons (**Bnt** or **Bt**).

2.2.3 Municipal Conservation Planning

The goal of compiling a municipal conservation plan is to provide direction for soil and water conservation programs and initiatives, that will be undertaken in a county. The objectives for compiling plans will differ depending upon the municipality. Barlott et al. (1990) suggested a table of contents for a municipal conservation plan (Figure 2).

For the purpose of this research the step with the greatest significance is step 3. That is, the documentation of land, soil and water resources within a municipality. Barlott et al. (1990) asserted that some interpretation of soil survey information is necessary for county level planning. They suggested that a land systems map be made from the existing soil survey report (of the county). The purpose of the map is to divide the county into broad regions that have similar soil, landform and land use characteristics and have the same conservation concerns. The land systems map is made by grouping similar soil-topography-landform areas on an overlay of the soil survey map, identifying typical agricultural land uses that relate to the land systems, and rating the soil landscapes for susceptibility to land degradation. The soils information required to compile this type of map is soil classification, texture, parent material and topography (Table 4) (Barlott et al. 1990). In addition to soils information, current land use data are essential for compiling municipal conservation plans. For example, it is essential to know if soils that are highly susceptible to erosion are cultivated or are in pasture. If cultivated then these areas would be targeted for further examination, whereas if these soils were under pasture then they would not present an erosion concern.

Municipality No. 1111

Soil and Water Conservation Plan

1990 - 1994

Table of Contents

1. Introduction and Overview (include municipal map)
2. Nature of Agriculture in Municipality No. 1111
3. Land, Soil and Water Resources in Municipality No. 111
   - 3.1 Soil Landscape Features
   - 3.2 Surface Water Resources
   - 3.3 Land Use and Cover
4. Conservation Problems in Municipality No. 1111
   - 4.1 Wind Erosion
   - 4.2 Water Erosion
   - 4.3 Salinity
   - 4.4 On-Farm Water Management
   - 4.5 Other (e.g. organic matter, rangeland and compaction)
5. Objectives
   - 5.1 Long-Term Objectives
   - 5.2 Short-Term Objectives (may be developed and listed by problem area)
6. Projects and Activities (usually presented for each short-term objective)
7. Budget and Cost-Share Arrangement (usually presented for each project and activity with a summary at the end)

Figure 2. A sample table of contents for a municipal conservation plan (from Barlott, Knapik and Voth 1990)

Conservation issues are addressed upon completion of the assessment of land resources of the county and the documentation of areas susceptible to degradation. Then, conservation priorities are assessed, long and short term conservation solutions are proposed and budgeting and scheduling of activities is undertaken.

2.2.4 Summary

In Alberta, soils information is essential for compiling conservation plans. The soils information required for compilation of conservation plans varies depending upon the land degradation concern (Table 4) and the type of plan (on-farm or municipal) (Table 5). On-farm plans require detailed soils information at map scales larger than 1:15,000. Municipal conservation plans require generalized soils information at scales smaller than 1:50,000.

2.3 Soil Survey in Alberta

Soil survey reports and maps are the principle source of soils information used by conservation planners to compile conservation plans. Since the initiation of soil mapping in Alberta, 63 reconnaissance soil surveys (scales ranging from 1:50 000 to 1:760 320) have been conducted by the Alberta Research Council, Agriculture Canada and the University of Alberta (Agriculture Canada 1990) (Figure 3). The soil surveys have been conducted by different pedologists, using different mapping concepts and soil classification systems. The result has been the production of a variety of soil reports and maps. In order for the information to be used effectively it is important to know what information is available from different vintage soil surveys and what their use limitations are for soil conservation planning.

For approximately the last 20 years soil mapping was conducted at a scale of 1:50 000 using 1:30 000 scale black and white aerial photographs. Initial stereoscopic examination of the photos was done in the office followed by a general field reconnaissance. This was followed by more intensive photo interpretation and ground truthing in the field. During mapping all roads and trails in a study area were traversed. In areas where vehicle access was impossible traverses were made on foot. Soils were examined to a 1 metre depth using a shovel and hand auger. Soil inspections were made at an intensity of approximately one recorded observation every 0.8 kilometres. Observations were supplemented by information obtained from several digs at each inspection site to determine the local distribution and variability of different soils.

Information gathered at each field inspection included landscape characteristics such as degree of slope (percent), landform description and slope position of field inspection. Soils information collected included description of soil classification and **profile** characteristics (**horizon** type, texture, structure, depth and thickness of horizons). Soil samples of representative pedons of soil series were collected.

Soils were classified using the Canadian System of Soil Classification (Agriculture Canada Expert Committee on Soil Survey 1987). The system is hierarchical and divides soils into five taxa; **order; great group; subgroup; family** and **series.** The system has nine orders; 29 great groups and 193 subgroups (Appendix 3). In Alberta there are approximately 650 defined soil series (Alberta Soil Series Working Group 1992). Series are differentiated on the basis of detailed features of the **pedon.** The pedon "is a real unit of soil in the landscape. Pedons belonging to a series have similar kinds and arrangements of horizons whose color, texture, structure, consistence, thickness, reaction and composition fall within a very narrow range" (Agriculture Canada Expert Committee on Soil Survey 1987). A series is a conceptual class, in the Canadian system of soil classification, based upon the generalization of properties of many pedons.

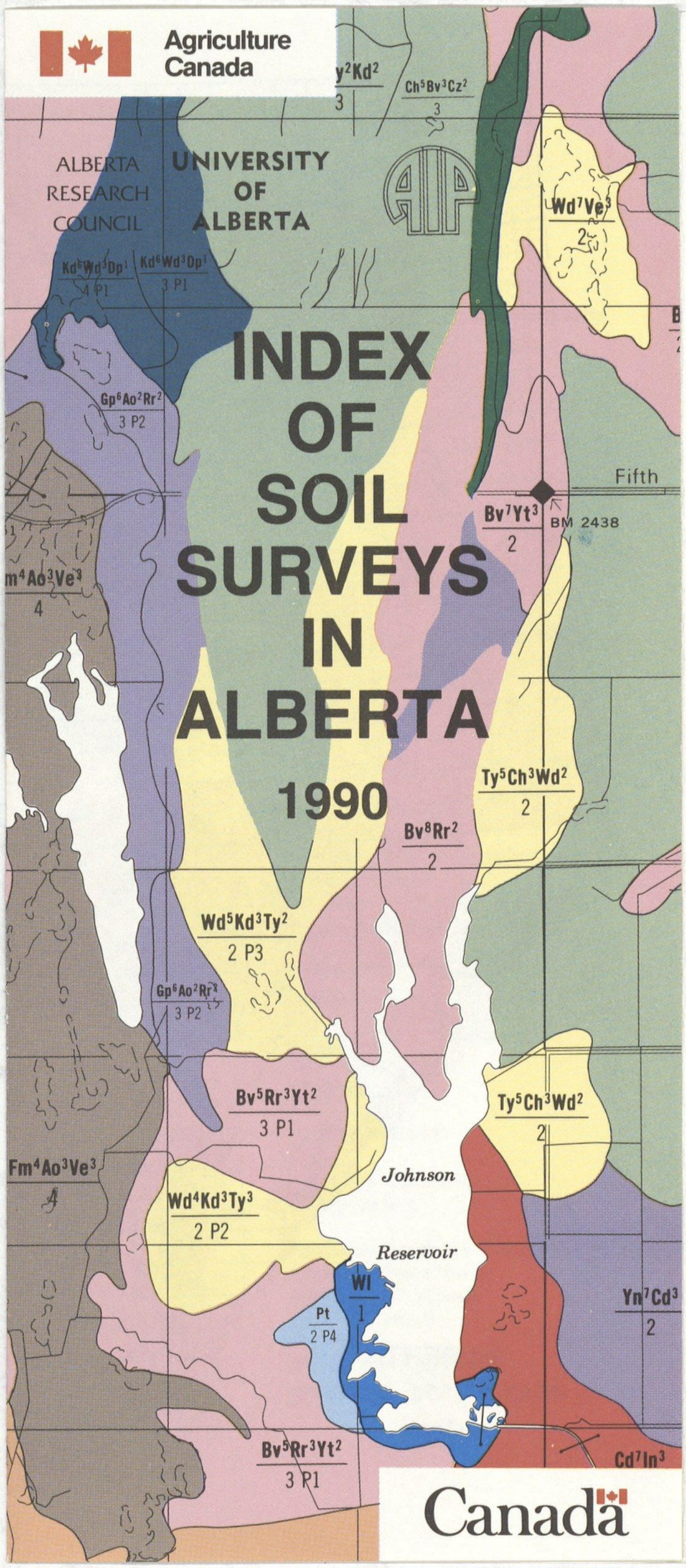
2.3.1 History

Soil surveys in Alberta were initiated in 1920 by Dr. Frank A. Wyatt of the Department of Soils at the University of Alberta (Bowser 1965). The purpose of the first survey was to delineate the province into broad soil - climatic zones. This project was completed in 1925 (Bowser 1965; McKeague and Stobbe 1978) and the map has since been revised and updated (Alberta Institute of Pedology 1967). It is compiled at a scale of 1:3 000 000.

The second soil survey was started by F.A. Wyatt and J.L. Doughty (Wyatt and Newton 1925) in response to government concerns related to the threat of wind erosion of soils and abandonment of farmsteads in southern Alberta. This survey was initiated in 1921 in the Macleod area and completed in 1925 (Wyatt and Newton 1925; Bowser 1965; McKeague and Stobbe 1978). The final report and map identified differences in soil texture across the surveyed area (Figure 4). Texture was denoted on maps by an abbreviation (for example, F.S.L. translated into fine sandy loam texture) associated with a specific color. Topography was denoted by cross hatching on the map. Some soil sampling was conducted to characterize the chemical composition of soils (Wyatt and Newton 1925; McKeague and Stobbe 1978). Samples were collected by depth rather than by horizon, because the concepts of soil genesis and classification had not yet evolved. Analyses conducted on soil samples included determination of nitrogen, phosphorous, calcium, magnesium, potassium and calcium carbonate content (Table 8) (Wyatt and Newton 1925). Soil interpretations were provided in the final report and briefly addressed organic matter loss and its effects on soil fertility, soil salinity, irrigation, summerfallow and wind erosion issues (Table 9). During the period 1922 to 1926, over 2.8 million hectares were surveyed in the southern portion of the province (Wyatt and Newton 1926, 1927; Bowser 1965; McKeague and Stobbe 1978). The work was financed by the University of Alberta and the provincial Department of Agriculture.

In 1925 C.F. Marbutt, the head of soil classification in the United States, visited Alberta for the first time. The visit was significant because interest was stimulated in the study of the complete profile and in the importance of the type and arrangement of horizons within the profile (Bowser 1965). In 1927, as part of the field tours of the first world soil science congress, Marbutt as well as a number of world renowned soil scientists visited Alberta (Bowser 1965). These two visits resulted in an exchange of ideas which brought forward additional criteria used for mapping soils. Previously, soils were separated only on the basis of texture. Subsequent to the visits additional profile characteristics were recognized (type of horizon, horizon thickness and color) and differentiation, sampling and chemical analysis of horizons was initiated (Bowser 1965).

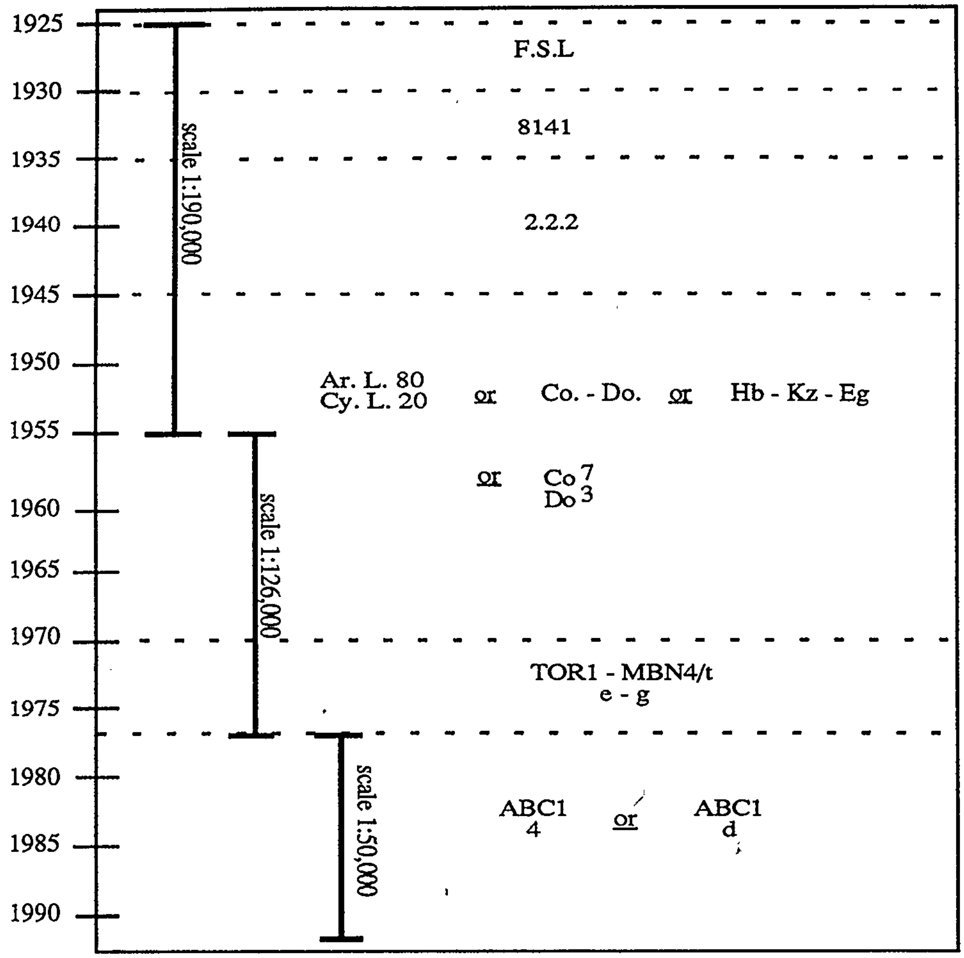
During this period (1925 - 1927) work began on the St. Ann map sheet (Wyatt et al. 1930). The survey represented a step forward in mapping techniques because it incorporated the concepts of the soil profile and soil series. The classification system used divided geographic areas into "soil belts" on the basis of differences in the soil profile. Soil belts were divided into series on the basis of local profile differences and the series were divided into soil classes on the basis of the texture of the A horizon, topography, stoniness and other factors (Wyatt et al. 1930). This system of classification combined genetic features and desirability for cultivation (Bowser 1965). The soil classes were shown in different colors. Each class was denoted by a number that indicated the class, series and belt to which the soil belonged (Figure 4). For example, the symbol 8141 denoted a loam textured soil found in the wooded Podsolic soil belt. No interpretive information was provided in the St. Ann sheet soil survey. Analyses conducted on samples included determination of percent nitrogen, phosphorous, calcium, magnesium, calcium carbonate content and pH (Table 8).



EXPLORATORY SOIL SURVEYS*

Report Number	Area	Scale	Published
58-1*	Exploratory Soil Survey - 84C(E½), 84B, 84A, 74D	1:760,320	1958
59-1*	Exploratory Soil Survey - 84D(N½), 84E, 84F, 84G	1:760,320	1958
60-1*	Exploratory Soil Survey - 84J, 84K, 84L	1:760,320	1960
61-1*	Exploratory Soil Survey - 84M, 84N, 84O	1:660,320	1961
62-1*	Exploratory Soil Survey - 84P, 84I, 84H	1:760,320	1962
63-1*	Exploratory Soil Survey - 74M, 74L, 74E, 73L(N½)	1:760,320	1963
64-1*	Exploratory Soil Survey - 83O, 83P, 73M	1:760,320	1964
64-2*	Exploratory Soil Survey - 83L, 83K, 83F, 83J	1:760,320	1964
	RECONNAISSANCE SURVEYS		
2	Medicine Hat	1:190,080	1926
8	Sullivan Lake	1:190,080	1938
9	Lethbridge and Pincher Creek	1:190,080	1939
10	Milk River	1:190,080	1941
11	Blackfoot and Calgary	1:190,080	1942,1960
12	Banff-Rosebud	1:190,080	1943
13	Wainwright and Vermilion	1:190,080	1944
14	Peace Hills	1:190,080	1947,1977
15	Rycroft and Watino	1:190,080	1950,1974
16	Red Deer	1:190,080	1951,1976
17	High Prairie and McLennan	1:190,080	1952,1976
18	Grande Prairie and Sturgeon Lake	1:190,080	1956
20	Beaverlodge-Blueberry Mountain	1:190,080	1961
21	Edmonton	1:126,720	1962,1974
22	Eastern Portion (SMRD)	1:63,360	1963
23	Hines Creek and Cherry Point	1:190,080	1965
24	Buck Lake and Wabamun Lake	1:126,720	1968
25	Grimshaw and Notikewin	1:190,080	1970
26	Hotchkiss and Keg River	1:190,080	1970
27	Whitecourt and Barrhead	1:126,720	1969
28	Chip Lake	1:126,720	1971
29	Tawatinaw	1:126,720	1973
30	Mt. Watt and Fort Vermilion	1:190,080	1972
31	Edson and Hinton	1:126,720	1973
34	Sand River	1:126,720	1975
36	Oyen	1:126,720	1977
39	Wapiti	1:126,720	1981
40	Brazeau Dam	1:126,720	1981
42	AQSERP	1:126,720	1982
43*	Iosegun	1:126,720	1983
72L	Medicine Hat	1:126,720	1990
82H	Lethbridge (NW) map only	1:126,720	1977
82H	Lethbridge (NE) map only	1:126,720	1980
82I	Gleichen (SE) map only	1:126,720	in prep.
82I	Gleichen (SW) map only	1:126,720	in prep.
	DETAILED RECONNAISSANCE SURVEYS		
31a	North Saskatchewan River Valley	1:50,000	1972
33	Waterton Lakes National Park	1:15,840	1976
35	County of Two Hills	1:30,000	1986
M-2	Fort McMurray Region	1:63,360	1975
38	Elk Island National Park	1:25,000	1977
41	County of Newell	1:63,360	1983
44	Banff and Jasper National Park	1:50,000	1982
45*	Calgary Region	1:50,000	1987
46	County of Warner	1:50,000	1986
47*	County of Beaver	1:50,000	
48	M.D. of Cardston	1:50,000	1990
49*	County of Paintearth	1:50,000	1988
50	Pincher Creek/Crowsnest Pass	1:50,000	in prep
51	County of Flagstaff	1:50,000	1988
52	County of St. Paul	1:50,000	1990
53	M.D. of Rocky View	1:50,000	in progress
54	County of Forty Mile	1:50,000	in progress

Figure 3. Index of soil surveys in Alberta (Agriculture Canada 1990)



Legend:

F.S.L. fine sandy loam soils

8141 loam textured soil found in wooded Podsolic soil belt

2.2.2 dark brown, zonally normal, non-saline, well drained soil developed on transported material that contains stones

Co - Do Codesa (Co) Orthic Gray Luvisol on loamy sand and silt loam materials; Donelly (Do) Gleyed Solonetzic Gray Luvisol on lacustro-till parent materials

TOR1 - MBN4/t Orthic Gray Luvisols developed on moderately fine to fine textured unconsolidated mudstone and colluvium are dominant and Brunisolic Gray Luvisols developed on the same materials occur in significant amounts (TOR1 association); and Orthic Gray Luvisols developed on medium to moderately fine texture till overlying bedrock are dominant and Brunisolic Gray Luvisols developed on the same material are present in significant amounts (MBN4/t association). Slopes range from 15 to 60 percent.

ABC1/4 Orthic Gray Luvisols developed on till (ABC). Slopes range from 6 to 9 percent.

Figure 4. Examples of soil map unit symbols used in soil surveys (1925 - 1992)

Table 8. Chemical and physical analyses conducted on soil samples in Alberta soil survey reports (1925 - 1992)

Analysis	Time Period 1925 -1929	1930 - 1935	1936 - 1945	1946 - 1955	1956 - 1975	1976 - 1992
Nitrogen (%)	x	x	x	x	x	x
Phosphorous (%)	x	x	x	x		
Calcium (%)	x	x	x	x		
Magnesium (%)	x	x	x	x		
Potassium (%)	x	x	x	x		
$CaCO_3$ (eq) %	x	x	x	x	x	x
pH		x	x	x	x	x
Soluble salts (%)			x	x		
% sand				x	x	x
% silt				x	x	x
% clay				x	x	x
Organic carbon					x	x
Exchangeable cations (cmol/kg)					x	x
Base saturation					x	x
CEC					x	x
EC					x	x
Soluble cations (mmol/l)						x

In 1928, the Alberta Research Council (ARC) began soil surveying in response to demand for homestead lands in the Peace River region of Alberta (Bowser 1965). The objective of the mapping was to identify and classify lands for homesteading and farming. Soils were divided into six categories: parkland soils, three classes of wooded soils, organic soils and eroded soils (Wyatt and Younge 1930; Wyatt 1935). These maps were thematic and provided information on the costs of clearing land, the potential commercial value of timber on land and the suitability of lands for arable agriculture. Mapping was conducted on approximately 8.1 million hectares, at a scale of 1:250 000 and was completed in three years. Completion of the survey marked the end of soil inventory activities by the Research Council for the next 17 years.

Table 9. Soil interpretations provided in Alberta soil survey reports (1925 - 1992)

	Time Period					
Interpretation	1925 - 1929	1930 - 1935	1936 - 1945	1946 - 1955	1956 - 1975	1976 - 1992
Organic matter loss	x*					
Soil salinity	x*					
Irrigation	x*					
Summerfallow	x*					
Wind erosion	x*					
Capability for arable agriculture**			x	x	x	x
Available water supplies				x*	x*	
Soil conservation				x*	x*	
Productivity ratings					x*	
Forestry					x*	
Wildlife					x*	
Engineering					x*	x***
Deep plowing and ripping						x***
Water erosion						x***

* general descriptions

** rating systems differ from time period to time period

*** not all soil surveys produced during this period contain this interpretive information

The onset of the great depression resulted in the termination of all soil survey field activities from 1932 to 1935. In 1935, soil mapping was revived as a result of the passing of the Prairie Farm Rehabilitation Act in which soils information was deemed necessary and basic for reclamation and rehabilitation of lands. The PFRA provided funding necessary to conduct soil surveying to the University of Alberta and the Experimental Farms Service of the Canada Department of Agriculture. Approximately 8.1 million hectares, lying within the Palliser triangle, were surveyed in the ten year period 1935 to 1945 (Bowser 1965). The soil maps produced had open legends. Maps with open legends have a unique symbol within each map delineation and there is no limitation on the number of symbols that may be used (Mapping Systems Working Group 1981). The result of using open legends was that a large amount of different polygon labels were used. The soils were mapped at

1:190 000 using a three number code which had evolved during the St. Ann survey. The code characterized soil zone, type and mode of deposition of parent material and soil profile development (Figure 4). For example the code 2.2.2 was representative of dark brown, zonally normal, non-saline, well drained soils developed on transported material that contained glacial stones. Soil texture was represented on the maps by different colors and topography by cross hatching. The position of the landscape that the soils occupied was not documented (Wyatt, Newton, Bowser and Odynsky 1937, 1938, 1939, 1941, 1942, 1943, 1944).

Soil samples were collected and analyzed to determine percent nitrogen, phosphorous, calcium, magnesium and calcium carbonate content, pH and soluble salts on a percentage basis (HCO_3, CO_3, Cl, SO_4, Ca, Mg and Na) (Table 8). Soil interpretations included a discussion on the effects that different farming practices have upon soils and an arable land rating (Table 9). The first soils reports produced during this period (Wyatt et al. 1938) divided soils into five classes for arable agriculture. Later reports divided soils into eight classes for arable agriculture, with class one soils being fair to poor for pasture and class eight soils being very good to excellent for arable agriculture (Wyatt et al. 1943, 1944).

In 1945, representatives from all survey units in Canada met for the first time. The purpose of this meeting was to exchange ideas, unify survey and classification methods and evaluate the work that had been completed to that time (Bowser 1965; McKeague and Stobbe 1978). One of the highlights of the meeting was a proposal for a field classification system for soils in Canada. The proposed system had seven categories:

1. Soil region
2. Soil zone
3. Soil sub-zone
4. Association or catena
5. Soil series, members or associates
6. Soil class or type
7. Soil phase

The classes within categories were real bodies in the landscape that included all soil variability within an area. The classification system was not a scientific or taxonomic one in which the classes had a defined range of properties (McKeague and Stobbe 1978). Rather it was intended to be used for classifying and naming soil mapping units in the field. The soil series continued to be the basic unit of classification.

The Alberta Research Council re-entered soil survey in 1945 and continued with work in the northern portion of the province. The purpose was to update work completed between 1928 and 1931 and continue the evaluation of lands relative to their suitability for arable agriculture (Bowser 1965). Soils were mapped at 1:190 000 using soil series names listed according to their predominance in the map areas that they occupied (Figure 4). Soils were denoted by two letter abbreviation and by color; and topography by cross hatched pattern. For example the symbol Hb-Kz-Eg delineated an area that contained Hubalta (Hb) Orthic Gray Luvisol on till; Kenzie (Kz) Terric Mesisol on organic materials derived from mosses; and Eaglesham (Eg) Terric Mesisol derived from sedges and coarse grasses. Topography was divided into six slope classes. Series recognition was based on soil zone, parent material, surface texture, drainage, landscape position and some profile characteristics.

Physical and chemical analyses were conducted on samples that had been collected on a series basis. Analyses included determination of percent sand, silt, clay, nitrogen, phosphorous, calcium, magnesium and calcium carbonate content, pH, and soluble salts on a percentage basis (HCO_3, CO_3, Cl, SO_4, Ca, Mg and Na) (Table 8). Soil interpretations addressed agricultural use of each mapped series and a general description of land development concerns, available water supplies and soil conservation for the entire mapped area (Table 9) (Bowser, Erdman, Wyatt and Newton 1947; Odynsky and Newton 1950; Bowser, Peters and Newton 1951; Odynsky, Wynnyk and Newton 1952, 1956). Reports produced between 1951 and 1956 also provided an arable land rating for each mapped series.

In 1955, the first Canadian taxonomic system of soil classification was outlined (McKeague and Stobbe 1978). This was a significant period for soil mapping because the definition of soil series was redefined. Rather than being a field entity, the series became part of a taxonomic hierarchy (Agriculture Canada Expert Committee on Soil Survey 1987). For the next 20 years the majority of soil surveys were conducted at 1:126 000 using uncontrolled legends. In an uncontrolled legend, combinations of series are not listed or described and more than one line of the legend has to be consulted to gain information about delineations that contain more than one soil (Mapping Systems Working Group (MSWG) 1981). Soil series were listed according to their predominance in the map areas that they occupied (Figure 4). They were denoted by a two or three letter abbreviation and by color. For example the symbol Co^7 - Do^3 represented an area that contained 70 percent Codesa (Co) Orthic Gray Luvisol on loamy sand and silt loam materials; and 30 percent Donnelly (Do) Gleyed Solonetzic Gray Luvisol on lacustro-till parent materials. Topography was divided into six slope classes and denoted by cross hatched pattern.

Series were recognized on the basis of horizons having similar differentiating characteristics and arrangement in the soil profile. In addition, series were defined based upon external features significant to their use such as topography, stoniness, salinity and so on. Physical and chemical analyses were conducted on selected soil series. Analyses included percent sand, silt, clay, nitrogen, organic carbon and calcium carbonate content; exchangeable cations, base saturation and cation exchange capacity; electrical conductivity and pH (Table 8). Soil interpretations addressed the agricultural capability of soils (usually a separate map from the soils map) and brief general descriptions of land development concerns, available water supplies, soil management and conservation, productivity ratings, forestry, wildlife and engineering were provided for the mapped area (Table 9) (Peters and Bowser 1960; Odynsky, Lindsay, Reeder and Wynnyk 1961; Twardy and Lindsay 1971).

The Soil Survey and Land Evaluation of the Hinton - Edson Area (Dumanski, Macyk, Veauvy and Lindsay 1972), conducted during the late 1960s, represented a significant departure from the way that soil survey information was displayed. The soil map had an uncontrolled legend in which soil associations were used to characterize landscapes. The soil association was defined as a group of closely interrelated soil series developed on similar parent materials and under essentially the same climate (Dumanski et al. 1972). The soil associations were a combination of map units. Therefore, it was possible for a single map delineation to contain as many as nine named soil series; however, proportions of the series which occupied a single map unit were not defined (Figure 4). Soils were denoted by a three to 12 alpha and numeric abbreviation (numerator) associated with a color and topography by an alphabetical descriptor for slope class (denominator). The soil chemical and physical analyses conducted were similar to those conducted in soil surveys in the previous 15 years.

For example the symbol TOR1-MBN4/t /e-g was representative of an area in which Orthic Gray Luvisols developed on moderately fine to fine textured unconsolidated mudstone and colluvium are dominant and Brunisolic Gray Luvisols developed on the same materials occur in significant amounts (TOR1 association); and Orthic Gray Luvisols developed on medium to moderately fine texture till overlying bedrock are dominant and Brunisolic Gray Luvisols developed on the same material are present in significant amounts (MBN4/t association) (Twardy and Corns 1980). Slopes range from 15 to 60 percent (e-g). Proportions of various soils are difficult to estimate because confusion exists as to whether the second association is present in the same proportions as the first. For example, if the TOR1 and MBN4 associations are present in equal amounts one could assume that Orthic Gray Luvisols developed on till and mudstone are dominant and Brunisolic Gray Luvisols developed on till and mudstone are present in significant amounts. If, however, the second soil association is present in lesser amounts than the first soil association, proportions of soils are very difficult to estimate.

During the late 1960s the Alberta soil survey also began investigating what mapping scale would be appropriate for the re-survey of the province. The County of Two Hills was mapped at a scale of 1:31 000 to determine if this scale was suitable and feasible (Macyk et al. 1985). This scale was deemed inappropriate because of the time and effort required to conduct the survey (Agriculture Canada Research Branch 1975). As a result, the decision was made to map Alberta municipalities at 1:50 000. This scale was appropriate because soil information was maximized, while the resource requirements to complete surveys were minimized.

During the mid 1980s surveys became a cooperative effort between Agriculture Canada and the Alberta Research Council. The Federal soil survey unit continued to map soils (independent of the ARC) in the southern portion of the province until 1989. In 1989, all operational field mapping was discontinued by the Federal unit. Agriculture Canada is currently involved in the standardization of soil names, definition of soil series, soil map correlation and redefinition of soil mapping systems and the Canadian system of soil classification. The Alberta Research Council continues to map counties at 1:50 000. At present, the decision on which county is mapped is made by the Alberta Coordinating Committee for Soil and Land Inventory (ACCSLI). To date eleven counties or municipalities have been completed or are currently being surveyed at 1:50 000 (Figure 3) (Agriculture Canada 1990).

Presently, soil map legends are closed and use a combination of a three or four letter soil series code, a numeric modifier to characterize map units (numerator) and an alpha or numeric indicator of slope class (denominator) (Figure 4). Closed legends have all soils, combinations of soils, phases and topography listed and described in the legend. For example, the symbol ABC1/4 is representative of a hummocky area (6 to 9 percent slopes) that contains mostly (60 to 90 percent) Orthic Gray Luvisols developed on till (ABC soils)

(Brierley, Andriashek and Nikiforuk in prep.). Soil maps are displayed on aerial photograph mosaics or black line topographic bases and the most recent surveys are available in electronic or digital form.

Physical and chemical analyses conducted on soils included percent sand, silt, clay, nitrogen, organic carbon and calcium carbonate content; exchangeable cations, soluble cations (in areas that have solonetzic soils), base saturation and cation exchange capacity; electrical conductivity and pH (Table 8). Agricultural capability rating of soils (for each series in tabular form) is provided in all recent soil surveys. Engineering interpretations, suitability of soils for deep plowing and deep ripping (in areas that have large amounts of solonetzic soils) and more recently susceptibility of soils to water erosion are provided in only some of the most recent reports (MacMillan 1987; MacMillan, Nikiforuk and Rodvang 1988; Wells and Nikiforuk 1988) (Table 9).

2.3.2 Summary

There have been seven major developments in soil survey during the last 70 years. These developments influenced the type of soils information collected and documented in soil survey reports.

1. The initiation of soil surveys in 1921 resulted in the production of thematic or single factor maps. These maps reflect the level of understanding of soils which existed at the time.

2. The development, in 1926, of the soil series concept that included surface texture as well as other soil profile and landscape attributes. The soil series was established as the foundation of soil surveys and marked the initiation of soil surveys as we recognize them today.

3. The use of the three number map legend between 1935 to 1945 provided for the description of features such as the mode of deposition of parent materials, landform (topography), location of some surface features (blow-out pits) and soil zones (Black, Thin Black, Dark Brown and Brown). This was an open and generic approach to mapping and describing soils in the field.

4. The development of a field classification system, in 1945, was the beginning of the definition of present day soil series. During this period the use of the three number legend was discontinued and replaced by abbreviations of soil series names.

5. The development of a taxonomic system for soils in Canada, in 1955, formalized the mapping system and allowed the mapper to identify the link between conceptual ideas and taxonomic features. The creation of a taxonomic system also contributed to a focus on soil taxonomy in soil surveys for approximately the next 25 years. This emphasis created many problems for those responsible for compiling, mapping and correlating soil series information because taxonomic rules forced mappers to separate soils that had very similar field properties. The result was that many similar soils series were created that could not be easily recognized and separated in the field. Even more confusion was created because many of the similar soil series were not properly recorded or documented.

6. The use of soil associations during the 1970s was confusing and very difficult to understand for the pedologist and layman. However the use of soil associations eventually evolved into legend formats that are currently being used in soil survey.

7. The use of controlled and closed legends beginning in the late 1970s and continuing to present resulted in a systematized approach to mapping and legend development.

Some confusion exists as a result of the use of soil series as the basic unit for soil mapping. In the last 70 years the term soil series has had several meanings. During the 1920s the term referred to a land or field unit. It was analogous to a geological formation (Agriculture Canada Expert Committee on Soil Survey 1987). Between 1935 to 1945 the concept of soil series referred to a combination of soil zone, mode of deposition of parent material and profile variation (Wyatt et al. 1938). That is, series were a number code and not a named entity. Odynsky and Newton (1950) defined soil series as the individual soils which make up a soil catena. During this time a soil catena was defined as a group of soils developed on similar parent materials. The soil series were defined as a result of a number of local environmental factors which affect drainage, temperature, moisture relationships, vegetation and give rise to differences in color, depth and structure of the profile (Odynsky and Newton 1950); that is, the series was a field unit. During this time the series designation changed from a number to a name. After the development of a formalized soil classification system in 1955, the soil series became a taxonomic rather than a field unit. The series is presently defined as a conceptual entity that has defined limits. The link between the conceptual entity (soil series) and real bodies of soil is the pedon (Agriculture Canada Expert Committee on Soil Survey 1987). The pedon is the entity that is observed and described in the field.

Because the taxonomic system and the concept of the soil series have evolved over the last 70 years, some series established prior to the development of the present classification system include pedons that may belong to different subgroups, great groups or orders. For example, the Codesa soil series has been classified as an Orthic Gray Luvisol (Reeder and Odynsky 1965), a Cutanic Podzo Regosol (Lindsay, Odynsky, Peters and Bowser 1968) and an Eluviated (degraded) Eutric Brunisol (Kocaoglu 1975).

Other series were representative of a particular landscape position. Navarre (meadow) soils were found in depressions and classified as Orthic Humic Gleysols (Bowser, Kjearsgaard, Peters and Wells 1962). In contrast, Navarre soils found in upland positions were classified as Gleyed Black Chernozemic. Navarre (meadow) soils have been renamed and are now Haight soils.

2.3.3 Conclusion

The soils information provided in soil survey reports is inconsistent because of changes in classification and mapping techniques since the initiation of soil mapping in Alberta (Table 8 and 9). The appearance and level of detail presented in soil survey maps has also changed over time. As a result of these changes, soil survey reports and maps may be difficult to use, contain information that is not apparent to conservation planners and may not provide the detail or information necessary for on-farm conservation planning.

3.0 RESULTS OF QUESTIONNAIRE

This chapter presents data collected from 53 questionnaires that were answered by conservation planners during June and July, 1991. The objectives of the questionnaire were to verify the soil information needs of conservation planners as defined in the literature review, determine the preferred map scales and products of farm conservation planners and determine if farm conservation planners understood the terms used in soil survey reports. A pretest of the questionnaire was conducted in May, 1991 on 5 soil science professionals. Feedback was solicited and recommendations from various reviewers were incorporated into the questionnaire. The information recorded included categorical responses to questions as well as any additional comments that were offered by conservation planners. The questionnaire is presented in Appendix 2.

3.1 Working Knowledge of Soil Survey Reports

Respondents were asked to evaluate their working knowledge of the soil survey report that exists in their municipality or county. The purpose for asking the question was to determine if conservation planners were familiar with or had used the published soil survey report available for their county or municipality. The data indicated that 37 percent of the respondents had excellent or very good working knowledge, 31percent indicated they had a good working knowledge and 32 percent had fair or poor working knowledge of the soil survey report in their geographic area (Table 10). The proportion of conservation planners who had good to excellent working knowledge of soil survey reports decreased slightly (5 to 10 percent) when consideration was given to planners who, during the course of the questionnaire, contradicted themselves. That is, although they indicated that they had a good working knowledge, they made statements that indicated their lack of familiarity with soil survey reports. However, the majority of the conservation planners interviewed demonstrated that they did not overstate their knowledge, were aware of and used information contained in soil survey reports.

3.2 Courses and Workshops

Respondents were asked to document their educational soil science background. The purpose was to ascertain whether the conservation planners had taken soils courses at the university or college level, or at a minimum attended soils workshops and as a result been exposed to soils terminology. The data indicated that 88 percent of the respondents had taken university or college level soils courses and 12 percent had not taken any soils courses. Of the respondents who had taken soils courses, 17 percent had taken at least one soils course and 14 percent had taken two soils courses (Table 11). In total, 43 percent of the respondents had taken fewer than three soils courses. All of the conservation planners who had not taken a university or college level soil science course had attended a soil and water conservation short course (one week long) offered by Olds College (Olds College and Alberta Agriculture 1989). The data also indicated that 79 percent of the respondents had attended soil conservation related workshops and 21 percent had not attended any soil conservation workshops.

Table 10. Working knowledge of soil survey reports

Working knowledge	Percent of Respondents
Excellent	11
Very good	26
Good	31
Fair	21
Poor	11

Table 11. Proportion of conservation planners who had taken university or college level soil science courses

Number of soils courses taken	Percent of respondents
0	12
1	17
2	14
3	14
4 or more	43

3.3 Comprehension of Soils Terminology

The purpose for recording this information was to determine if terminology used in soil survey reports and maps was understood by farm conservation planners. If a term was not understood it was recorded under the "did not understand the terminology" column and an explanation was provided so that a respondent could evaluate its use for conservation planning. Terms which were understood by all respondents were slope (percent), slope length, location of erosion, location of salinity, erosion potential and agriculture capability (Table 12). Terms which were understood by 92 to 98 percent of the respondents were agroclimatic zone, parent material, profile description, drainage class, landscape distribution, chemical properties, range carrying capacity and conservation tillage suitability. The three least understood terms were landform (75 percent), soil classification (75 percent) and soil series (71 percent) (Table 12). When the terms topography, hummocky, undulating and rolling were substituted for the term landform, conservation planners understood the concept. Soil classification and soil series usually required a detailed explanation before those who did not understand the concepts, could evaluate their utility for conservation planning.

Table 12. Soil terminology comprehension of conservation planners

	Comprehension Level	
Variable	Understood (%)	Not Understood (%)
Agroclimatic zone	94	6
Parent material	92	8
Landform	75	25
Slope (%)	100	0
Slope length	100	0
Soil classification	75	25
Soil series	71	29
Profile description	96	4
Drainage class	98	2
Landscape distribution	92	8
Chemical properties	98	2
Location of erosion	100	0
Location of salinity	100	0
Erosion potential	100	0
Agricultural capability	100	0
Range carrying capacity	98	2
Conservation tillage suitability	94	6

The soil series and soil classification terms were examined further. Independently, these two terms were not understood by 25 and 29 percent of the respondents, respectively. However if the two terms are examined together, 37 percent of the respondents did not understand the terms. This number is higher than the responses to the individual terms because while some of the respondents did not understand either term, other respondents understood only one of the terms.

3.4 Utility of Soils Information for Farm Conservation Planning

Respondents were asked to evaluate the usefulness of soils information derived from Alberta soil survey reports for conservation planning (Table 13). Eleven of the 17 variables that conservation planners were asked to evaluate pertained to soil physical and chemical properties. The remaining six variables pertained to interpretive information that is currently available in some soil survey reports, interpretive information that is not currently reported but which could become a component of soil survey reports and information that could be potentially presented on soil survey maps. The data showed that for 15 of the 17 variables, 78 percent or more of the respondents indicated that the variables were moderately and highly useful. The two variables that deviated from this were soil series and range carrying capacity. The data indicated that 57 percent of the respondents found that soil series information was moderately and highly useful. Range carrying capacity was found to be moderately and highly useful by 71 percent of the respondents. The proportion who rated the variable non or slightly useful overlooked the connection between over grazing lands and soil erosion.

3.5 Map Product Preference for Farm Conservation Planning

Respondents were asked to rate soil survey map products for their usefulness in helping them make decisions for on-farm and municipal conservation plans.

For municipal conservation planning, five different soil map products were described and respondents were asked to rank them in order from 1 to 5 with 1 being the most useful and 5 being the least useful. Respondents were also asked to provide reasons for their ranking. The data indicated that 29 percent of the respondents preferred color maps, 27 percent preferred maps in digital form, 25 percent preferred black and white aerial photograph mosaic maps, 19 percent preferred LANDSAT base maps and 0 percent preferred black line maps (Table 14).

Respondents were also asked to rate soil survey map products for their usefulness in making decisions for on-farm conservation plans. Four different soil map products were described and respondents were asked to rank them in order from 1 to 4 with 1 being the most useful and 4 being the least useful. The data indicated that 55 percent of the respondents preferred black and white aerial photograph mosaic maps, 27 percent preferred color maps, 18 percent preferred maps in digital format and 0 percent preferred black line maps (Table 15).

Table 13. Usefulness of soils information for farm conservation planning

	Usefulness of Variable			
Variable	No use %	Slightly %	Moderately %	Highly %
Agroclimatic zone	4	14	39	43
Parent Material	2	20	43	35
Landform	4	10	37	49
Slope (%)	4	4	29	63
Slope length	4	10	55	31
Soil classification	0	14	31	55
Soil series	4	39	41	16
Profile description	2	10	47	41
Drainage class	2	12	33	53
Landscape distribution	0	12	45	43
Chemical properties	8	14	41	37
Location of erosion	0	2	18	80
Location of salinity	4	8	27	61
Erosion potential	0	4	20	76
Agriculture capability	0	8	51	41
Range carrying capacity	4	25	53	18
Conservation tillage suitability	4	12	41	43

Table 14. Soil map product preference for municipal conservation planning

	Map Product				
Preference	Black and white aerial photograph mosaic (%)	Black line (%)	Color (%)	Digital (%)	LANDSAT (%)
1	25	0	29	27	19
2	19	17	25	19	20
3	27	17	23	14	19
4	15	39	17	17	12
5	15	27	6	23	29

Table 15. Soil map product preference for on-farm conservation planning

	Map Product			
Preference	Black and white aerial photograph mosaic (%)	Black line (%)	Color (%)	Digital (%)
1	55	0	18	27
2	27	16	35	22
3	10	47	25	18
4	8	37	22	33

Color maps were the first choice of municipal conservation planners because landscape patterns are easily recognizable on these products. Some planners preferred the color maps because they were most familiar with this product. Color maps were published in soil survey reports from the initiation of survey in 1920 to the mid 1970s. The use of color maps was discontinued as a result of the high costs associated with production of these products. Since the mid 1970s, soil survey maps have been published on black and white aerial photograph mosaic and black line NTS map bases. These map bases are used because they are inexpensive to reproduce. More recently, black line maps have been used because they provide a stable base from which soil lines can be converted to digital form.

Digital soil maps are a recent innovation. Many planners preferred this product even though they had no previous experience with this type of map base The interest was based on the potential use and portability of the product. Planners commented that they would be able to derive interpretive products or be able to quickly call up soils information on a computer screen. For on-farm planning part of the attraction was that customized soil reports and maps could be produced, with relative ease, for individual farmers.

The black and white aerial photograph mosaic base was the choice of the majority of on-farm conservation planners (55 percent). It was preferred because landscape and other features could be easily recognized or identified. This is supported by Crosson and Protz (1974) who preferred the use of photograph mosaics rather than line maps for presenting soils information because of the additional information that is provided by a photographs background. Many conservation planners believed black and white aerial photographs are an effective tool that could be used when discussing and delivering conservation plans to farmers.

The LANDSAT base (although never used in a soil survey in Alberta) was attractive because it combined the qualities of color maps with aerial photography. That is, conservation planners saw potential for easy identification of landscape patterns and features.

The least preferred base was black line maps. Unfortunately, this is the base on which current soil maps are displayed. Black line maps are used because they are inexpensive to reproduce and provide a stable base from which soil lines can be converted to digital format (digitized).

3.6 Map Scale Preference for Farm Conservation Planning

Many conservation planners had difficulty understanding the concept of map scale. However, the purpose of the question was to determine their preferred map scale, not whether they understood the concept of scale. Therefore during the course of the interviews, the concept of map scale was explained.

Respondents were asked to rate map scales for their usefulness in helping them make decisions for municipal conservation plans. Four representative map scales used in Alberta soil surveys were described and respondents were asked to rank them in order from 1 to 4 with 1 being the most useful and 4 being the least useful. Respondents were also asked to provide reasons for their ranking order. The data indicated that 39 percent of the respondents preferred 1:50 000 scale soil maps, 31percent preferred 1:100 000 scale soil maps, 20 percent preferred 1:190 000 scale soil maps and 10 percent preferred 1:20 000 scale soil maps (Table 16).

Table 16. Soil map scale preference for municipal conservation planning

	Map Scale			
Preference	1:190 000 (%)	1:100 000 (%)	1:50 000 (%)	1:20 000 (%)
1	20	31	39	10
2	12	45	39	12
3	29	22	21	18
4	39	2	0	59

The primary reason for preferring 1:50 000 maps was that this scale represented a compromise between generalized maps and detailed maps. Other reasons given by respondents included "most familiar with this map scale", "nice size to work with" and "as detailed as you would need".

Municipal conservation planners who chose the 1:100 000 scale preferred it because it provided an overview of a county or municipality. Other reasons for choosing this map scale included "larger area, smaller map", "enough detail without being bulky" and "it's a good compromise scale".

Respondents were also asked to rate map scales for their usefulness in helping them make decisions for on-farm conservation plans. Four different map scales were described and respondents were asked to rank them in order from 1 to 4 with 1 being the most useful and 4 being the least useful. The data indicated that 88 percent of the respondents preferred 1:20 000 scale soil maps, 8 percent preferred 1:50 000 scale soil maps, 4 percent preferred 1:190 000 scale soil maps and 0 percent preferred 1:100 000 scale soil maps (Table 17).

Table 17. Soil map scale preference for on-farm conservation planning

	Map Scale			
Preference	1:190 000 (%)	1:100 000 (%)	1:50 000 (%)	1:20 000 (%)
1	4	0	8	88
2	2	8	84	6
3	0	90	8	2
4	94	2	0	4

On-farm conservation planners preferred the 1:20 000 map scale because it provided the most detail about soils in an area. A very small proportion of the interviewees (4 percent) indicated that the 1:190 000 map scale was adequate for on-farm planning needs. This response indicated either a lack of understanding of the concept of map scale or the respondents were comfortable using existing 1:190 000 maps.

4.0 DISCUSSION

4.1 On-Farm Conservation Planning

The farm conservation planning process uses a series of steps that include setting objectives, conducting inventories of existing resources, providing conservation recommendations, evaluating the conservation practices after implementation and suggesting alternatives if the practices are not working.

The on-farm conservation plans produced in Alberta vary in the style of presentation but their content is similar. One criticism of plans compiled by conservation planners, who are not soil science experts, is that soils information is not properly reported or is presented in technical rather than interpreted form. Reporting technical information is contradictory to the needs of the users of soils information who are interested in what the management capabilities of soils are rather than what the soils are (Smith 1986).

A second criticism of on-farm conservation planning, in Alberta, is that the entire focus of the process is on agriculture, while other environmental issues such as wildlife habitat conservation and preservation are not addressed (Goddard 1992). Usually, habitat conservation issues are addressed only if a farmer or landowner makes a specific request to incorporate wildlife and waterfowl into their farm conservation plan.

A major limitation to the on-farm conservation planning process is that soil surveys, used as an information source for compiling plans, are published at scales too general to be used for this type of planning. That is, they do not provide the level of detail necessary for compilation of on-farm plans. Consequently, farm conservation planners must be capable of collecting site specific soils information to compile on-farm plans or interpolating and interpreting existing information for on-farm scales. Therefore, they must be familiar with methods used for collection of soils information. Results of the questionnaire indicated that many conservation planners did not have an extensive educational background in soils and did not understand some of the terminology used in soil survey reports and maps. The results support personal experience with conservation planners who lack the skills or experience necessary for collecting or interpreting soils information. Regardless of the adequacy of the soil survey information, if a conservation planner is unable to collect or interpret soils information to supplement existing data, the on-farm conservation plan will be of substandard quality.

A second limitation to on-farm conservation planning is that algorithms and models necessary for quantifying land degradation are either too simple or do not exist. This is supported by Goddard (1992) who indicated that some land degradation or erosion models do not exist or are used beyond the scope of their limits. For example, quantitative algorithms do not exist for estimating the potential for soil salinity, organic matter loss and compaction. Other models (specifically the wind and water erosion and soil acidification models) are used beyond the scope of their limits. Some criticisms of the water erosion model (USLE) include:

1. It is an empirical equation derived from plot data predominantly in the southeastern and midwestern United States. Therefore applying it to the Canadian prairies may be extrapolating its use beyond the conditions for which it was derived (Goddard 1988).
2. It predicts soil loss on an average basis for specified field conditions. This does not take into account soil and landscape variability.
3. It estimates sheet and rill location, not gully erosion or soil deposition (Wischmeier 1976).

Similarly, criticisms can be made of the wind erosion model (WEE) used in Alberta. These are:

1. Soil loss is determined on an average basis for specified field conditions. Differences in soils and landscapes, soil cover, vegetation, soil moisture and climatic conditions are not accounted for in all parts of a field.
2. Interpretations are subject to errors in estimates of wind speed, soil moisture, crop yields and residue cover (Coote and Pettapiece 1989).

A criticism of the use of the soil acidification model (Bloom and Grigal 1985) is that although it was developed for soils under forest vegetation it is being extrapolated for use in agricultural areas. Agricultural soils were excluded from the model because additions of fertilizer and lime can influence soil acidity more than inputs of acidic precipitation. Similarly, the model used by Holowaychuk and Fessenden (1987) also did not account for inputs of fertilizer and lime. A second criticism of the Bloom and Grigal model, is that it is of limited use for soils that do not adsorb significant quantities of sulfate. This excludes most Alberta soils that are weak adsorbers of sulfate (Holowaychuk and Fessenden 1987). The result is that estimates of soil sensitivity to acid deposition on agricultural soils in Alberta may be incorrect.

The result of the lack of or misuse of models is that estimating the potential for and extent of certain types of land degradation becomes a subjective rather than objective process. Accurate estimates of land degradation will be required if and whenever programs and policies are instituted that tie soil conservation to farm benefits.

4.2 Municipal Conservation Planning

The municipal conservation planning process is well defined (Barlott et al. 1990). In order to compile a municipal conservation plan, a conservation planner must identify land use from aerial photographs, overlay soil survey information on the land use maps and interpret the soils and land use information for various land degradation concerns. Upon completion of the final overlay, areas susceptible to land degradation can be targeted for conservation measures and those areas which have been degraded can be remediated.

To date, municipal conservation plans have been compiled by soil scientists or conservation planners with extensive soil science backgrounds. That is, a soil science background and familiarity with aerial photography is a necessity for the compilation of municipal conservation plans. This can either be viewed as positive or negative. From a critical perspective, municipal conservation planning should be conducted by those who are most familiar with the resources in a county, aware of the conservation problems and know the long and short term conservation objectives of farmers within the county. This allows planners to set goals for reduction of land degradation and erosion. However, most resident conservation planners are inadequately trained or do not have the soils background necessary to compile a county level plan. Therefore, in Alberta, most municipal conservation plans are compiled by soil scientists external to the county, who evaluate the resources, identify areas susceptible to land degradation and propose short and long term conservation objectives. These scientists provide a technical evaluation of soil conservation concerns but are not familiar enough with local concerns to integrate the conservation objectives of local farmers into their planning.

4.3 Adequacy of Soil Survey Reports for Farm Conservation Planning

Soil conservation gradually evolved from the development and implementation of individual management practices targeted at controlling erosion on farms (terracing, strip cropping, stubble management) to managing and planning resource use for entire farms or parcels of land. This transition occurred only after techniques for erosion control were developed and proven to be effective.

Consequently the soil information needs of planners have changed. The first conservation efforts involved reducing the effects of wind erosion. Therefore soils information that helped to identify areas susceptible to erosion was adequate and necessary for reducing and remediating areas affected by wind. Soil survey maps and reports, such as those produced by Wyatt and Newton (1925, 1926, 1927), were adequate for providing information to conservation planners of the era, so that wind affected areas could be identified and targeted for remediation. Later, models were developed to provide quantitative estimates of various types of land degradation. The result of the creation of these models was the need for additional soils information. For example, prior to the development of quantitative models, soil texture was the only soil variable necessary for evaluating the susceptibility of soils to wind erosion. After the development of the WEE additional variables were necessary for estimating amounts and potential for wind erosion. These variables include soil erodibility (soil texture and structure), surface roughness, climatic, soil moisture and vegetative factors (Alberta Agriculture 1985; Coote and Pettapiece 1989).

Concurrent with additional soil information needs were the development of formalized classification systems for soils and new mapping techniques. That is, the information contained in soil survey reports and maps changed. However, some of the information provided in older soil surveys, although relevant and important to some users, is of limited use for current conservation planning (Table 18). For example exchangeable cation data presented in soil surveys to 1955 is reported as a percent of the total soil. This information is very difficult to convert into units that are currently in use (cmol/kg) and necessary for soil interpretations such as whether or not soils belong to the Solonetzic order. Other soils information provided in some reports is inconsistent, too general, antiquated and therefore inadequate for the compilation of soil conservation plans (Table 18).

The majority of the information necessary for determining the potential of soils to erode or degrade can be obtained from existing soil survey reports (Tables 18 to 25). However, the information necessary for determining the degree and extent of degradation cannot be obtained from existing reports because it is event dependent. That is, quantification of the degree and extent of erosion or degradation occurs after the erosion event has taken place. Therefore, conservation planners, using methods outlined by Alberta Agriculture (1985; 1986) must be capable of collecting soils data necessary for estimating quantity and recognizing the extent of recent erosion and degradation.

Table 18. Required versus available soils information for farm conservation planning

	Soils information provided in Alberta soil surveys					
Soil property or variable required for conservation planning	1925 - 1929	1930 - 1935	1936 - 1945	1946 - 1955	1956 - 1975	1976 - 1992
Landform	x	x	x	x	x	x
Slope length						
% slope			a	x	x	x
Slope position of soils					x	x
Parent materials type			x	x	x	x
Distribution of soils	x	x	x	x	x	x
Stoniness			x	x	x	x
Land use	x	x	x	x	x	x
Drainage	x	x	x	x	x	x
Color	b	b	b	x	x	x
Soil classification			c	c	c	x
Soil series				c	x	x
Horizon thickness			x	x	x	x
Topsoil depth		x	x	x	x	x
Type of subsoil				x	x	x
Soil structure			x	x	x	x
Texture	f	f	f	f	x	x
pH		x	x	x	x	x
Electrical conductivity					x	x
Exchangeable cations	g	g	g	g	x	x
Soluble cations			g	g	x	x
% carbon					x	x
% CaC03 (eq.)	x	x	x	x	x	x
Cation exchange capacity					x	x
Base saturation						x
Agriculture capability			j	j	x	x

blank information is not available
x information is available (no conversion necessary)
a information is available but must be extrapolated from general descriptions
b information is available but colors were determined without the use of color charts
c information is available but conversion to concepts currently in use is required
f information is available but not verified by laboratory analysis
g information is available but difficult to convert to units currently used
j information is available but the rating system is outdated

4.3.1 Adequacy of Soil Surveys Compiled From 1925 to 1935

Comparison of the required versus available soil information shows that soil survey reports compiled prior to 1935 do not provide all the information necessary for assessing the erosion and degradation potential of soils (Tables 18 to 25). The soils, in these surveys, were not mapped using the current concepts of soil horizons and parent materials. Consequently the soils cannot be correlated to present soil classification systems. The reports do not contain information on chemical and physical properties of soils, topography and other horizon features necessary for assessing the potential for all forms of land degradation. It is also not possible to extrapolate the information contained in these reports to current taxonomic and mapping conventions. The information is also presented at scales that are too general (1:190 000 and smaller) for on-farm and municipal conservation planning.

4.3.2 Adequacy of Soil Surveys Compiled From 1936 to 1945

Soil surveys compiled between 1936 to 1945 provide information necessary for assessing the potential of wind and water erosion (Tables 18 to 20 and 25). However, some information, such as soil series designation is not readily available to the conservation planner. That is, the number legend codes used on these maps contain information that requires expert interpretation to bring data to current taxonomic and mapping conventions. Keys for conversion of the number codes to series names exists as an Agriculture Canada internal document (Tajek pers. comm. 1992) but is not available to conservation planners or other users. Without this key, soil classification conversion to current taxonomy and names is not possible, and consequently much of the information presented in these reports has only limited use for conservation planning.

The soil chemical analytical data necessary for assessment of soil salinity, compaction, organic matter loss and acidification, as presented in these reports, is inadequate because insufficient analyses were conducted on the soils and methods of reporting results are antiquated. For example, soluble and exchangeable cation data were reported as a percent of total soil. Conversion of this information to current methods of reporting this data (cmol/l and cmol/kg) is not possible (Abboud pers. comm. 1992). Analytical data required, but not provided, includes electrical conductivity, cation exchange capacity, base saturation and organic carbon content. Other information necessary for conservation planning, but not recorded in soil surveys of this time period, includes location of soils in the landscape (that is, what slope position do the soils occupy) and type of subsoil (Table 25).

Table 19. Information available in Alberta soil survey reports for assessment of the degree, extent and potential for wind erosion

	Year of soil survey report					
Soil property or variable	1925 - 1929	1930 - 1935	1936 - 1945	1946 - 1955	1956 - 1975	1976 - 1992
Landform	x	x	x	x	x	x
Parent materials type			x	x	x	x
Distribution of soils	x	x	x	x	x	x
Land use	x	x	x	x	x	x
Drainage	x	x	x	x	x	x
Color	b	b	b	x	x	x
Soil classification			c	c	c	x
Soil series			c	x	x	x
Topsoil depth		x	x	x	x	x
Soil structure			x	x	x	x
Texture	f	f	f	f	x	x
pH		x	x	x	x	x

blank information is not available
x information is available (no conversion necessary)
b information is available but colors were determined without the use of color charts
c information is available but conversion to concepts currently in use is required
f information is available but not verified by laboratory analysis

Table 20. Information available in Alberta soil survey reports for assessment of the degree, extent and potential for water erosion

	Year of soil survey report					
Soil property or variable	1925 - 1929	1930 - 1935	1936 - 1945	1946 - 1955	1956 - 1975	1976 - 1992
Landform	x	x	x	x	x	x
Slope length						
% slope			c	x	x	x
Parent materials type			x	x	x	x
Distribution of soils	x	x	x	x	x	x
Stoniness			x	x	x	x
Land use	x	x	x	x	x	x
Drainage	x	x	x	x	x	x
Color	b	b	b	x	x	x
Soil series			c	x	x	x
Soil classification			c	c	x	x
Topsoil depth		x	x	x	x	x
Soil structure			x	x	x	x
Texture	f	f	f	f	x	x
pH		x	x	x	x	x

blank information is not available
x information is available (no conversion necessary)
b information is available but colors were determined without the use of color charts
c information is available but conversion to concepts currently in use is required
f information is available but not verified by laboratory analysis

Table 21. Information available in Alberta soil survey reports for assessment of the degree, extent and potential for soil salinity

	Year of soil survey report					
Soil property or variable	1925 - 1929	1930 - 1935	1936 - 1945	1946 - 1955	1956 - 1975	1976 - 1992
Landform	x	x	x	x	x	x
Slope position (soils)					x	x
% slope			c	x	x	x
Parent materials type			x	x	x	x
Distribution of soils	x	x	x	x	x	x
Land use	x	x	x	x	x	x
Drainage	x	x	x	x	x	x
Soil series			c	x	x	x
Soil classification			c	c	x	x
Type of subsoil				x	x	x
Texture	f	f	f	f	x	x
Electrical conductivity (EC)					x	x
Exchangeable cations (cmol/kg)					x	x
Soluble cations (mmol/l)					x	x
Cation exchange capacity					x	x

blank information is not available
x information is available (no conversion necessary)
b information is available but colors were determined without the use of color charts
c information is available but conversion to concepts currently in use is required
f information is available but not verified by laboratory analysis

Table 22. Information available in Alberta soil survey reports for assessment of the degree, extent and potential for organic matter loss

	Year					
Soil property or variable	1925 - 1929	1930 - 1935	1936 - 1945	1946 - 1955	1956 - 1975	1976 - 1992
Landform	x	x	x	x	x	x
Slope position of soils					x	x
Distribution-of soils	x	x	x	x	x	x
Land use	x	x	x	x	x	x
Color	b	b	b	x	x	x
Soil classification			c	x	x	x
Topsoil depth		x	x	x	x	x
% carbon					x	x
Cation exchange capacity					x	x

x information is available (no conversion necessary)
b information is available but colors were determined without the use of color charts
c information is available but conversion to concepts currently in use is required

Table 23. Information available in Alberta soil survey reports for assessment of the degree, extent and potential for soil acidification

	Year					
Soil property or variable	1925 - 1930	1930 - 1935	1935 - 1945	1945 - 1955	1955 - 1975	1975 - 1992
Parent materials type			x	x	x	x
Distribution of soils	x	x	x	x	x	x
Land use	x	x	x	x	x	x
Soil classification			c	c	x	x
Soil series			c	x	x	x
Texture	f	f	f	f	x	x
pH		x	x	x	x	x
% $CaCO_3$	x	x	x	x	x	x
Cation exchange capacity					x	x
Base saturation						x

blank information is not available
x information is available (no conversion necessary)
b information is available but colors were determined without the use of color charts
c information is available but conversion to concepts currently in use is required
f information is available but not verified by laboratory analysis

Table 24. Information available in Alberta soil survey reports for assessment of the degree, extent and potential for soil compaction

	Year					
Soil property or variable	1925 - 1929	1930 - 1935	1936 - 1945	1946 - 1955	1956 - 1975	1976 - 1992
Parent materials type			x	x	x	x
Distribution of soils	x	x	x	x	x	x
Land use	x	x	x	x	x	x
Drainage	x	x	x	x	x	x
Soil series			c	x	x	x
Soil classification			c	c	x	x
Type of subsoil				x	x	x
Soil structure			x	x	x	x
Texture	f	f	f	f	x	x
Exchangeable cations (cmol/kg)					x	x
Soluble cations (mmol/l)					x	x

blank information is not available
x information is available (no conversion necessary)
c information is available but conversion to concepts currently in use is required
f information is available but not verified by laboratory analysis

Table 25. Adequacy of soil survey information for conservation planning

	Time period of soil survey					
Conservation Issue	1925 - 1930	1930 - 1935	1935 - 1945	1945 - 1955	1955 - 1975	1975 - 1992
Wind erosion	N-1,4,6 7,8	N-1,6,7,8	N-1	Y	Y	Y
Water erosion	N-1,2,4, 6,7,8,9,10	N-1,2,4 6,7,9	N-1,2	N-2	N-2	N-2
Salinity	N-1,3,4, 11	N-1,3,4, 11	N-1,3,4, 11	N-3,4	Y	Y
Acidification	N-1,4,5,6	N-1,4,5,6	N-1,4,5	N-4,5	N-5	Y
Organic matter loss	N-1,3,4,8	N-1,3,4	N-1,3,4	N-3,4	Y	Y
Compaction	N-1,4,6, 7,11	N-1,4,6 7,11	N-1,11	N-4	Y	Y

<u>Adequacy of information</u>
N inadequate Y adequate
<u>Reason for inadequacy</u>

1	Soil classification	7	Soil structure
2	Slope length	8	Topsoil depth
3	Slope position	9	Percent slope
4	Soil chemistry	10	Stoniness
5	Base saturation	11	Type of subsoil
6	Parent materials		

The information as presented in these soil survey reports is inadequate for municipal or on-farm conservation planning. However, these soil surveys could be made marginally useful for municipal-conservation planning if conversion keys, that related the soil legend to current mapping and taxonomic conventions, were made available to users. The scale of mapping is also too general (1:190 000 and smaller) to be of use for on-farm and municipal conservation planning.

4.3.3 Adequacy of Soil Surveys Compiled From 1946 to 1955

Reports produced between 1946 and 1955 generally provide all the physical data (with the exception of slope length) required for determining the potential of soils for erosion. Slope lengths are essential for determining susceptibility of soils to water erosion. Information necessary for conservation planning, that is not supplied in these reports, is location of soils in landscapes (needed for salinity and organic matter loss assessment) and soil chemical and physical properties (needed for salinity, compaction and acidification) (Tables 18 to 25). These soil surveys are adequate for municipal conservation planning but inadequate for on-farm conservation planning because the data is presented at scales too small to be of use (1:190 000 or smaller).

Although the soil classification system used during this time period was different than the current taxonomic system, efforts have been made to correlate soil series to current names (Alberta Soil Series Working Group 1992). The Agriculture Canada Soil Survey Unit are compiling a "soil layer file" that contains soil chemical and physical data and is linked to the Alberta soil names file (Tajek pers. comm. 1992). Upon publication of the soil layer file, conservation planners will have access to soil chemical and physical data for all named soils in the province.

4.3.4 Adequacy of Soil Surveys Compiled From 1956 to 1992

Reports produced during this time period provide all the soils information necessary (with the exception of slope lengths) for municipal conservation planning. However, the information as presented does not provide the detail necessary for on-farm conservation planning use. That is, the most detailed soils information is presented at a 1:50 000 map scale whereas on-farm conservation plans are compiled at scales of 1:15 000 or larger.

Slope lengths can be interpolated from landform descriptions. For example, the Agriculture Canada Expert Committee on Soil Survey (1987) inferred rolling landscapes as having slope lengths of greater than 1.6 km and undulating landscapes have slope lengths less than 0.8 km. Tajek et al. (1985) provided estimates of average slope lengths for typical landforms found in Alberta (Table 26). The estimated slope lengths are much lower that those provided by the Agriculture Canada Expert Committee on Soil Survey (ACECSS) (1987). The ACECSS slope length estimates are indicative of maximum slope lengths rather than average slope lengths. This accounts for the differences in the estimated slope lengths between Tajek et al. (1985) and the Agriculture Canada Expert Committee on Soil Survey (1987).

Table 26. Slope lengths of typical landforms in Alberta (Tajek et al. 1985)

Landform modifiers	Slope (%)	Slope length (m)
Undulating or terraced (Mu, Ft, Lu, Lv/Lu)	0 - 5	30
Level (Ll, Fl)		50
Level to inclined (Ll, Li)		200
Hummocky or ridged (Mh, Mr)	5 - 9	30
Rolling or inclined (Mm, Mi, Mb/Rm)		100
Inclined (Mi, Li, Mv/Ri)		200
Hummocky or ridged (Mh, Mr)	9 - 15	50
Rolling or inclined (Mm, Mi)		100
Steeper slopes (Mh, Mvb/Rm)	> 15	30

F = Fluvial   b = blanket   u = undulating   t = terraced
L = Lacustrine   h = hummocky   v = veneer   i = inclined
M = Morainal   m = rolling   r = ridged   l = level
R = Rock

Some interpretive information is also necessary for conservation planning. Of particular use to conservation planners is agriculture capability information. The capability ratings are used for determining if lands are marginal for agriculture (Class 4 or worse). Marginal lands are eligible for retirement from production of cereal crops under programs like the Permanent Cover Program (Alberta Agriculture and Agriculture Canada 1989) and Prairie Care (Ducks Unlimited Canada 1989). The ratings provided in soil survey reports that were published prior to the initiation of the Canada Land Inventory (CLI) in 1963 (Brocke 1977) are outdated. The ratings in these maps were obtained by use of the Storie system (Storie 1933). The Canada Land Inventory system was replaced in 1987 by the Land Capability Classification for Arable Agriculture in Alberta (LCCAAA) (Alberta Soils Advisory Committee 1987). The CLI and the LCCAAA ratings are similar with few exceptions. Therefore, most CLI ratings can be used in the absence of ratings obtained with the LCCAAA.

4.4 Comprehension of Soil Survey Information

The results of the questionnaire showed that a large proportion of farm conservation planners had taken fewer than three soils courses at a university or college. This suggests that many planners have not had a great deal of exposure to soils or soils terminology. These planners may have more difficulty in implementing conservation plans based on soil survey data compared to planners with more training. Conservation planners who had taken two or fewer courses had taken an introductory level soils course and either a soils management or soil conservation course. Those farm conservation planners who had not taken any formal soils courses had supplemented their knowledge by attending the soil and water conservation course offered by Olds College and Alberta Agriculture. The conservation course is offered over a five day period and reviews basic soil properties, soil mapping, classification, problem soils, soil and water management and conservation planning (Olds College and Alberta Agriculture 1989).

Some conservation planners reported only fair to poor working knowledge of the soils reports in their geographic area. However the majority of farm conservation planners interviewed were familiar with the existing soil survey report in their county or municipality. These planners demonstrated, during the course of the interviews, that they were aware of, understood and used information contained in soil survey reports.

The questionnaire may have been flawed because the conservation planners were asked to provide answers that indicated their knowledge (or lack of) about soils. However, at the start of the questionnaire, every assurance was given to the planners that the information collected would not be used in any way against them. This resulted in responses that were well thought out and did not reflect the self interest of conservation planners.

The most interesting finding of the questionnaire was the response that conservation planners had for the utility of soil series information for conservation planning. Soil series information was moderately or highly useful to 57 percent of the interviewees. This compared to 86 percent of the conservation planners who found soil classification information to be moderately or highly useful. The difference indicates that a large proportion of the conservation planners do not thoroughly comprehend the relationship between soil classification and soil series. The lack of connection is alarming since the use of soil series is standard in survey reports. If conservation planners do not understand the soil series concept, it is unlikely that they can make effective use of survey reports.

4.5 Map Scale and Product Preferences of Farm Conservation Planners

Results of the questionnaire indicated that conservation planners preferred 1:50 000 maps for municipal conservation planning and 1:20 000 maps for on-farm planning. The results of the questionnaire also indicated that conservation planners preferred color maps for municipal conservation planning and black and white aerial photograph mosaic map products for on-farm planning.

Currently in Alberta, county level soil survey mapping projects are being conducted at 1:50 000. This scale provides information that is adequate for municipal conservation planning. However, data collection at this scale is a slow and costly process. An average size Alberta county (400,000 hectares) takes approximately eight person years to complete at a cost of approximately $1.60 to $2.00 per hectare. At this rate of progress, it would take approximately 300 to 400 person years to complete the mapping of the province at this scale at an estimated cost of 32 to 43 million dollars. The alternatives are to map at smaller scales or develop new mapping methodologies with which data is collected. In a survey of soil report users in British Columbia, Valentine et al. (1981) stated that users would prefer a less precise map delivered faster over a more precise map that took longer to deliver. In Alberta, this is supported by MacMillan (1985) who suggested that 1:100 000 maps would be adequate for most users of the information. The 1:100 000 maps could be compiled at four times the speed and at one quarter the cost of traditional 1:50 000 maps.

The 1:20 000 soil survey maps, which are preferred for on-farm planning, take longer to compile and are therefore costlier than 1:50 000 maps. The manpower requirements and costs are approximately three to four times that of collecting information at 1:50 000. An average size Alberta county would take about 15 person years work at an estimated cost of between 1.0 and 1.5 million dollars. These costs eliminate the possibility or probability of 1:20 000 mapping occurring (in Alberta) in the future, except on an as needed basis.

Problems exist with presenting and reproducing information in the form that conservation planners prefer for municipal and on-farm planning. Color maps were the first choice of municipal conservation planners. However, they are expensive to produce. Aerial photograph mosaics were the preferred display media for on-farm planning. However, aerial photographs are distorted towards their edges and provide an unstable base for conversion into electronic form.

Until hardware and software are developed which allow scanning and digitizing of soil lines from aerial photographs, inexpensive black line NTS bases are most likely to be used for display of soil survey data. The dilemma is that no conservation planners preferred black line maps for displaying soil lines. In order to meet the map product demands of municipal conservation planners, black line soils maps can be digitized and displayed in a variety of ways. This provides soil surveyors with the ability to produce a variety of map products for any user group (conservation planners).

4.6 Summary

Soil surveys compiled in Alberta do not provide the detail necessary for the compilation of on-farm conservation plans. Soil surveys produced prior to 1935 do not provide the soils information necessary for municipal conservation planning. Soil surveys produced from 1935 to 1955 can be used for municipal conservation planning, if conversion keys that allow the changing of symbols on older maps to current classification and soil names, are provided to conservation planners. Soil surveys compiled after 1955 provide adequate soils information for municipal conservation planning but are not detailed enough for on-farm planning.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions are presented and recommendations offered for farm conservation planning based upon the research conducted, interviews with conservation planners and personal experience in soil survey activities. The recommendations address:

1. The soil conservation planning process and planners in Alberta
2. Limitations of soil survey reports and maps for on-farm and municipal conservation planning
3. Alternative methods of soil survey map and report presentation to meet the needs of conservation planners

Implementation of the recommendations will contribute to the effective delivery and use of soil survey information by conservation planners in Alberta. To meet the soil information requirements of conservation planners all the recommendations must be given consideration.

5.1 Farm Conservation Planning

Review of the literature indicated that models or algorithms either do not exist for estimating or quantifying certain types of land degradation or have been used in situations that are beyond their limits. The development of models is necessary if accurate estimates of the potential and severity of degradation are to be recorded. This information may be necessary if, in the future, conservation legislation is enacted that ties farm benefits to soil conservation activities. Development of models may also change the soils information requirements of conservation planners. The change may result in the collection of additional (different) soils information by soil mappers.

5.1.1 Recommendation

Studies should be conducted to define algorithms which address the inadequacies of the soil erosion, acidification, compaction, organic matter loss and salinity models.

A criticism of soil conservation planning is that the major focus has been on agriculture, while other uses such as wildlife habitat conservation and preservation are not addressed. This focus is driven by the needs of agricultural producers whose main concern is with minimizing inputs while maximizing crop output. To these producers, the production of wildlife and waterfowl is a secondary benefit of soil conservation. To most farmers the creation of wealth means dollars in the bank as opposed to quality of life through the protection and enhancement of wildlife and waterfowl habitat. With adequate training in wildlife conservation and preservation, conservation planners could provide landowners with alternative land uses to agriculture that are potentially lucrative.

5.1.2 Recommendation

Soil conservation planners should be provided with a good background in integrated resource management so that wildlife conservation and preservation can be incorporated into farm conservation plans.

5.2 Adequacy of Soil Survey Products

Historically, soil surveys in Alberta have been produced for and contain information suitable to many users. The result is the production of soil surveys that attempt to meet the needs of a variety of users. However, Oschwald (1975) and Fessenden (1984) suggested that audience identification and preparation of reports for specific rather than general audiences would improve utilization of soil surveys. This approach was used in some soil surveys in Alberta. That is, in addition to conducting soil surveys to improve the existing data base, soil surveys were conducted for specific purposes. For example, the first soil surveys were conducted to identify the magnitude of wind erosion in southern Alberta and determine the suitability of lands for arable agriculture in northern Alberta. More recently, the soil survey of the County of Paintearth (Wells and Nikiforuk 1988) was initiated for Alberta Agriculture in response to a demand for deep plowing interpretations; and the County of Beaver soil survey (Howitt 1988) was initiated in response to a request by Alberta Municipal Affairs to improve information for tax assessment purposes.

However, the high cost of soil survey predicates the production of a general purpose inventory product targeted at a variety of users. The high cost of mapping also reduces the probability of a survey being conducted specifically for any one use such as conservation planning. Therefore, the purpose of most inventories conducted is to improve the existing data base rather than satisfying the needs of a particular user group (Butler 1980). Consequently, conservation planners must be capable of extracting soils information relevant to conservation planning from general purpose maps.

Review of soil survey reports and maps showed that report and map formats, map scales, correlation, taxonomic systems (or lack of), mapping concepts and soils information reported, differed between soil surveys. These differences contribute to the ineffective use of soil surveys by some conservation planners. All soil surveys do not contain the soils information necessary for compiling on-farm and municipal conservation plans. The inadequacies of these surveys can be addressed and corrected through a variety of delivery methods.

5.2.1 Soil Survey Initiatives

The review of soil information requirements of conservation planners and soil survey reports and maps showed that soil surveys compiled prior to 1946 provide inadequate information for all forms of land degradation (Table 25). Soil surveys produced between 1946 and 1955 are inadequate for most forms of land degradation and soil surveys produced after 1956 are adequate for most forms of land degradation (Table 25).

5.2.1.1 Recommendation

To satisfy the information requirements of conservation planners, soil surveys compiled prior to 1956 should be updated and improved.

There are five possible options for soil mapping that would address the inadequacies of soil surveys used for municipal conservation planning. The options considered would involve the reinterpretation and recompilation of existing data or collection of new data so that the information needs of conservation planners are met. That is, the soil survey reports and maps would contain information necessary for soil degradation models.

In the first option, areas that were mapped prior to 1946 could be resurveyed using current taxonomy and mapping conventions. This would be a costly procedure given that the area to be resurveyed occupies approximately 12 million hectares. However this option is the most desirable of the five proposed options because information collected would provide adequate detail for conservation planning and would use current taxonomic and mapping conventions.

A second, less expensive, solution would be to publish a key or correlation matrix that allows conservation planners to convert map unit symbols used on maps compiled between 1935 and 1945 to soil names currently in use. This key exists as an unpublished Agriculture Canada document (Tajek pers. comm. 1992). The disadvantage in implementing this option is that map units as presented on these surveys are simplified descriptions of landscapes and do not accurately describe the complexity of soils within landscapes. This option is easiest to apply on soil surveys compiled between 1945 and 1955. These surveys used series names and could be correlated to current names by using the Alberta Soil Names File (Alberta Soil Series Working Group 1992).

In order to fulfill the requirements of various degradation models, it is necessary to link the soil names with files that contain soil chemical and physical data (Alberta Soil Layer File). The Soil Layer File provides users with soil chemical and physical information for all soil series in Alberta. The information has been compiled either using actual laboratory measurements, or in the absence of these data, estimates of variables have been made. The publication of a map symbol conversion key and the Soil Layer File would provide conservation planners with information that utilizes current terminology and can be used in various degradation models.

5.2.1.2 Recommendation

In the absence of the re-mapping of areas covered by soil surveys compiled prior to 1956, map symbol conversion keys and soil physical and chemical information should be published.

The third option is a value added product of the second option. That is, after converting map symbols to soil names in current use, soil mappers could add map unit numbers to soil names. The addition of unit numbers to names would make map unit symbols more like symbols in current use and also imply soil and landscape complexity. This type of product was produced for the Municipal District of Rocky View (Turchenek and Howitt 1989).

The fourth option is to provide users with uniform and consistent map coverage by resurveying all soils in Alberta. The concept of a uniform map product was first proposed by MacMillan (1985), but has not been adopted. The soils information collected would have to meet the requirements of conservation planners, municipal assessors and other user groups. Cheel (1991) identified (in general terms) who the users of soils information in Alberta and defined (in general terms) the information needs of the various users. Further studies should be conducted to identify the soil variables that should be collected to fulfill the needs of users. This is the most expensive option and is least likely to be considered or adopted given the current economic conditions.

The fifth option involves the production of land system maps that provide conservation planners with a generalized overview of soils and landscapes within a county. The land systems are defined using existing soils, surficial geology, topography, bedrock geology and other information, and published at a scale of 1:250 000. They can be combined with land use information, derived from LANDSAT imagery, to produce municipal conservation plans.

None of the five options address the inadequacy of detail, as presented in current reports, for on-farm conservation planning. Therefore, on-farm planners must be capable of using existing soil surveys and supplementing them with collection of additional soils information. Consequently the training and education of soil conservation planners, who do not have extensive soil science training or experience, is necessary if on-farm plans are to be compiled.

5.2.2 Soil Mapping Scale for Conservation Planning

Different amounts of detail are required for municipal and on-farm conservation planning. Barlott et al. (1990) suggested map scales of 1:50 000 or smaller are necessary for municipal conservation planning. Results of the questionnaire indicated that municipal conservation planners preferred the 1:50 000 soil map scale. However, 1:50 000 soils mapping is too costly to conduct and financial support for this scale of mapping is no longer being provided by the Alberta Government (Alberta Research Council 1992). MacMillan (1985) suggested a map scale of 1:100 000 for resurvey of soils in Alberta. Results of the questionnaire indicated that 1:100 000 scale maps were the second choice of municipal conservation planners.

Alberta Agriculture recommended map scales larger than 1:15 000 for on-farm conservation planning. Results of the questionnaire indicated that on-farm planners preferred the map scale that provided the most detail (in the case of the questionnaire this was 1:20 000). However the high costs of production of detailed soil maps ($5 to $6 per hectare) predicates that these surveys be conducted only on an as needed basis.

5.2.2.1 Recommendation

To satisfy the demands of conservation planners and given current economic constraints, future soil surveys should be compiled at map scales of 1:100 000.

5.3 Alternative Methods for Delivery of Soil Survey Information

In the absence of updated or detailed soils information (necessary for on-farm conservation planning) alternative methods for delivery of soil survey data, which address the inadequacies of, and ineffective use of soil survey maps and reports, should be investigated. Since there are many ways to deliver soil survey information, efforts to promote effective use of soil survey information should include human interaction, printed media or text and interactive computer technology. Use of all three systems is necessary if conservation planning and other user group needs are to be met (Bicki 1991).

5.3.1 Human Interaction

The increased awareness of the use of soils information to support activities such as conservation planning has increased the demand for more interpretive and higher level soils training (Souster and Peters 1991). However, based upon interviews with conservation planners and personal experience in soil survey extension, the author concludes that many conservation planners have not had exposure to soils, soil survey methods and terminology or lack the training necessary to correctly evaluate soils information. Consequently they are unable to present and interpret soil survey information for farmers

5.3.1.1 Recommendation

Planners who have not been exposed to or used soil surveys, or have minimal exposure to soils terminology, should attend training courses, such as the Soil and Water Conservation Course offered by Olds College.

The effect of educating conservation planners so that they understand and correctly interpret soils data would be a reduction in the need for pedologists to serve in an extension role. Soil mappers can continue to produce a variety of soil map and report products if conservation planners (and other users) have the ability to understand and interpret soils information regardless of the scale of mapping and form in which it is presented.

An alternative solution to educating and training conservation planners is to place experienced soil mappers in a county or municipality or have them act in an extension role. These mappers would be available, upon completion of a soil survey project, to re-examine soils, interpret soils information and update soil surveys for various user groups (Bicki 1991). The mappers would help reduce translation barriers that impede communication of soil facts and be available to interact directly with users so that effective use of the information is made.

The creation of soil survey extension positions is viewed as a short term solution. The person(s) required to fill such a positions would require a strong soil inventory background. Their responsibilities would be to respond to information requests by planners, accompany planners on conservation planning exercises, teach basic soils information to planners, attend group conservation planning exercises and hold discussions with conservation groups on the merits of having good soils information. More than one soil surveyor would be required to address the needs of planners in the province.

This solution, although valid, does not address soil survey inadequacies, rather maintains the situation as it currently exists. That is, the inadequacies of soil surveys are addressed by making soil mappers available to supplement the information demands of conservation planners.

5.3.2 Content of Soil Survey Reports

Another method of addressing the inadequacies that soil survey reports have for conservation planning, is to change their content. Current soil survey reports contain technical language and are targeted to a general audience and are not explicit in their descriptions of the relationships between soils and landforms (Hudson 1992). In reality, because of the technical content of surveys, their use is limited and soil scientists are probably the predominant users of the information. The use of technical language and complex tables in soil survey reports poses translation problems for some conservation planners. Stobbe (1945), Oschwald (1975) and Brown (1985b) suggested that non-technical terms should be used whenever possible if soil surveys are to be effective communication channels for non-soil scientist audiences. The user must understand the language and style of information contained in the descriptive map legend, and the basis for and limitations of the interpretive tables and text in the report, before he or she can make effective use of the information.

Less use of technical language and clear definitions will help remove language barriers and allow planners to make more effective use of the information. This is supported by results of the questionnaire interviews. Soil survey reports should include the definition and elaboration of terms that are least understood but essential for farm conservation planning (that is, landform, soil classification and soil series). For example the term landform could be elaborated upon and specific terms such as hummocky, rolling and undulating could be substituted in its place.

Understanding soil classification and soil series terms is essential to conservation planners because they are the essence of farm conservation planning. Therefore, soil survey reports should include not only an explanation of technical information but also the importance of certain soil variables for soil conservation planning. However, the reduction in the use of technical language in soil survey reports should not compromise the needs of technical users.

In addition to reducing the use of technical language other portions of the soil survey report could be modified to meet conservation planning needs. Oschwald (1975) suggested the use of visual aids, interpretive maps and block diagrams in survey reports. The use of simple interpretive maps might be more appropriate than presenting data in tabular form, providing that explanation of the criteria used for compilation of interpretive maps was documented in the soil survey report.

Published soil surveys should also contain maps and an accompanying report. Hudson (1992) is critical of the use of soil survey maps without accompanying reports, for delivery of soils information. He stated that the use of soil maps alone is an ineffective way to deliver soils information because maps are poor vehicles for conveyance of scientific concepts or complex knowledge. That is, the communication of landscape models used by soil mappers, to users of the information, is poor. Presentation and communication of landscape models used to produce maps would result in an increase in the understanding of the relationship between soils and landforms.

5.3.2.1 Recommendation

Future soil survey reports should contain less technical language, provide explanations and descriptions of landscape models used during the compilation of soils maps, provide clear and concise definition of soil science terms, have less data presented in tabular form and contain more interpretive maps.

Interpretive maps can be provided by computerized delivery systems. It is possible to merge soils databases with interpretations to quickly produce customized interpretive maps. This capability also reduces the need to mass produce generic interpretive maps and allows soil mappers to be more flexible and responsive to user needs.

5.3.3 Format of Soil Survey Reports

The report format for soil surveys, in Canada, was first suggested in 1945 (Stobbe 1945) and has not been drastically modified or altered. Soil survey reports usually contain information on the physical setting of a surveyed area, followed by technical soils information, soil interpretations and appendixes. The appendixes contain technical information on soil chemical and physical properties and a glossary of terms. This format is logical, conservative and not friendly to the non-technical user. Changes to the report format, although necessary, would be viewed as a major departure from the standard report currently delivered in Alberta.

5.3.3.1 Recommendation

To provide a soil survey report that is easier to use for conservation planners, alternative soil survey report formats should be investigated and evaluated in terms of user requirements and associated costs of production.

There are a variety of ways that soil survey reports can be reformatted to address the needs of conservation planners and other users. Valentine (1983) proposed that the interpretive soils information be placed at the beginning of the survey report and the technical information be placed at the end. In this format, the non-technical user would encounter the information that they are most interested in first (that is, what is the appropriate use and management of soils). This is supported by Smith (1986) who indicated that most non-technical users of soils information do not want to know what the soils are, rather what how they can be managed and what their capabilities are. This format is opposite to the way in which current survey reports are produced.

Bicki (1991) suggested the publication of two separate volumes, one containing technical information (bound) and one containing interpretations (unbound). The technical report would contain descriptions of soils, landscapes, map units, tabular data related to soil interpretations and the soil maps. It would be bound, because changes to the information would not be warranted for a long time. The volume would meet the requirements of the technical user but would not necessarily address the needs of the non-technical users.

The interpretive report would contain maps and information related to soil interpretations. It would bound into a 3-ringed binder. This would allow for the update of interpretive maps, the addition of interpretations at later dates and allow the soil mapper to produce interpretive products specific to the needs of selected user groups. If the non-technical user wanted technical (or additional) information about the soils he could refer to the technical soil report and maps.

5.3.4 Supplements to Soil Survey Reports

The probability of converting all existing soil survey documents to two volume format in the near future is low. In the absence of reformatted soil survey reports one possible alternative is to produce a supplement to aid in the understanding of soil survey reports and maps. The Ontario Institute of Pedology (1985) produced a field manual designed to help technical and non-technical users with the description of landscapes and classification of

Ontario soils. The manual explains soil mapping procedures and provides methods for collecting basic soils information. Other field manuals have been produced that could be used as guides for production of a field manual in Alberta (Taylor and Pohlen 1970; Hodgson 1976; B.C. Ministry of Environment 1980).

In general, the field manual should contain generic information on Alberta soils, taxonomy, soil texturing, soil drainage, derivation of slope position and so on. It should not be a stand alone document but rather a supplement to field training, soils courses and survey reports. One modification, that could be considered to the existing manuals, is that rather than targeting the manual at all users, the manual could contain inserts specific to different user needs. For example, an on-farm conservation planning insert could contain information on how to map land use, determine agriculture capability and determine the potential of soils to degrade.

5.3.4.1 Recommendation

To supplement existing soil survey reports and maps, consideration should be give to the production of a soil survey field manual or guidebook.

5.3.5 Electronic and Interactive Computer Technology

A criticism of hard copy reports is that they are difficult to update or to expand (Bicki 1991). Conversely, computer technology allows users quick and easy access to information. The affordability of computer hardware and software, coupled with technological advances has made systems accessible to many users. Numerous soil information systems have been developed. Some are more complicated than others, each have different capabilities and most are interactive and user friendly.

The use of electronic and interactive computer technology for transfer of soil survey information is a recent innovation. Examples of systems developed for the transfer of soil survey information are "SIDMAP" (Hiley, Patterson, Peterson, Pettapiece and Wehrhahn 1986), the "Warner Soil Information System (WSIS)" (van Duerson, MacMillan, Howitt and Forrest 1990), "ELLY" (Agriculture Canada 1992) in Alberta; the "Soil Survey Information System (SSIS)" in Minnesota (Robert 1987); and "LANDBASE" in Saskatchewan (Saskatchewan Soil Survey 1990). All of these systems run on IBM PCs and compatibles.

The majority of these systems are interactive and user friendly. SSIS (Robert 1987) is vector (polygon) based and contains a variety of information including landuse, vegetation, wildlife and soils. The information is displayed at 1:15,000 and is targeted for the non-technical user. The system is capable of generating soils and interpretive maps, acreages and descriptions of soil properties and interpretations.

The WSIS and ELLY systems are raster (cell) based and contain soils information which is derived from the SIDMAP database (1:250 000). Both systems are capable of generating soils and interpretive maps and acreages. WSIS is also capable of providing descriptions of soil properties and interpretations. Information is displayed at 1:50 000 in WSIS and displayed at 1:250 000 in ELLY. The LANDBASE software has similar capabilities to WSIS.

5.3.5.1 Recommendation

To provide users quick and easy access to soil survey information, efforts should be made to publish all future soil survey reports in electronic form.

Further advances in the development of software are possible and necessary. It may be possible to have expert systems software available with the soil survey report and maps. Expert systems would allow non-technical users to derive soil interpretations with minimal input by pedologists. The potential exists to create interactive computer software that could be used for training and as an encyclopedia of soils information.

The use of electronic and interactive computer technology provides soil surveyors the greatest potential of any of the delivery systems. Once the soils maps are in electronic form they can be plotted on any type of base, thus satisfying the needs of all users. Electronic reports and expert systems must be developed which "walk" users through the steps involved with deriving soils interpretations. The hardware is portable and software could be developed to satisfy many user needs (including training, education and extension).

There are numerous implications and questions involved in the production and development of electronic soils data bases, reports and maps. One implication is that there is potential for reduction in the need for mass produced paper copies of the soil survey report and maps. This will minimize publication costs and result in a soil survey cost reduction.

The questions that arise relate to the content and storage of a soil survey database. The questions that need to be addressed include:

1. What will the database look like?
2. What information will be contained in the database?
3. Where will the database reside?
4. What will the standards for the production of maps be?
5. Who will be responsible for maintenance and update of the information?
6. How much will the information cost?

Interactive computer technology should be viewed as a tool for the display of information. Consequently the information system is only as good as the data that resides in it. That is, if the soils information entered into the system is antiquated, it is no better than the existing paper copies.

5.4 Summary

Soil surveys have been compiled for the last 70 years in Alberta. The production of general purpose inventory maps, using a variety of classification and mapping systems has contributed to the misunderstanding of some soils data. In other instances the information provided in soil surveys is antiquated or insufficient for certain uses. Some of the misunderstanding of soil survey information can be alleviated through the production of maps using current classification and mapping standards. Alternative methods of soil survey delivery should also be investigated in the absence of re-mapping areas or recompiling soil survey information. Human interaction, production of reports using alternative formats, use of computer technology and education and training programs are other ways in which soil surveys could be delivered to conservation planners and consequently used more effectively.

The results of the questionnaire indicated that the majority of soil conservation planners are familiar with the soils information needed to compile conservation plans. However, some conservation planners have not or only recently been exposed to soils terminology. These planners must be required to take supplemental courses to increase their understanding of soils.

Soil survey information can also be supplemented through the production and use of field manuals, map symbol conversion keys and soil physical and chemical data. These publications are the tools that can be used to aid conservation planners in the collection and understanding of soils data necessary for assessment of land degradation.

In general, soil surveys provide the detail necessary for municipal conservation planning but do not provide adequate detail for on-farm conservation planning. The most recent soil surveys contain all the information necessary for assessment of land degradation. However, conservation planners must be capable of collecting additional soils information and analyzing and interpreting soil survey data at the on-farm scale level to supplement existing data. This data should be collected without the help of trained soil mappers.

Non agricultural land uses should also be considered during the compilation of conservation plans. Consequently, farm conservation planners should have interdisciplinary backgrounds with training in soils, wildlife and range management and engineering. Farm conservation planners do not necessarily have to be experts in these fields. However, they must be knowledgeable in these fields so that they can be conversant with experts when problems are encountered or additional information is required for the compilation of conservation plans.

In conclusion, the education of conservation planners in soil survey methods and terminology is fundamental for making existing soil surveys more useful. The goal of the effective use of soil survey data for conservation planning is to ensure that realistic and understandable conservation plans are delivered to land owners. The delivery of these plans is one way of reducing the amount of land degradation in Alberta, maintaining soils for future generations and ensuring that agriculture in Alberta remains competitive and vibrant in the world markets.

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Appendix 1: Location of Experimental Farms and Stations in Canada (Anstey 1986)

Newfoundland

St. John's West

Prince Edward Island

Charlottetown

Nova Scotia

Kentville

Nappan

New Brunswick

Fredericton

Quebec

Sainte-Anne-De-La-Pocatiere

Cap Rouge

Farnham

Lennoxville

La Ferme

L'Assomption

Normandin

Macamic

Saint-Charles-De-Caplan

Fort Chimo

Ontario

Harrow

Walkerville

Kapuskasing

Delhi

Thunder Bay

Ottawa

Woodslee

Smithfield

Manitoba

Brandon

Morden

Melita

Manitoba (cont.)

Portage La Prairie

Wabowden

Saskatchewan

Indian Head

Rosthern

Scott

Swift Current

Regina

Melfort

Alberta

Lethbridge

Lacombe

Fort Vermilion

Beaverlodge

Manyberries

Yukon and Northwest Territories

Mile 1019, Alaska Highway

Fort Simpson

British Columbia

Agassiz

Saanicton

Invermere

Summerland

Windermere

Kamloops

Smithers

Prince George

Creston

Appendix 2: Questionnaire

Date ____________

Questions:

a. Job classification

Agr. fieldman ____ District Agriculturalist ____ Field agrologist ____
Other__________________

b. Region of province

North ____ Central ____ South ____

c. Are you currently involved in any aspects of conservation planning?

Yes ______ No ______

(If **yes**, proceed to **question e.**, if **no** proceed to **question d.**)

d. If no, do you foresee becoming involved in any aspects of conservation planning?

Yes ______ No ______

(if **no**, questionnaire **ends at question e.**)

e. How would you rate your working knowledge of the existing soil survey report in your area?

Excellent ___ Very good ___ Good ___ Fair ___ Poor ___

f. Have you ever taken any soils courses at a University or College?

Yes ______ No ______

Which courses?

g. Have you ever attended any soil seminars or workshops?

Yes ______ No ______

Which seminars or workshops?

h. The following question pertains to information derived from soil survey reports. I would like you to tell me how useful each variable is in helping you make management decisions necessary for soil conservation planning. At this time I would like you to write down the following words: non, slightly, moderately and highly. These are the 4 choices you have for rating the usefulness of the variable.

For example, if the variable given was soil zone, the rating may be moderately useful.

If you think the variable is important for conservation planning but do not completely understand the terminology associated with it, I will provide an explanation. It's important for you to express the need for explanation or clarification of terminology. If a variable is relevant for conservation planning but not completely understood, it may be possible to simplify the way in which it is presented in the soil survey report.

		Knowledge	Usefulness			
		Did not understand terminology	Non	Slightly	Moderately	Highly
1.	Agroclimatic zone (2A, 2AH, 3A)	[ ]	[ ]	[ ]	[ ]	[ ]
2.	Parent material (till, fluvial)	[ ]	[ ]	[ ]	[ ]	[ ]
3.	Landform (hummocky, rolling, inclined, undulating)	[ ]	[ ]	[ ]	[ ]	[ ]
4.	Slope (%) (eg. 6 - 9%)	[ ]	[ ]	[ ]	[ ]	[ ]
5.	Slope length (eg. 100 m)	[ ]	[ ]	[ ]	[ ]	[ ]

		Knowledge	Usefulness			
		Did not understand terminology	Non	Slightly	Moderately	Highly
6.	Soil classification (eg. Black Chernozemic or Gray Luvisol)	[ ]	[ ]	[ ]	[ ]	[ ]
7.	Soil series (DEL, BZR, KNZ)	[ ]	[ ]	[ ]	[ ]	[ ]
8.	Soil profile description (including soil textures, structure, horizon thickness)	[ ]	[ ]	[ ]	[ ]	[ ]
9.	Soil drainage (MW, P, I, W)	[ ]	[ ]	[ ]	[ ]	[ ]
10.	Distribution of soils within the landscape	[ ]	[ ]	[ ]	[ ]	[ ]
11.	Soil chemical properties (OM content, pH)	[ ]	[ ]	[ ]	[ ]	[ ]
12.	Location and extent of erosion	[ ]	[ ]	[ ]	[ ]	[ ]
13.	Location of salinity	[ ]	[ ]	[ ]	[ ]	[ ]
14.	Susceptibility of soils to wind and water erosion	[ ]	[ ]	[ ]	[ ]	[ ]
15.	Agriculture capability	[ ]	[ ]	[ ]	[ ]	[ ]
16.	Range carrying capacity	[ ]	[ ]	[ ]	[ ]	[ ]
17.	Suitability of of conservation tillage systems	[ ]	[ ]	[ ]	[ ]	[ ]

i. The next question deals with soil map presentation. I would like you to rank the following map products for their usefulness in helping you make decisions necessary for county level or municipal soil conservation planning. I will give you 5 different kinds of map products. Rank them in order from 1 to 5. One is the most useful, 5 the least useful. If you do not understand the terminology please ask for an explanation or for clarification.

	Ranking
Black and white air photo mosaic	[ ]
Black line maps on topographic (NTS) map sheets	[ ]
Color (NTS) map sheets	[ ]
Digital maps	[ ]
Enlarged satellite image (Landsat)	[ ]

Why did you choose the __________ as being the most useful for county level planning?

j. This question deals with soil map presentation. I would like you to rank the following map products for their usefulness in helping you make decisions necessary for on-farm soil conservation planning. Rank the map presentations in order from 1 to 4. One is the most useful, 4 the least useful. If you do not understand the terminology please ask for an explanation or for clarification.

	Ranking
Black and white air photo mosaic base	[ ]
Black line maps on NTS map sheets	[ ]
Color NTS map sheets	[ ]
Digital maps	[ ]

Why did you choose the __________ as being the most useful for on-farm conservation planning?

k. I would like you to rank the following soil map scales on their usefulness in helping you make decisions necessary for county level or municipal soil conservation planning. Rank the map scales in order from 1 to 4. One is the most useful, 4 the least useful. If you do not understand the terminology please ask for an explanation or for clarification.

	Ranking
1:190,000 (1" = 3 miles) (minimum size map unit is 500 acres)	[ ]
1:100,000 (1" = approximately 2 miles) (minimum size map unit is 125 acres)	[ ]
1:50,000 (1" = approximately 1 mile) (minimum size map unit is 30 acres)	[ ]
1:20,000 (3" = 1 mile) (minimum size map unit is 5 acres)	[ ]

Why did you choose the __________ as being the most useful for county level conservation planning?

1. I would like you to rank the following soil map scales for their usefulness in helping you make decisions necessary for on-farm soil conservation planning. Rank the map scales in order from 1 to 4. One is the most useful, 4 the least useful. If you do not understand the terminology please ask for an explanation or for clarification.

	Ranking
1:190,000 (1" = 3 miles) (minimum size map unit is 500 acres)	[ ]
1:100,000 (1" = approximately 2 miles) (minimum size map unit is 125 acres)	[ ]
1:50,000 (1" = approximately 1 mile) (minimum size map unit is 30 acres)	[ ]
1:20,000 (3" = 1 mile) (minimum size map unit is 5 acres)	[ ]

Why did you choose the __________ as being the most useful for on-farm planning?

Appendix 3. Outline of the Canadian System of Soil Classification (Agriculture Canada Expert Committee on Soil Survey 1987)

Order	*Great Group*	*Subgroup*
Brunisolic	Melanic Brunisol	Orthic Melanic Brunisol O.MB Eluviated Melanic Brunisol E.MB Gleyed Melanic Brunisol GL.MB Gleyed Eluviated Melanic Brunisol GLE.MB
	Eutric Brunisol	Orthic Eutric Brunisol O.EB Eluviated Eutric Brunisol E.EB Gleyed Eutric Brunisol GL.EB Gleyed Eluviated Eutric Brunisol GLE.EB
	Sombric Brunisol	Orthic Sombric Brunisol O.SB Eluviated Sombric Brunisol E.SB Duric Sombric Brunisol DU.SB Gleyed Sombric Brunisol GL.SB Gleyed Eluviated Sombric Brunisol GLE.SB
	Dystric Brunisol	Orthic Dystric Brunisol O.DYB Eluviated Dystric Brunisol E.DYB Duric Dystric Brunisol DU.DYB Gleyed Dystric Brunisol GL.DYB Gleyed Eluviated Dystric Brunisol GLE.DYB
Chernozemic	Brown	Orthic Brown O.B Rego Brown R.B Calcareous Brown CA.B Eluviated Brown E.B Solonetzic Brown SZ.B Gleyed Brown GL.B Gleyed Rego Brown GLR.B Gleyed Calcareous Brown GLCA.B Gleyed Eluviated Brown GLE.B Gleyed Solonetzic Brown GLSZ.B
	Dark Brown	Orthic Dark Brown O.DB Rego Dark Brown R.DB Calcareous Dark Brown CA.DB Eluviated Dark Brown E.DB Solonetzic Dark Brown SZ.DB Gleyed Dark Brown GL.DB Gleyed Rego Dark Brown GLR.DB Gleyed Calcareous Dark Brown GLCA.DB Gleyed Eluviated Dark Brown GLE.DB Gleyed Solonetzic Dark Brown GLSZ.DB
	Black	Orthic Black O.BL Rego Black R.BL Calcareous Black CA.BL Eluviated Black E.BL Solonetzic Black SZ.BL Gleyed Black GL.BL Gleyed Rego Black GLR.BL

Order	*Great Group*	*Subgroup*
Chernozemic	Black	Gleyed Calcareous Black GLCA.BL Gleyed Eluviated Black GLE.BL Gleyed Solonetzic Black GLSZ.BL
Chernozemic	Dark Gray	Calcareous Dark Gray CA.DG Solonetzic Dark GraySZ.DG Gleyed Dark Gray GL.DG Gleyed Rego Dark Gray GLR.DG Gleyed Calcareous Dark Gray GLCA.DG Gleyed Solonetzic Dark Gray GLSZ.DG
Cryosolic	Turbic Cryosol	Orthic Turbic Cryosol O.TC Brunisolic Turbic Cryosol BR.TC Regosolic Turbic Cryosol R.TC Gleysolic Turbic Cryosol GL.TC
	Static Cryosol	Orthic Static Cryosol O.SC Brunisolic Static Cryosol BR.SC Regosolic Static Cryosol R.SC Gleysolic Static Cryosol GL.SC
	Organic Cryosol	Fibric Organic Cryosol FI.OC Mesic Organic Cryosol ME.OC Humic Organic Cryosol HU.OC Terric Fibric Organic Cryosol TFI.OC Terric Mesic Organic Cryosol TME.OC Terric Humic Organic Cryosol THU.OC Glacic Organic Cryosol GC.OC
Gleysolic	Luvic Gleysol	Solonetzic Luvic Gleysol SZ.LG Fragic Luvic Gleysol FR.LG Humic Luvic Gleysol HU.LG Fera Luvic Gleysol FE.LG Orthic Luvic Gleysol O.LG
	Humic Gleysol	Solonetzic Humic Gleysol SZ.HG Fera Humic Gleysol FE.HG Orthic Humic Gleysol O.HG Rego Humic Gleysol R.HG
	Gleysol	Solonetzic Gleysol SZ.G Fera Gleysol FE.G Orthic Gleysol O.G Rego Gleysol R.G
Luvisolic	Gray Brown Luvisol	Orthic Gray Brown Luvisol O.GBL Brunisolic Gray Brown Luvisol BR.GBL Podzolic Gray Brown Luvisol PZ.GBL Gleyed Gray Brown Luvisol GL.GBL Gleyed Brunisolic Gray Brown Luvisol GLBR.GBL Gleyed Podzolic Gray Brown Luvisol GLPZ.GBL

Order	*Great Group*	*Subgroup*
Luvisolic	Gray Luvisol	Orthic Gray Luvisol O.GL Dark Gray Luvisol D.GL Brunisolic Gray Luvisol BR.GL Podzolic Gray Luvisol PZ.GL Solonetzic Gray Luvisol SZ.GL Fragic Gray Luvisol FR.GL Gleyed Gray Luvisol GL.GL Gleyed Dark Gray Luvisol GLD.GL Gleyed Brunisolic Gray Luvisol GLBR.GL Gleyed Podzolic Gray Luvisol GLPZ.GL Gleyed Solonetzic Gray Luvisol GLSZ.GL Gleyed Fragic Gray Luvisol GLFR.GL
Organic	Fibrisol	Typic Fibrisol TY.F Mesic Fibrisol ME.F Humic Fibrisol HU.F Limno Fibrisol LM.F Cumulo Fibrisol CU.F Terric Fibrisol T.F Terric Mesic Fibrisol TME.F Terric Humic Fibrisol THU.F Hydric Fibrisol HY.F
	Mesisol	Typic Mesisol TY.M Fibric Mesisol FI.M Humic Mesisol HU.M Limno Mesisol LM.M Cumulo Mesisol CU.M Terric Mesisol T.M Terric Fibric Mesisol TFI.M Terric Humic Mesisol THU.M Hydric Mesisol HY.M
	Humisol	Typic Humisol TY.H Fibric Humisol FI.H Mesic Humisol ME.H Limno Humisol LM.H Cumulo Humisol CU.H Terric Humisol T.H Terric Fibric Humisol TFI.H Terric Mesic Humisol TME.H Hydric Humisol HY.H
	Folisol	Hemic Folisol HE.FO Humic Folisol HU.FO Lignic Folisol LI.FO Histic Folisol HI.FO
Podzolic	Humic Podzol	Orthic Humic Podzol O.HP Ortstein Humic Podzol OT.HP Placic Humic Podzol P.HP Duric Humic Podzol DU.HP Fragic Humic Podzol FR.HP

Order	*Great Group*	*Subgroup*
Podzolic	Ferro-Humic Podzol	Orthic Ferro-Humic Podzol O.FHP
		Ortstein Ferro-Humic Podzol OT.FHP
		Placic Ferro-Humic Podzol P.FHP
		Duric Ferro-Humic Podzol DU.FHP
		Fragic Ferro-Humic Podzol FR.FHP
		Luvisolic Ferro-Humic Podzol LU.FHP
		Sombric Ferro-Humic Podzol SM.FHP
		Gleyed Ferro-Humic Podzol GL.FHP
		Gleyed Ortstein Ferro-Humic Podzol GLOT.FHP
		Gleyed Sombric Ferro-Humic Podzol GLSM.FHP
	Humo-Ferric Podzol	Orthic Humo-Ferric Podzol O.HFP
		Ortstein Humo-Ferric Podzol OT.HFP
		Placic Humo-Ferric Podzol P.HFP
		Duric Humo-Ferric Podzol DU.HFP
		Fragic Humo-Ferric Podzol FR.HFP
		Luvisolic Humo-Ferric Podzol LU.HFP
		Sombric Humo-Ferric Podzol SM.HFP
		Gleyed Humo-Ferric Podzol GL.HFP
		Gleyed Ortstein Humo-Ferric Podzol GLOT.HFP
		Gleyed Sombric Humo-Ferric Podzol GLSM.HFP
Regosolic	Regosol	Orthic Regosol O.R
		Cumulic Regosol CU.R
		Gleyed Regosol GL.R
		Gleyed Cumulic Regosol GLCU.R
	Humic Regosol	Orthic Humic Regosol O.HR
		Cumulic Humic Regosol CU.HR
		Gleyed Humic Regosol GL.HR
		Gleyed Cumulic Humic Regosol GLCU.HR
Solonetzic	Solonetz	Brown SolonetzB.SZ
		Dark Brown Solonetz DB.SZ
		Black Solonetz BL.SZ
		Alkaline Solonetz A.SZ
		Gleyed Brown Solonetz GLB.SZ
		Gleyed Dark Brown Solonetz GLDB.SZ
		Gleyed Black Solonetz GLBL.SZ
	Solodized Solonetz	Brown Solodized Solonetz B.SS
		Dark Brown Solodized Solonetz DB.SS
		Black Solodized Solonetz BL.SS
		Dark Gray Solodized Solonetz DG.SS
		Gray Solodized Solonetz G.SS
		Gleyed Brown Solodized Solonetz GLB.SS
		Gleyed Dark Brown Solodized Solonetz GLDB.SS
		Gleyed Black Solodized Solonetz GLBL.SS
		Gleyed Dark Gray Solodized Solonetz GLDG.SS
		Gleyed Gray Solodized Solonetz GLG.SS
	Solod	Brown Solod B.SO
		Dark Brown Solod DB.SO
		Black Solod BL.SO
		Dark Gray Solod DG.SO

Order	*Great Group*	*Subgroup*
Solonetzic	Solod	Gray Solod G.SO Gleyed Brown Solod GLB.SO Gleyed Dark Brown Solod GLDB.SO Gleyed Black Solod GLBL.SO Gleyed Dark Gray Solod GLDG.SO Gleyed Gray Solod GLG.SO

Appendix 4. Glossary of Terms (Agriculture Canada 1976; Soil Conservation Society of America 1976)

Bnt A subsurface horizon enriched with sodium and clay.

Bt A subsurface horizon enriched with clay.

catena A non taxonomic grouping of a sequence of soils of about the same age, derived from similar materials and occurring under similar climatic conditions, but having unlike characteristics because of variations in relief and drainage.

chroma The relative purity, strength or saturation of color. It is directly related to the dominance of the determining wavelength of light.

great group A category in the Canadian system of soil classification. It is a taxonomic group of soils having certain morphological features in common and a similar pedogenic environment.

horizon A layer of soil or soil material approximately parallel to the land surface; it differs from adjacent genetically related layers in properties such as color, structure, texture, consistence and chemical, biological and mineralogical composition.

order A category in tbe Canadian system of soil classification. There are nine soil orders in Canada. All soils within an order have one or more characteristics in common.

pedon The smallest volume that can be called a soil. It has three dimensions. It extends downward to the depth of the plant roots or to the lower limit of the genetic soil horizons. Its lateral cross section is roughly hexagonal and ranges from 1 to 10 square meters in size depending on the variability in the horizons.

profile A vertical section of the soil through all its horizons and extending into the parent material.

series A category in the Canadian system of soil classification. This is the basic unit of soil classification and consists of soils that are essentially alike in all major profile characteristics except the texture of the surface.

subgroup A category in the Canadian system of soil classification. These soils are subdivisions of the great groups and therefore each soil is defined more specifically.

value The relative lightness of color, which is approximately a function of the square root of the total amount of light.