Alberta Benchmark Site Selection and Sampling Protocols

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AESA Soil Quality Resource Monitoring Program

September 2002

ACKNOWLEDGEMENTS

The AESA Soil Quality Benchmark Program is indebted to the AESA Program for funding in establishing the provincial benchmark site program. The AESA Program has been instrumental for the continuation of the benchmark program in Alberta.

I would like to especially thank each of the owner/operators of the benchmark sites for their on-going cooperation in the Soil Quality Benchmark Program. This program benefits from their willingness to be participants and their contributions are greatly appreciated!

Members of the Soil Quality Committee are acknowledged for their support and guidance in developing the benchmark program.

Many people and several organizations have contributed to the benchmark program over the past five years. It takes incredible coordination across numerous individuals to get the annual yield and soil sampling completed. Their continuing participation is important for the success of the benchmark program.

- For soil profile descriptions and initial site characterization: CAN-AG Enterprises Ltd.
- For assistance in site selection, annual plant and soil sampling: AAFRD Regional Conservation Teams from each of the five provincial regions
  - Peace Region: Randy Perkins and John Zylstra
  - Northwest Region: Tara Golby, Ben Froebel, Carrie Selin, Dave Burdek and Janet Dietrich
  - Northeast Region: Kathy Hendren, Kevin Yaremchuk, Dale Chrapko, and Janet Dietrich
  - Central Region: Christine Sweet, Karen Yakimishyn, Tom Shultz, Annette Svederus and Shayne Steffen
  - South Region: Wally Sawchuk, Rob Dunn, Bryce Surina, Connie Tomas and Delaney Anderson
- For chemical and physical analyses of soil and plant material
  - Norwest Labs Ltd., Edmonton
  - University of Alberta Renewable Resources Lab, Edmonton
  - Soil and Crop Unit, Agri-Food Laboratories Branch, AAFRD
- For yield threshing: Kelsey Spicer, Lisa Simpson, Germar Lohstraeter, Jody Winder and Kerrianne Koehler-Munro
- For GPS and GIS support: Annette Svederus and Germar Lohstraeter

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1.0 INTRODUCTION

Soil quality is important to support and sustain crop, range and woodland production. It is also important to maintain other resources such as water, air and wildlife habitat. Soils vary in quality due to external factors such as land use, management and environmental interactions. Maintaining and improving soil quality has been identified as a priority by industry stakeholders and is one of the key elements in the Alberta Environmentally Sustainable Agriculture (AESA) Program. Increasing awareness of the environment and our use of natural resources led to the establishment of the AESA Soil Quality Monitoring Program in 1997.

The AESA program was built on work completed under the Canada-Alberta Environmentally Sustainable Agriculture (CAESA) Soil Quality Program (1994-1997) where data was collected on wind and water erosion, salinity, organic matter, and land use. Soil parameters on four national benchmark sites across Alberta were also monitored. There are three goals for the AESA Soil Quality Monitoring Program. The first is to determine the state of soil quality across Alberta. The second is to determine the risk of change in soil quality with various management practices. The third is to determine how soil quality integrates into environmental sustainability.

Members of the Soil Quality Committee provide the program with guidance and support with the necessary scientific and technical expertise. The Soil Quality Committee members are:

Tom Goddard (Chairman)	Conservation and Development, AAFRD
Gerald Coen	Land Resources Unit, AAFC
Yongsheng Feng	Department of Renewable Resources, U of A
Frank Hecker	Irrigation Branch, AAFRD
Noorallah Juma	Department of Renewable Resources, U of A
Len Kryzanowski	Agronomy Unit, AAFRD
Karen Cannon (Coordinator)	Conservation and Development, AAFRD

In January 1998, a Soil Quality Workshop was held to provide advice for development of the AESA Soil Quality Resource Monitoring Program (AESA Soil Quality Committee 1998). Workshop attendees, involved in soil quality research and initiatives, were invited from the University of Alberta, Agriculture Canada, and branches of Alberta Agriculture, Food and Rural Development. Workgroup sessions were set up to determine what key variables should be used as indicators for measuring soil quality, to describe a sampling scheme for monitoring soil quality across Alberta and to discuss the issue of how to handle samples being collected at different scales.

Workshop participants agreed that modeling would be a key strategy/technique to assess soil quality on a provincial scale. In order to verify modeled estimates, a cross-validation dataset is required representing the range of conditions across Alberta. Once these sites are established some basic data could be collected annually to verify any long term temporal changes.

Long-term soil sampling was started in the fall of 1998 in order to monitor soil quality across Alberta landscapes. The Conservation and Development Branch of Alberta Agriculture, Food and Rural Development (AAFRD) through partnerships between other AAFRD staff, has selected 43 soil quality benchmark sites. Monitoring of the benchmark sites is part of the AESA Soil Quality Monitoring Program initiative.

The purpose of this report is to document the benchmark site selection and sampling procedures.

2.0 SOIL QUALITY BENCHMARK OBJECTIVES

The main objectives of the fall benchmark sampling across Alberta are to:

- provide baseline soil information
- evaluate landscape effects on soil quality
- provide a dataset to test and validate simulation models (i.e. crop growth, wind erosion, water erosion, etc.)
- monitor changes in soil quality over time on a field landscape basis

As well as providing data for modeling, the benchmark sites will give an indication of year to year changes in soil fertility status at the same point. They will also provide data on the landscape effects upon soil properties.

3.0 METHOD OF BENCHMARK SELECTION AND CHARACTERIZATION

3.1 Criteria

The January 1998 Soil Quality Workshop participants recommended that an annual soil and crop sampling should occur at the ecodistrict level (Figure 1). About 1/3 of the 100 ecodistricts in the agricultural area, distributed geographically across the province, would be monitored. Samples should be stratified by major land use and landscape patterns. The participants also felt that the sites should have long-term security and that there would be as little as possible interference to the farmer during the growing season.

Benchmarks were spatially stratified in accordance with the national ecostratification network (Ecological Stratification Working Group 1995) to take advantage of other databases and provide a basis for comparison with other initiatives. Ecodistricts were chosen as the scale to monitor the benchmarks because at a provincial scale a finer degree of resolution is not always informative and the available range of databases diminishes rapidly at a finer scale.

The AESA Soil Quality Committee developed criteria to guide the selection of the benchmark sites. The goal was to monitor about forty ecodistricts, geographically spread across all ecoregions in the agricultural area of Alberta. The benchmark sites were to occur only on cultivated land and be representative of soil-landscape patterns of ecodistrict, and land-use in ecodistrict

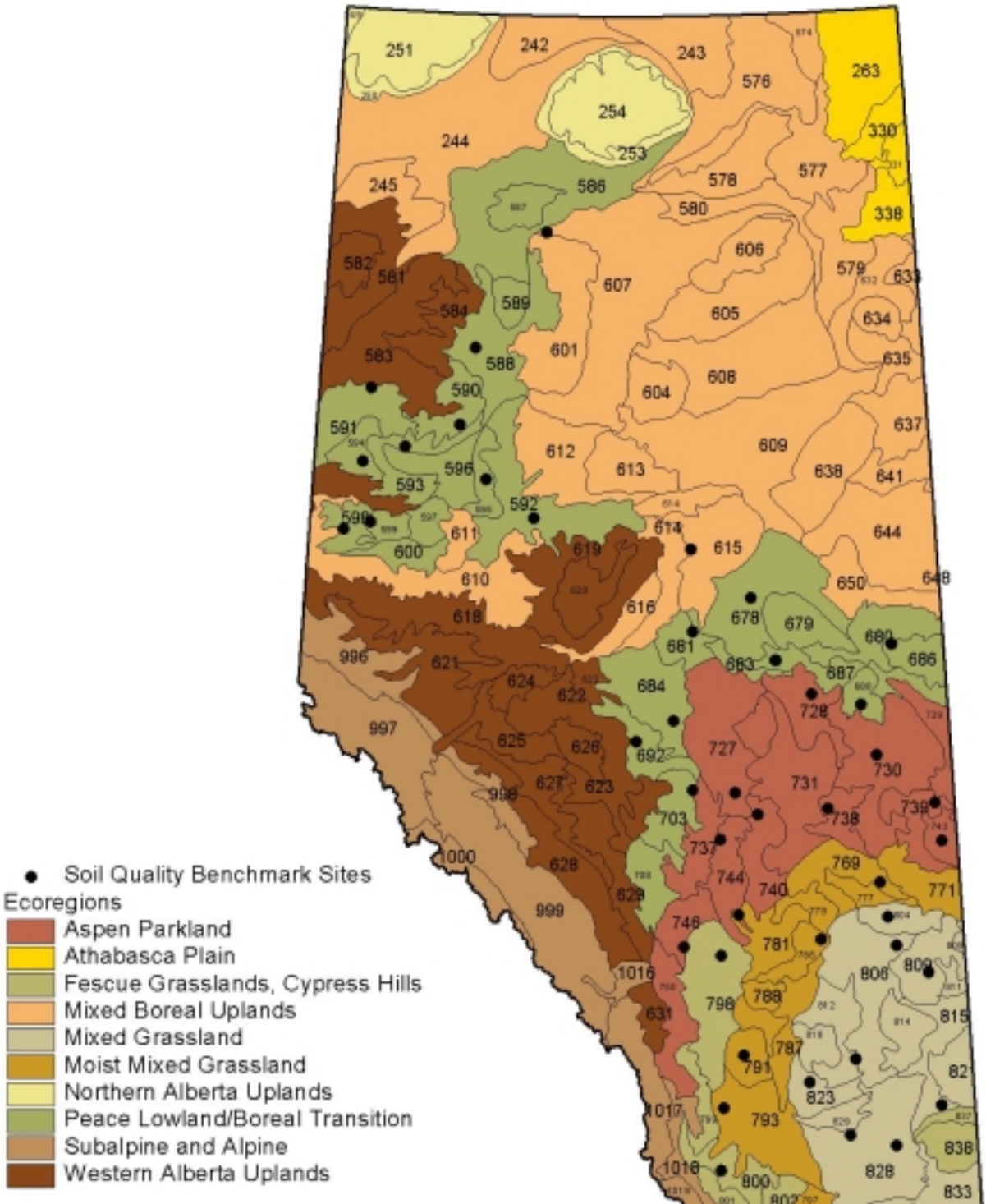

Figure 1. Location of Benchmark Sites, Ecoregions and Ecodistricts in Alberta.

The AESA Soil Quality Committee wanted to avoid the following areas:

- headlands
- pipeline right-of-ways
- water courses
- field corners, and
- areas of weed infestations

3.2 Benchmark Site Selection

Soils and landscape information for Alberta ecodistricts was obtained using the *Agricultural Region of Alberta Soil Inventory Database* (AGRASID) (CAESA-Soil Inventory Project Working Group 1998) as well as *The National Ecological Framework For Canada* (Ecological Stratification Working Group 1995). Characteristic surface landforms, soil textures and soil types were identified for each ecodistrict (Appendix 7.1) and used in the site selection process.

Assistance with site selection was obtained from the AAFRD Regional Conservation Coordinators and Technicians. They made the initial contact and request with cooperative farmers/landowners of potential fields for the sites. Cooperation is required because of the annual agronomic information supplied to the benchmark program by the farmer. Potential fields were selected in 1998 and 1999.

3.3 Preliminary Interpretation and Field Preparation

The benchmark coordinator and AESA regional conservation staff initially located the sites using characteristic ecodistrict information. Benchmark sites were located in each field with differential global positioning system (DGPS) to permit positioning in subsequent sampling years. Legal descriptions of the sites were also recorded. In addition to the legal description, a general description and air-photo showing the approximate location of the sampling points were documented.

3.4 Field Soil Inspection and Description

Each benchmark site consisted of three sample locations at an upper, mid and lower slope position along a catena (transect). Profile descriptions and site characteristics were completed for each of the landscape positions within the benchmark site by a pedologist under contract with AAFRD (Can-Ag Enterprises Ltd.). This was done to ensure that each of the benchmark sites was representative of the ecodistrict in which it was located.

Can-Ag conducted the initial soil inspections of 20 benchmarks between September 22 and October 6, 1998. Twenty-two more site inspections were conducted between September 30 and November 23, 1999. One last site inspection was carried out on November 2, 2000. The inspections were done, after harvest and late in the fall when soils were relatively dry, but not frozen.

Soil profiles along a transect at upper, mid and lower landscape positions were examined and sampled to a depth of 100 cm and classified according to *The Canadian System of Soil Classification, 3rd Edition* (Soil Classification Working Group 1998). At each site a drop sheet with a 30 cm hole was placed on the ground. The site description pit was dug through this hole and soil from each of the principle horizons was placed on the sheet in the order it was obtained (Figure 2). After site characterization, the soil was replaced, by principle horizon, so that no extra soil was deposited at the site.

Figure 2. Site characterization.

At each landscape position topsoil depth was measured at eight points in a 2 to 3 m radius from the center of the classification pit to determine the variation in topsoil depth. Pedon descriptions included parent geological material, pedological horizons and thickness, color, texture, structure, consistence, and vegetation rooting characteristics. Landscape descriptions were conducted noting slope position, drainage, stoniness, aspect, present erosion, and moisture regime of the site (Can-Ag Enterprises Ltd. 2000).

Soil samples of each of the principle horizons (A, B, BC and/or C) were collected and delivered to Norwest Labs Ltd., Edmonton for analysis. Analyses to characterize each site included: particle size analysis (texture) by hydrometer; cation exchange capacity (CEC); pH in $CaCl_2$; pH in H_2O; EC in saturated paste extract; SAR calculated from soluble Ca, Mg, and Na ions of the saturated paste extract (when EC > 4); available NH_4, NO_3-N, P, K and SO_4-S; total nitrogen; organic carbon; and calcium carbonate ($CaCO_3$).

Standard methods of analysis for pedological characterization were used (Appendix 9.2). Some topsoil characteristics are shown in Appendix 9.3.

Bulk density samples of topsoil were taken in duplicate at a depth of 3 to 15 cm, and in subsoil at a depth of 20 cm to 50 cm. These samples were collected and delivered to AAFRD for dry weight determinations. The bulk density cores were 7.6 cm high x 7.5 cm in diameter.

Photographs of each soil pit and transect location were taken (Can-Ag Enterprises Ltd. 2000).

4.0 DESCRIPTION OF BENCHMARK SITES

4.1 Location

The 43 benchmark sites are located throughout the cultivated area (white area) of the province. They lie within the Boreal Plains and Prairies ecozones and represent the following seven ecoregions: Peace Lowlands, Mid-Boreal Uplands, Boreal Transition, Aspen Parkland, Moist Mixed Grassland, Fescue Grassland, and Mixed Grassland (Table 1, Figure 1).

Table 1. Grouping of benchmarks by ecoregion and ecozone..

Ecozone	**Ecoregion**	**Ecodistricts**
Boreal Plains	Peace Lowland	586, 588, 590, 591, 592, 593, 594, 595, 598, 599
	Mid-Boreal Uplands	615
	Boreal Transition	678, 680, 681, 684, 687, 688, 692, 703
Prairies	Aspen Parkland	727, 728, 730, 738, 739, 740, 743, 744, 746
	Moist Mixed Grassland	769, 781, 786, 791, 793
	Fescue Grassland	798, 800
	Mixed Grassland	804, 806, 809, 812, 815, 823, 828A, 828B

The site numbers correlate with ecodistricts as described by Ecological Stratification Working Group (1995).

4.3 Ecodistrict Representation

Ecodistricts for each site were examined based on characteristics described in *The National Ecological Framework for Canada* (Ecological Stratification Working Group 1995). Their dominant, subdominant and inclusive characteristics and the characteristics of each of the benchmark sites are noted in Table 2 for comparison (Can-Ag Enterprises Ltd. 2000). Detailed soil survey data was collected and presented in soil survey data sheets (Can-Ag Enterprises Ltd. 2000).

Table 2. Salient Features of Ecodistricts and Benchmark Sites.

Ecodistrict	Surface Form	Parent Material Texture	Soil Subgroup	Land Use
Peace Lowland Ecoregion				
High Level Plain	Undulating (81)[1] Level (16)	clay (45) loam (33) organic (15) clay loam (6)	Gray Luvisol (41) Gray Solonetz (20) Gleysol (16) Mesisol (9)	Broadleaf forest (39) Cultivated (34) Mixed forest (19) coniferous forest (8)
Site 586	Level	silty clay loam clay	Dark Gray Luvisol (upper) Gleyed Dark Gray Luvisol (mid and lower)	cultivated
Selected site has more organic matter (darker A horizon) than dominant soils (Orthic Gray Luvisols) within the ecodistrict.				
Manning Plain	Undulating (82) Dissected (6) Hummocky (6) Level (5)	clay loam (49) clay (39)	Gray Luvisol (61) Dark Gray Chernozem/Luvisol (17) Regosol (8) Gleysol (8)	broadleaf forest (59) cultivated (20) mixed forest (14) coniferous forest (6)
Site 588	Gentle slopes	Clay	Orthic Gray Luvisol (upper) Dark Gray Luvisol (mid) Gleyed Dark Gray Luvisol (lower)	cultivated
Selected site is a good representative of Orthic and Dark Gray Luvisols within ecodistrict.				
Grimshaw Plain	Undulating (91) Level (5)	clay loam (69) clay (25) organic (5)	Gray Luvisol (62) Dark Gray Chernozem/Luvisol (26) Gleysol (7) Mesisol (5)	broadleaf forest (39) cultivated (34) mixed forest (19) coniferous forest (8)
Site 590	Very gentle slopes	clay loam	Dark Gray Luvisol (upper, mid and lower)	cultivated
Selected site is a good representative of Dark Gray Luvisols within ecodistrict.				
Peace Lowland	Undulating (53) Level (16) Sloping (14) Rolling (8) Hummocky (6)	clay (48) clay loam (19) loam (18) organic (6) sand (6)	Gray Luvisol (28) Brunisolic Gray Luvisol (21) Dark Gray Chernozem/Luvisol (18) Gleysol (9) Regosol (8) Gray Solonetz (7) Mesisol (5)	cultivated (35) mixed forest (32) broadleaf forest (28) coniferous forest (5)
Site 591	Gentle slopes	clay loam silty clay loam loamy sand	Dark Gray Chernozem (upper and mid) Gleyed Dark Gray Chernozem (lower)	cultivated
Selected site is a good representative of Dark Gray Chernozems within ecodistrict.				
McLennan Plain	Undulating (73) Level (12) Rolling (7) Hummocky (6)	clay loam (41) clay (30) loam (15) organic (7) sandy loam (5)	Gray Luvisol (71) Gleysol (9) Regosol (6) Mesisol (5)	broadleaf forest (48) cultivated (25) mixed forest (20) coniferous forest (7)
Site 592	Level	Loam clay loam	Gleyed Black Chernozem (upper and lower) Gleyed Eluviated Black Chernozem (mid)	cultivated
Selected site has more organic matter (darker A horizon) than dominant soils (Gray Luvisols) within the ecodistrict.				

[1]Numbers in brackets indicate percentage values of dominance.

Table 2: Continued…

Ecodistrict	Surface Form	Parent Material Texture	Soil Subgroup	Land Use
Peace Lowland Ecoregion				
Rycroft Plain	undulating (80) hummocky (12)	clay (64) clay loam (16) sandy loam (10) loam (9)	Dark Gray Chernozem/Luvisol (51) Gray Luvisol (21) Black Chernozem (10) Black Solonetz (6)	broadleaf forest (84) cultivated (12)
Site 593	level	clay	Solonetzic Dark Gray Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of Black Chernozemic soils within ecodistrict.				
Blueberry Upland	undulating (98)	clay (98)	Gray Luvisol (57) Gleysol (19) Dark Gray Chernozem/Luvisol (16) Gray Solonetz (7)	cultivated (45) mixed forest (26) broadleaf forest (26)
Site 594	moderate slopes	clay	Orthic Gray Luvisol (upper and mid) Gleyed Gray Luvisol (lower)	cultivated
Selected site is a good representative of Orthic Gray Luvisols within ecodistrict.				
Fahler Plain	undulating (95)	clay (87) clay loam (9)	Dark Gray Chernozem/Luvisol (44) Gray Luvisol (42) Gleysol (8) Regosol (5)	cultivated (84) broadleaf forest (16)
Site 595	nearly level	clay	Orthic Dark Gray Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Beaverlodge Plain	undulating (94) rolling (5)	clay (73) clay loam (20)	Dark Gray Chernozem/Luvisol (43) Gray Luvisol (22) Black Chernozem (16) Black Solonetz (15)	cultivated (85) mixed forest (7) broadleaf forest (7)
Site 598	very gentle slopes	clay loam clay	Dark Gray Luvisol (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Grande Prairie Plain	undulating (91) rolling (9)	clay (85) clay loam (13)	Black Chernozem (81) Black Solonetz (8) Dark Gray Chernozem/Luvisol (7)	cultivated (96)
Site 599	nearly level slopes	clay	Solonetzic Black Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of Solonetzic Black Chernozems within ecodistrict.				
Mid Boreal Uplands Ecoregion				
Cross Lake Upland	hummocky (43) undulating (26) level (22)	clay loam (65) organic (23) sandy loam (8)	Gray Luvisol (72) Mesisol (15) Fibrisol (15)	coniferous forest (43) mixed forest (31) broadleaf forest (20) cultivated (6)
Site 615	very gentle slopes	clay loam	Orthic Gray Luvisol (upper and mid) Humic Luvic Gleysol (lower)	cultivated
Selected site is a good representative of Orthic Gray Luvisols within ecodistrict.				

Table 2: Continued…

Ecodistrict	Surface Form	Parent Material Texture	Soil Subgroup	Land Use
Boreal Transition Ecoregion				
Athabasca Plain	undulating (54) level (30) hummocky (10)	clay loam (52) organic (30) sandy loam (11)	Gray Luvisol (48) Fibrisol (22) Dark Gray Chernozem/Luvisol (8)	mixed forest (47) cultivated (31) broadleaf forest (19)
Site 678	very gentle slopes	clay clay loam	Orthic Gray Luvisol (upper and mid) Dark Gray Luvisol (lower)	cultivated
Selected site is a good representative of Orthic and Dark Gray Luvisols within ecodistrict.				
Beaver River Plain	undulating (50) hummocky (35) dissected (6)	clay loam (56) loam (26) sand (7)	Gray Luvisol (62) Dark Gray Chernozem/Luvisol (13)	broadleaf forest (48) cultivated (35) mixed forest (15)
Site 680	very gentle slopes	clay loam	Dark Gray Luvisol (upper and mid) Orthic Dark Gray Chernozem (lower)	cultivated
Selected site is a good representative of Dark Gray Luvisols and Dark Gray Chernozems within ecodistrict.				
Westlock Plain	undulating (77) level (12)	clay loam (63) loam (20)	Dark Gray Chernozem/Luvisol (34) Black Chernozem (21) Gray Luvisol (15)	cultivated (84) range land and pasture (13)
Site 681	nearly level undulating	clay loam	Dark Gray Luvisol (upper and mid) Gleyed Dark Gray Luvisol (lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Lac Ste Anne Upland	hummocky (44) rolling (30) undulating (16)	clay loam (78) loam (11)	Gray Luvisol (61) Dark Gray Chernozem/Luvisol (15) Black Chernozem (6)	range land and pasture (86)
Site 684	level undulating gentle slopes	clay loam silty clay loam	Orthic Gray Luvisol (upper) Dark Gray Luvisol (mid) Gleyed Black Chernozem (lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Onion Lake Plain	undulating (53) hummocky (38)	clay loam (43) loam (42) sandy loam (9)	Dark Gray Chernozem/Luvisol (65) Gray Luvisol (15) Black Chernozem (9)	cultivated (74) range land and pasture (12) mixed forest (8) broadleaf forest (5)
Site 687	undulating very gentle slopes	sandy clay loam silty clay loam	Eluviated Black Chernozem (upper and mid) Gleyed Eluviated Black Chernozem (lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Myrnam Upland	hummocky (74) undulating (14)	clay loam (86) sandy loam (8)	Gray Luvisol (65) Dark Gray Chernozem/Luvisol (23) Black Chernozem (6)	crop land (79) range land and pasture (21)
Site 688	very gentle slopes undulating	sandy loam	Orthic Dark Gray Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of sandy soils within ecodistrict.				
Breton Upland	undulating (39) hummocky (28) rolling (19)	clay loam (62) clay (14) loam (13)	Gray Luvisol (59), Dark Gray Chernozem/Luvisol (14)	range land and pasture (85), mixed forest (12)
Site 692	undulating	clay silt	Orthic Gray Luvisol (upper and mid) Gleyed Dark Gray Luvisol (lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				

Table 2: Continued…

Ecodistrict	Surface Form	Parent Material Texture	Soil Subgroup	Land Use
Rimbey Upland	rolling (47) undulating (28)	clay (83) loam (9)	Gray Luvisol (73) Dark Gray Chernozem/Luvisol (13)	range land and pasture (80) cultivated (14)
Site 703	undulating very gentle slopes	clay loam silty clay loam	Dark Gray Luvisol (upper and mid) Humic Luvic Gleysol (lower)	pasture
Selected site is a good representative of cultivated land within ecodistrict.				
Aspen Parkland Ecoregion				
Leduc Plain	undulating (78) hummocky (14)	clay loam (62), loam (18),	Black Chernozem (61), Dark Gray Chernozem/Luvisol (13)	cultivated (78), pasture land (14)
Site 727	Undulating nearly level to very gentle slopes	clay loam silty clay loam	Eluviated Black Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Andrew Plain	undulating (82) hummocky (15)	clay loam (73) loam (14)	Black Chernozem (72)	cultivated (99)
Site 728	undulating very gentle slopes	clay loam	Eluviated Black Chernozem (upper) Orthic Black Chernozem (mid) Gleyed Eluviated Black Chernozem (lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Vermillion Upland	hummocky (82) undulating (12)	clay loam (78) sandy loam (11)	Black Chernozem (66) Dark Brown Chernozem (18)	cultivated (80) range land and pasture (20)
Site 730	hummocky moderate slopes	clay loam loam	Eluviated Black Chernozem (upper and mid) Gleyed Eluviated Black Chernozem (lower)	cultivated range and pasture land
Selected site is a good representative of cultivated land within ecodistrict.				
Sedgewick Plain	undulating (78) hummocky (18)	clay loam (89) loam (6)	Black Chernozem (35) Black Solonetz (30)	cultivated (96)
Site 738	nearly level undulating	loam	Orthic Black Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Ribstone Plain	hummocky (74) undulating (26)	sand (53) sandy loam (27) loam (11) clay loam (9)	Dark Brown Chernozem (66) Regosol (22) Black Chernozem (9)	range and pasture land (83) cultivated (17)
Site 739	very strong slopes	very fine sandy loam	Orthic Black Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Bashaw Upland	hummocky (57) undulating (22) ridged (10) rolling (6) dissected (5)	clay loam (74) sandy loam (13) loam (10)	Black Chernozem (76) Dark Brown Chernozem (10) Regosol (7)	cultivated (70) range and pasture land (22)
Site 740	undulating nearly level very gentle slopes	clay loam loam	Orthic Black Chernozem (upper and mid) Gleyed Rego Black Chernozem (lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict, but topsoil has higher levels of organic matter.				

Table 2: Continued…

Ecodistrict	Surface Form	Parent Material Texture	Soil Subgroup	Land Use
Provost Plain	undulating (71) hummocky (26)	loam (45) clay loam (32) sandy loam (15) sand (5)	Dark Brown Chernozem (96)	cultivated (72) range and pasture land (28)
Site 743	very strong slopes	clay loam clay	Calcareous Dark Brown (upper and mid) Orthic Dark Brown Chernozem (lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Pine Lake Upland	hummocky (42) rolling (34)	clay loam (77) loam (13)	Black Chernozem (77) Dark Gray Chernozem/Luvisol (17)	cultivated (85) range and pasture land (15)
Site 744	very strong slopes	clay loam	Orthic Black Chernozem (upper) Eluviated Black Chernozem (mid) Gleyed Black Chernozem (lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Ecodistrict	**Surface Form**	**Parent Material Texture**	**Soil Subgroup**	**Land Use**
Olds Plain	undulating (67) rolling (28)	clay loam (78) loam (19)	Black Chernozem (99)	cultivated (87) range and pastureland (13)
Site 746	undulating moderate slopes	clay loam loam	Orthic Black Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Moist Mixed Grassland Ecoregion				
Castor Plain	undulating (71) hummocky (20)	clay loam (89) sandy loam (7) loam (6)	Dark Brown Solonetz (77) Dark Brown Chernozem (21)	cultivated (77) range and pasture land (23)
Site 769	very gentle slopes undulating	loam	Orthic Dark Brown Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of Dark Brown Chernozems within ecodistrict.				
Drumheller Plain	rolling (35) undulating (35)	clay (49) clay loam (33)	Dark Brown Chernozem (71) Black Chernozem (13)	cultivated range and pasture land
Site 781	very gentle slopes undulating	clay clay loam	Orthic Black Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of Black Chernozems within ecodistrict.				
Wintering Hills	hummocky (56) dissected (18) rolling (13)	clay loam (84) loam (14)	Dark Brown Chernozem (73) Dark Brown Solonetz (16)	cultivated (71) range and pasture land (29)
Site 786	undulating rolling moderate slopes	loamy sand loam	Rego Dark Brown Chernozem (upper) Orthic Dark Brown Chernozem (mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Vulcan Plain	rolling (54) hummocky (28) undulating (18)	loam (63) clay loam (37)	Dark Brown Chernozem (92) Black Chernozem (8)	cultivated (94) range and pasture land (6)
Site 791	strong slopes	loam	Orthic Dark Brown Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				

Table 2: Continued…

Ecodistrict	Surface Form	Parent Material Texture	Soil Subgroup	Land Use
Lethbridge Plain	undulating (80) dissected (13)	loam (60) clay loam (27) sandy loam (8)	Dark Brown Chernozem (89) Regosol (8)	cultivated (84) range and pasture land (16)
Site 793	nearly level	loam	Calcareous Dark Brown Chernozem (upper) Orthic Dark Brown Chernozem (mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Fescue Grassland Ecoregion				
Delacour Plain	undulating (75) rolling (20)	clay loam (66) loam (24)	Black Chernozem (72) Dark Brown Chernozem (25)	cultivated (96)
Site 798	nearly level undulating	loam	Calcareous Black Chernozem (upper) Orthic Black Chernozem (mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Ecodistrict	**Surface Form**	**Parent Material Texture**	**Soil Subgroup**	**Land Use**
Cardston Plain	undulating (45) rolling (29) hummocky (24)	clay loam (66) loam (24)	Black Chernozem (88)	cultivated (83) range and pasture land (14)
Site 800	very gentle slopes	clay	Orthic Black Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Mixed Grassland Ecoregion				
Sounding Creek Plain	undulating (79) hummocky (21)	clay loam (54) sandy loam (30) sand (14)	Brown Solonetz (69) Brown Chernozem (14) Regosol (8) Dark Brown Chernozem (6)	cultivated (74) range and pasture land (26)
Site 804	gentle slopes	clay loam loam	Orthic Dark Brown Chernozem (upper and mid) Solonetzic Dark Brown Chernozem (lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Berry Creek Plain	hummocky (50) undulating (43) dissected (8)	clay loam (85) loam (11)	Brown Solonetz (75) Brown Chernozem (10) Dark Brown Chernozem (9)	cultivated (53) range and pasture land (47)
Site 806	gentle slopes	clay loam loam	Orthic Brown Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Oyen Upland	hummocky (81) undulating (15)	clay loam (67) loam (23) sandy loam (7)	Brown Chernozem (66) Dark Brown Chernozem (15) Brown Solonetz (15)	range and pasture land (60) cultivated (40)
Site 809	gentle slopes	clay loam loam	Orthic Brown Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				

Table 2: Continued…

Ecodistrict	Surface Form	Parent Material Texture	Soil Subgroup	Land Use
Brooks Plain	undulating (88) hummocky (8)	sandy loam (30) loam (28) sand (26) clay loam (16)	Brown Chernozem (84) Regosol (11) Brown Solonetz (5)	cultivated (53) range and pasture land (47)
Site 812	level	sandy clay loam loam sandy loam	Calcareous Brown Chernozem (upper, mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Bindloss Plain	hummocky (40) undulating (37) dissected (22)	loam (59) sand (20) sandy loam (19)	Brown Chernozem (61) Regosol (39)	range and pasture land (78) cultivated (21)
Site 815	strong slopes	clay loam sandy loam	Calcareous Brown Chernozem (upper and mid) Eluviated Brown Chernozem (lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Ecodistrict	**Surface Form**	**Parent Material Texture**	**Soil Subgroup**	**Land Use**
Vauxhall Plain	undulating (95)	loam (44) clay loam (31) sandy loam (25)	Brown Chernozem (93)	cultivated (53) range and pasture land (47)
Site 823	nearly level	clay loam silty clay loam	Calcareous Brown Chernozem (upper) Orthic Brown Chernozem (mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Foremost Plain	undulating (44) hummocky (41) dissected (10) rolling (5)	loam (51) clay loam (46)	Brown Chernozem (84) Regosol (15)	cultivated (53) range and pasture land (47)
Site 828A	very gentle slopes	Loam clay loam	Rego Brown Chernozem (upper) Orthic Brown Chernozem (mid and lower)	cultivated
Selected site is a good representative of cultivated land within ecodistrict.				
Foremost Plain	undulating (44) hummocky (41) dissected (10) rolling (5)	loam (51) clay loam (46)	Brown Chernozem (84) Regosol (15)	cultivated (53) range and pasture land (47)
Site 828B	very gentle slopes	Loam clay loam	Orthic Brown Chernozem (upper, mid and lower)	cultivated and irrigated
Selected site is a good representative of cultivated land within ecodistrict.				

4.4 Landscape and Soil Features

The soil quality benchmark sites cover a range of agricultural practices and soil landscapes. For example, sites are located on both dryland and irrigated landscapes and management practices include annual cultivation as well as pasture and/or grass rotations (Figure 3). The majority of sites (65%) were developed on morainal parent material (Figure 4) with the rest being formed on fluvial or lacustrine parent material. The sites are representative of the Chernozemic and Luvisolic soils found in the agricultural areas of Alberta (Figure 5). The most common surface landform (19 sites) is undulating while only one site is characterized as hummocky (Figure 6). The remaining sites are divided between level and rolling landforms. Almost 70% of the benchmark sites have slopes of 0 to 5 % (Figure 7) and are categorized as having level to very gentle slopes. Nearly all of the sites have a loamy surface texture (Figure 8). Only 10% of the benchmark sites have sandy textures.

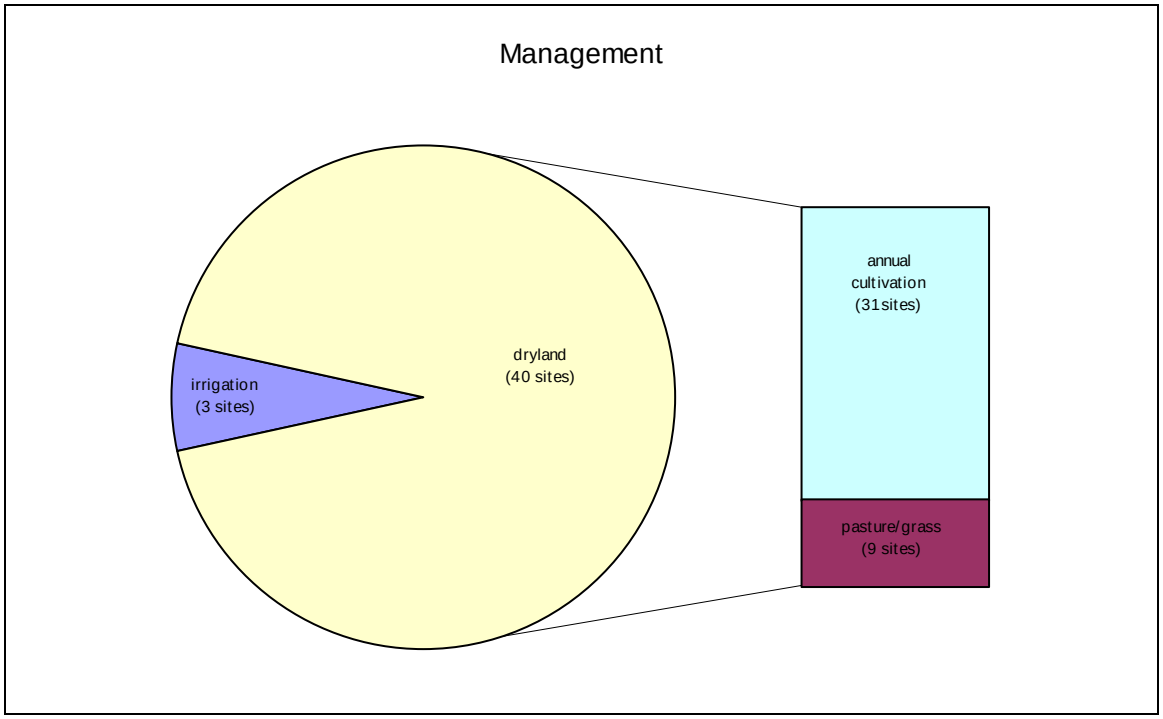

Figure 3. Management practices for the 43 benchmark sites.

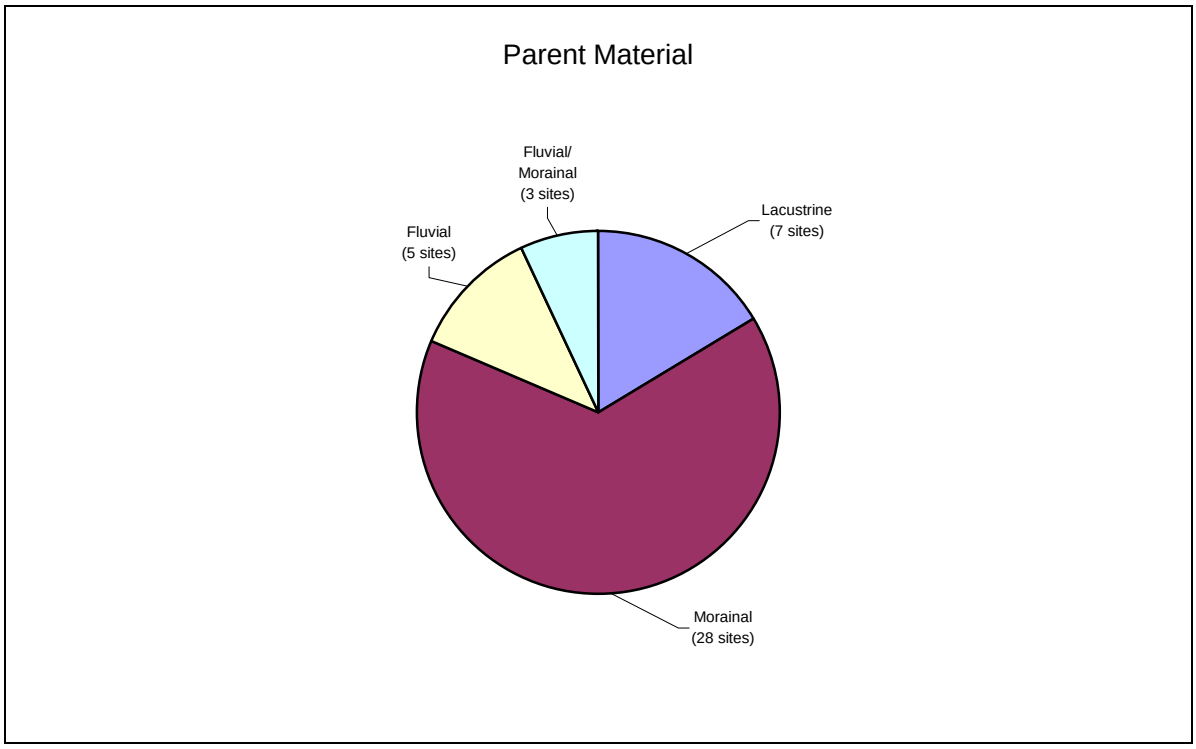

Figure 4. Parent material.

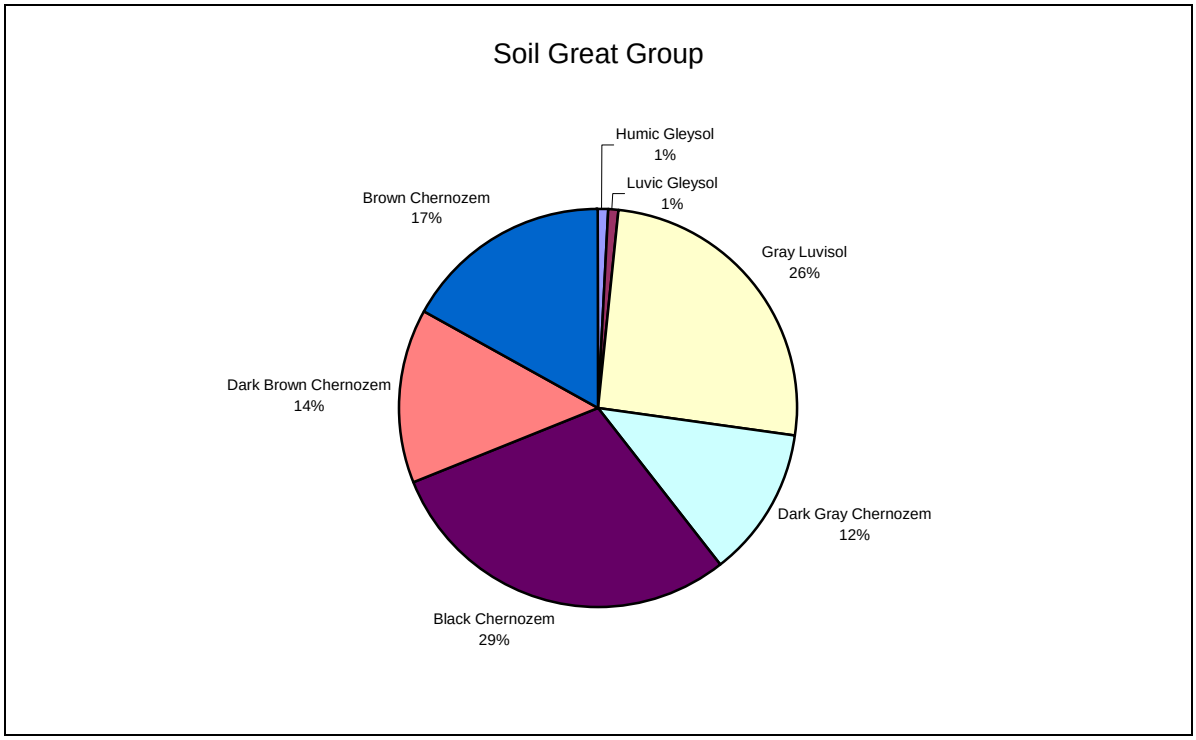

Figure 5. Soil great groups.

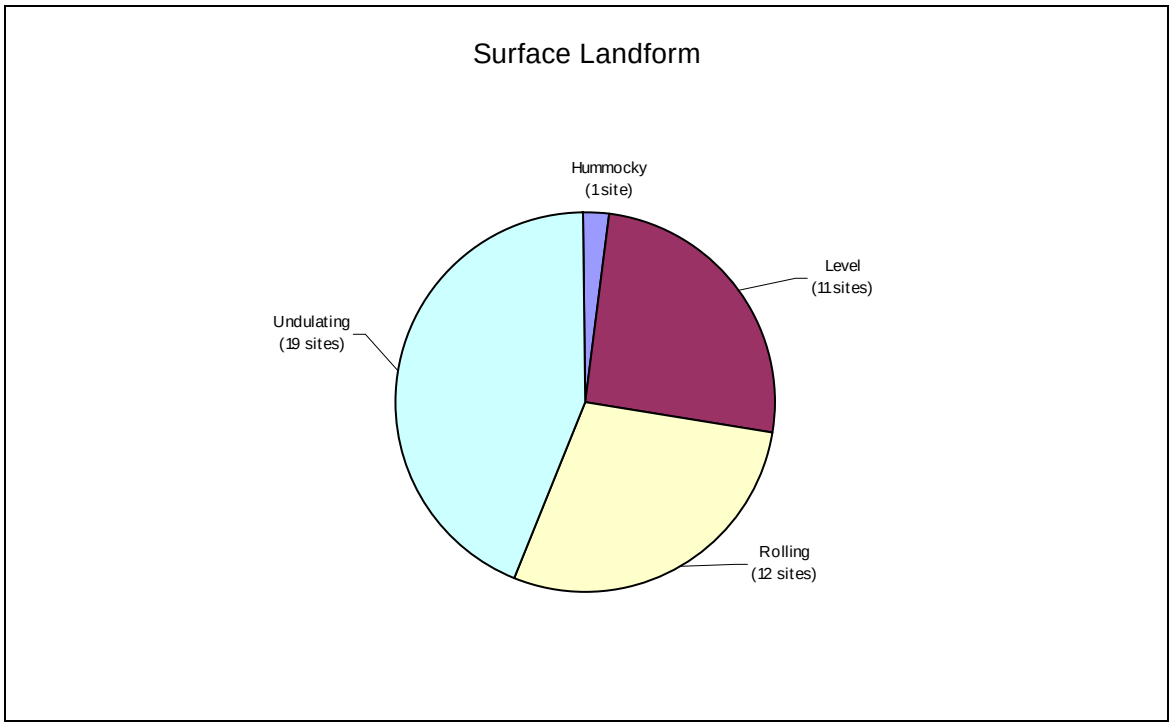

Figure 6. Surface landform.

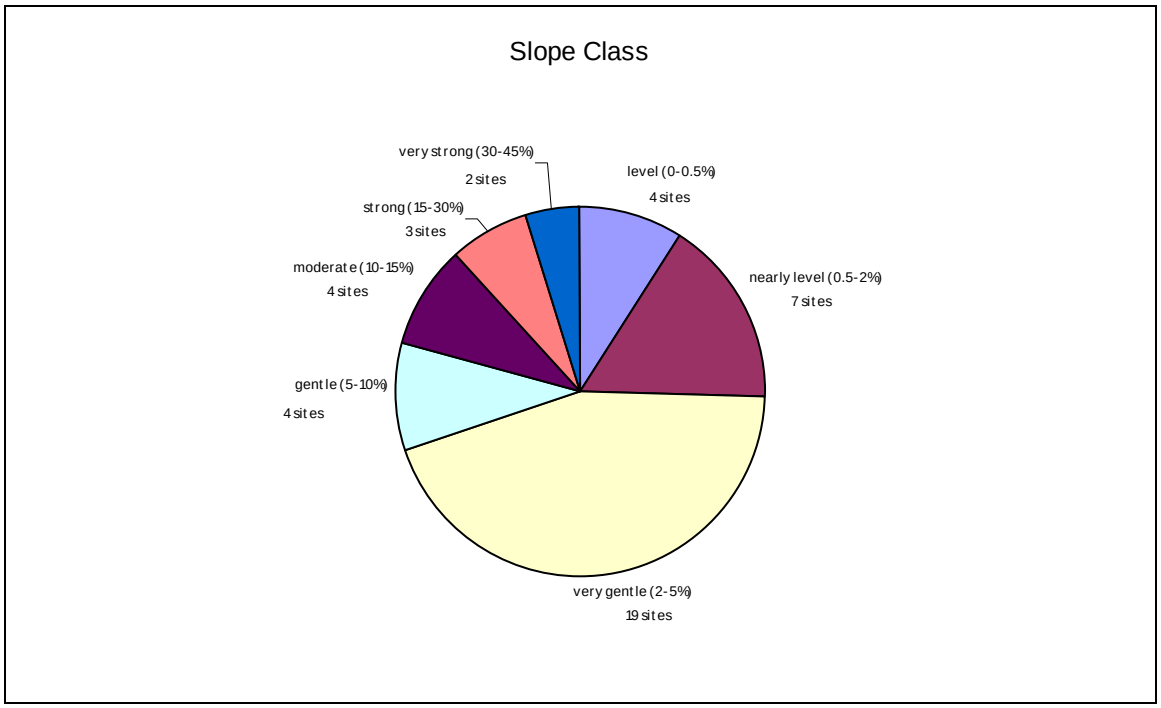

Figure 7. Slope class.

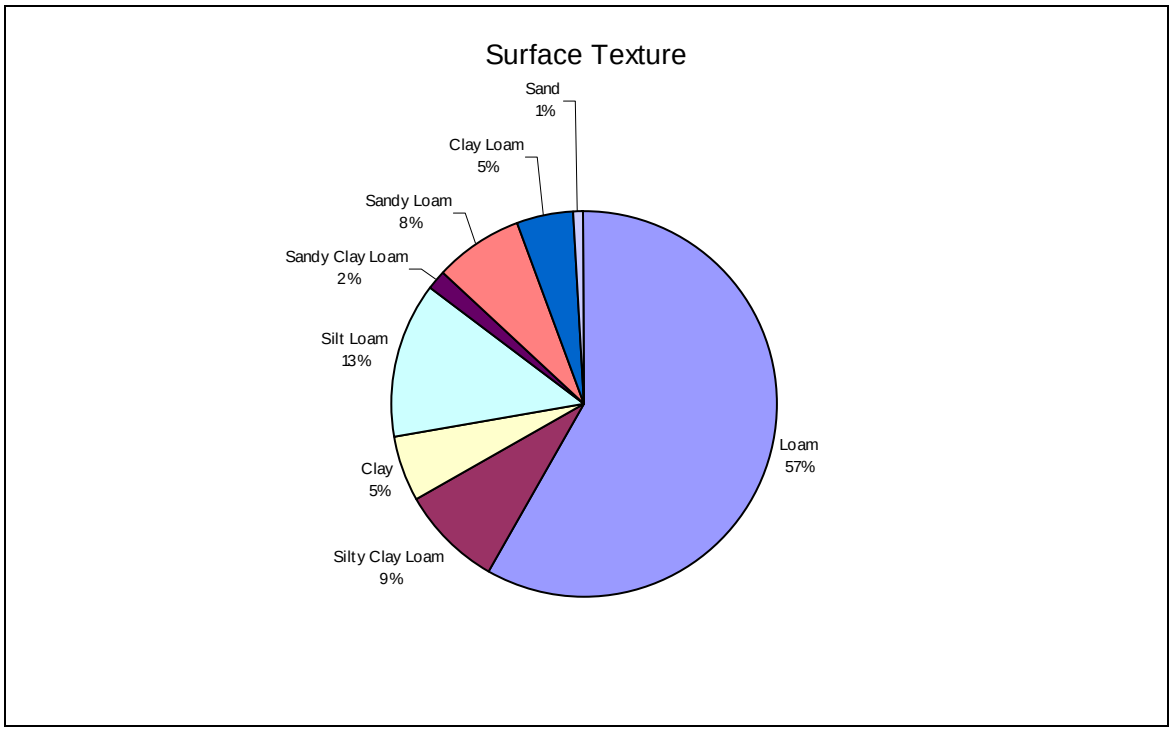

Figure 8. Surface texture.

4.5 Climatic Features

Climatic parameters, such as growing degree days > 5 ^{o}C, January and July mean daily temperatures, growing season days and annual precipitations were determined for each of the ecoregions in which benchmark sites occur based on 1971-2000 climate normals (Figures 9-13) (Shen et al. 2002). These figures show upper extreme values (excluding outliers), upper quartile, median, lower quartile, and lower extreme values (excluding outliers). An outlier is defined as 1.5 times the inter-quartile range and is identified on the figures when they occur. The Mixed Grassland and Moist Mixed Grassland ecoregions have the highest temperatures and growing degree days, but also have the lowest annual precipitation.

5.0 METHOD OF ANNUAL SAMPLING AND ANALYSIS

5.1 Sampling Protocol Rationale

In order to have confidence in field and lab test results, the AESA Soil Quality Committee felt it was necessary to develop sampling procedures/practices to minimize sampling variability that can occur. There are five different AAFRD Regional Conservation teams carrying out the benchmark site sampling each year. Variations in soil test and biomass/yield measurements can occur due to differing sampling procedures.

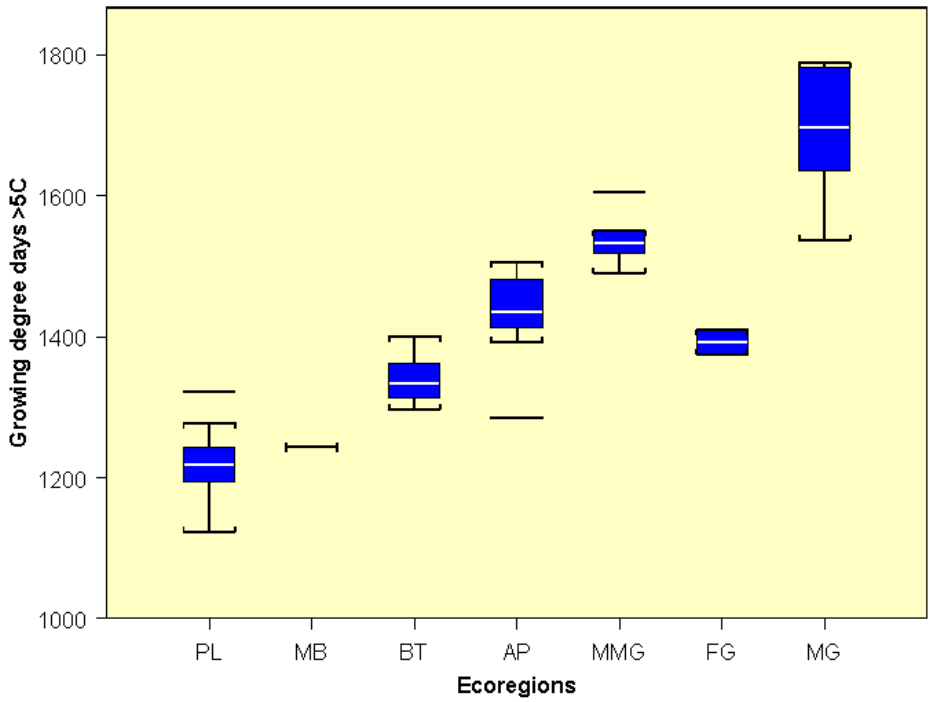

Figure 9. Growing degree days > 5^0C.

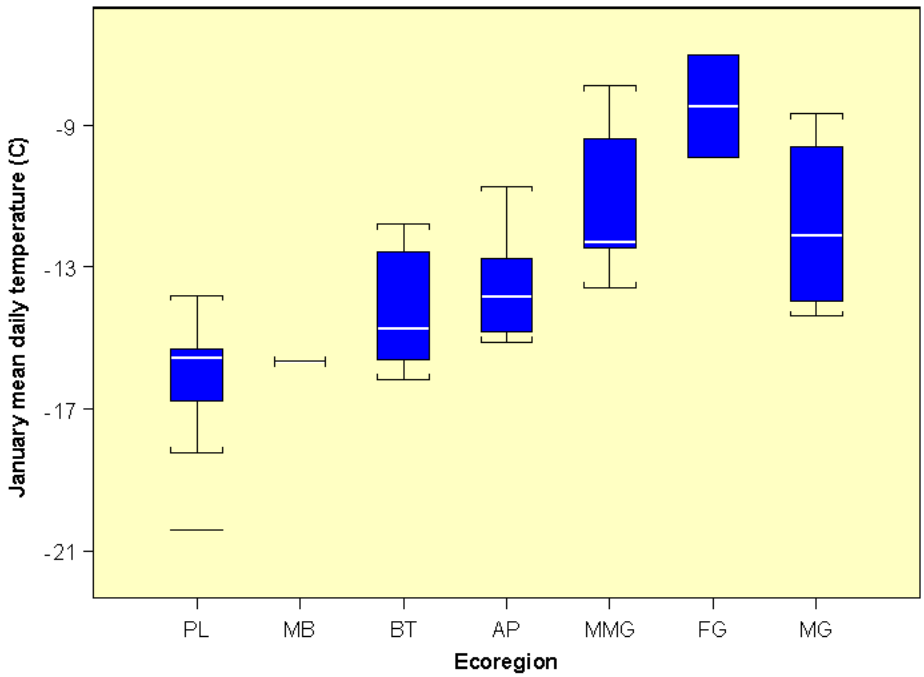

Figure 10. Mean January daily temperature.

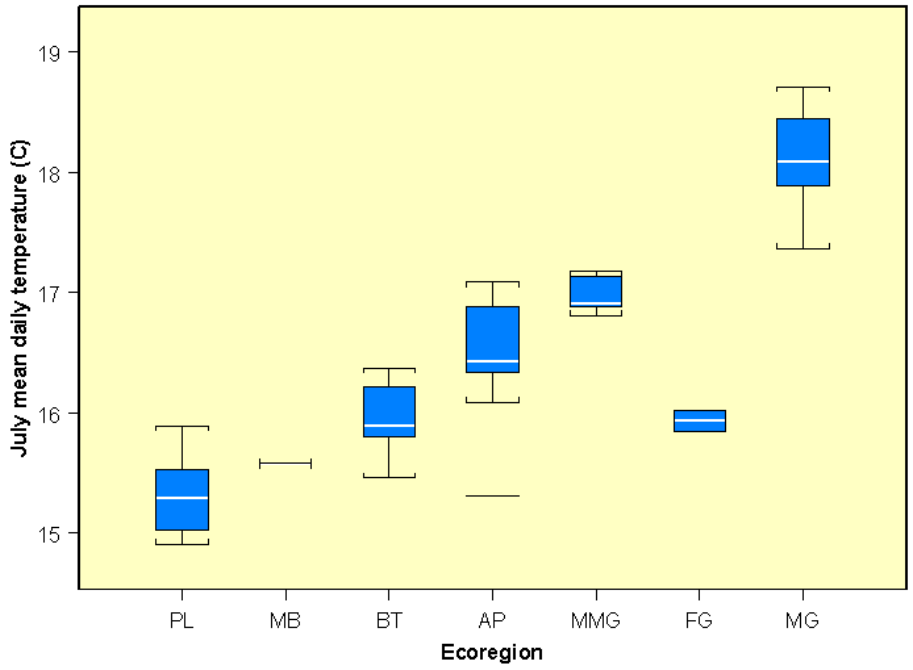

Figure 11. Mean July daily temperature.

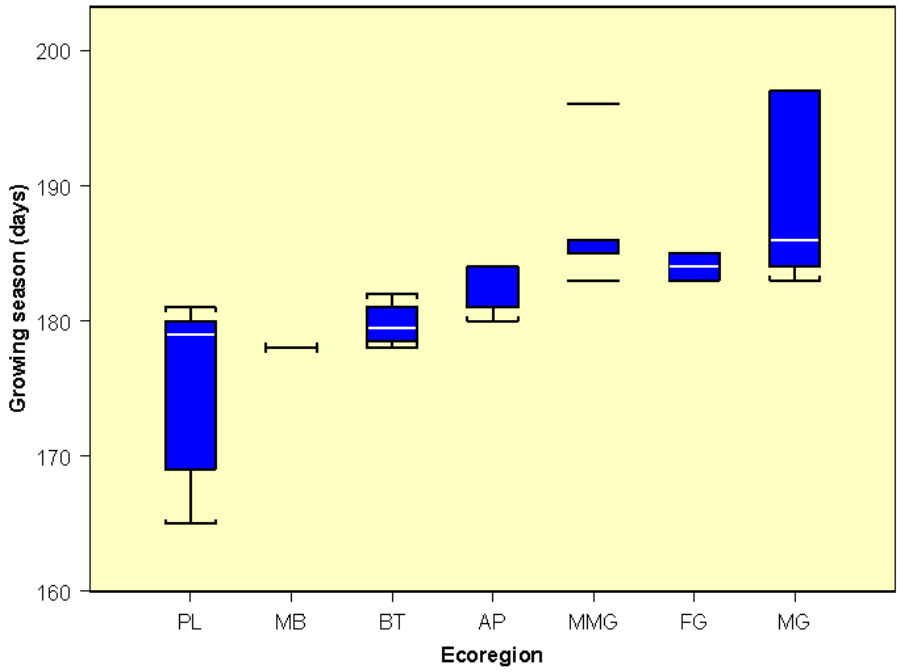

Figure 12. Growing season days.

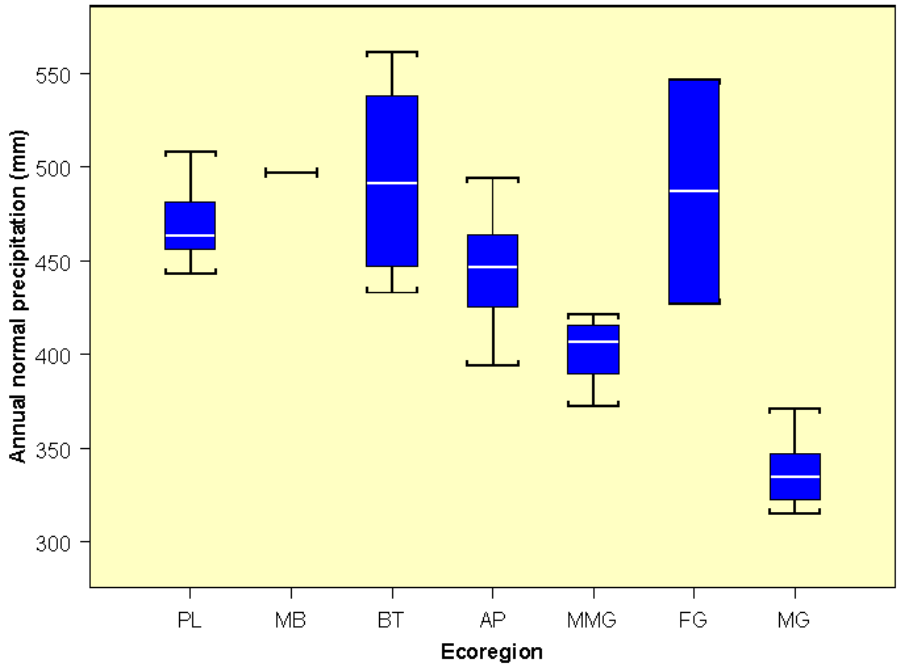

Figure 13. Annual precipitation.

Therefore, it is important to have a sampling protocol in place. Although we cannot remove all sources of variability, we can minimize it.

Sampling variations can occur as a result of temporal and spatial variability. Temporal variability could include differences in temperature, moisture, biological activity and crop growth stages. It is important to sample at the same time each year to minimize these variations from year to year allowing for better monitoring of trends in soil test values over time. Spatial variability could include differences in natural soil forming factors, topsoil depth, fertility distributions, landscape positions and management practices. It is important that each site is geographically referenced to minimize the effects of location on sampling variation.

Another source of variation that can occur is within the lab itself. Therefore, it was decided to use the same lab each year so that the samples are analyzed using the same methodology. As well, the lab carries out quality assurance and quality control (QA/QC) procedures to help minimize errors and variability.

Sampling protocols were designed for both plants and soils. Annual sampling of soils and vegetation is carried out by AAFRD Regional Conservation Teams.

5.2 GPS Positioning of Benchmarks

High quality real-time DGPS were used to position the benchmarks. Two makes of the same class of receivers were used: Trimble AgGPS®132 and Satloc SLXg (use of names does not imply endorsement of the product over competitive products). Both systems used a real-time geostationary differential correction service (in our case, OmniStar) so that the quality of corrections would be consistent regardless of where within the province the equipment was being used.

DGPS receivers were connected to handheld PC devices with software that were capable of position logging, averaging and navigation.

5.2.1 Initial Location of Benchmarks

After the pedologist had finished classifying the site, the DGPS antenna was placed over the center of the 30cm diameter soil excavation site. Positions were averaged until we were confident of a sub-decimeter position (horizontal).

5.2.2 Relocation of Benchmarks

There are no permanent markers left in the field to mark the positions. Each year the AESA regional conservation staff relocate the benchmark positions and flag them. The DGPS is used to navigate back to the site and the site is marked with a wire flag marker. This is done three times and the visual average location of the three flags is picked as the benchmark site. It is recommended to walk the transect three times to do this flagging so that the three positionings at the site are spaced out in time.

Where there is little or no cultivation at the site (e.g. forages, no till annual cropping) field staff have painted rocks with fluorescent paint and left them at the site. DGPS is still used to confirm the rocks have not been moved by equipment.

The resultant final flag should be at the original excavation hole. Sampling is done radially around the flag so that the disturbed area is not sampled.

5.3 Plant Samples

Biomass/yield samples are sampled as close to harvest as possible.

5.3.1 Plant Sampling Procedure

1. Three landscape positions; upper, mid and lower slope positions, have been chosen for sampling and are located using GPS equipment.
2. Three plant harvest clips are taken at each landscape position.
3. Plants are clipped to the ground, leaving no stubble.
4. If rows are discernable, at least 4 rows are harvested, each for a metre in length. If crop is thin, at least 8 rows are harvested.

5. If rows are not discernable, square metre cuts are harvested. If crop is thin, at least 2 square metres are harvested.
6. Samples are bagged and labeled.
7. Samples are sent to AAFRD Conservation and Development Branch as quickly as possible so they do not get moldy.

The crop samples are air dried first or immediately dried in ovens at 50^{o} C. Total biomass is determined by weighing the dried plant sample. The sample is then threshed if it is cereal or oilseed or, ground if it is grass or forage. Grain samples are weighed to determine grain yields. Straw yield is determined as the difference between total biomass and grain yield.

Sub-samples of the grain or biomass are then sent to AAFRD Food Safety Division, Agrifood Laboratories Branch for analysis of protein, calcium, and phosphorus. Oilseeds are also analyzed for oil content. These parameters are determined by NIRS (Near-Infrared Reflectance Spectroscopy) (Appendix 8.2).

Grain or biomass samples not analyzed are archived in 100 ml plastic vials and stored in a cool, dry location.

5.4 Soil Samples

Soil samples are taken in the fall after harvest, but before freeze-up and prior to any fall fertilization. Bulk densities are taken at the same time each year, but before any fall tillage.

5.4.1 Soil Sampling Procedures

Soil Samples

1. Three landscape positions, upper, mid and lower slope positions, have been chosen for sampling and are located using DGPS equipment.
2. Five to ten cores are taken within a radius of 2 metres from the central marker at each of the landscape positions.
3. Soil samples are taken at 0 to15 and 15 to 30 cm depths using a STAR SS soil sampler or Dutch auger.
4. The cores from each depth are bulked/mixed.
5. Samples are bagged and labeled.
6. Excess soil is removed away from the sample field.
7. Samples are kept cool and sent to lab as soon as possible (within 24 hours).

Once at the lab, the soil samples are air-dried and ground to pass a 20-mesh sieve (< 2 mm diameter) prior to lab analysis. Soils are analyzed for fertility, pH in water and CaCl2, EC, SAR if EC >4), mineralizable N and light fraction C (McKeague 1978, Campbell et al. 1997, Gregorich and Ellert 1993) (Appendix 9.2).

Soil not analyzed is archived in 500 ml glass jars and stored in a cool, dry location.

Bulk density samples

1. Bulk density measurement for the surface horizon is done in the field with a tube density sampler. (We used an ELE International Density Drive Sampler with a 3-inch drive head (EI29-5450). The inner tube diameter was 7.25 cm and the height of the tube was 6.76 cm).
2. One bulk density sample is taken at each landscape position.
3. Sample will be taken within the 0-15 cm depth, one or two cm below the soil surface.
4. Drive in the sampler far enough to cover the tube.
5. Carefully dig around the tube to remove from the ground, minimizing disturbance.
6. Examine the sample. If it has been disturbed or there are rocks present, sampling is repeated.
7. Trim the soil level to the edges of the tube with a knife or trowel.
8. Remove the soil core into a plastic bag.
9. Samples are stored in plastic bags, labeled and sent to AAFRD Conservation and Development Branch laboratory.

Once at the lab, the samples are oven dried at 105^{o}C for 24 hours and then weighed. Bulk density is then determined by dividing the oven-dried weight by the known volume of the bulk density core (McKeague 1978).

5.5 Agronomic Practices

The cooperators at each benchmark site have agreed to provide past and current cropping histories and agronomic practices.

Current land management practices are recorded annually and include:

- crop rotations and crop cultivar (crop seeded, method and rate)
- fertilizer applications (type, method, rate)
- tillage systems (method and frequency)
- herbicide applications (type, method, rate)
- harvest methods, and
- an indication of crop yields

Dates of field operations are also recorded since they are very important, for crop growth model input.

Each cooperator fills in an agronomic practices recording sheet every year with the above information (Appendix 9.4). Regional AESA conservation staff ensure each year that the cooperators have properly completed forms and send them to the benchmark coordinator.

5.6 Weather Data

Climatic data is important in explaining yield data. Although yearly temperature climate data from nearby meteorological stations can be used with some confidence, rainfall is more variable. Rain gauges were sent to each benchmark cooperator so that a more accurate read on growing season precipitation could be made at each of the sites. Precipitation throughout the growing season (from April to end of September) is recorded. The cooperators are asked to document each precipitation event and note any other event such as frost or hail. This activity is optional but encouraged.

5.7 Reports

After the initial benchmark sites were established, a binder that included site and soil profile descriptions, fertility analyses, soil and profile pictures, air photos, and soil profile chemical analyses was given to each of the farmers.

Individual 'mini-reports' for each farmer cooperator and AESA regional conservation staff are completed yearly for each of the benchmark sites and include soil fertility and plant analyses for the samples taken. The report also provides information to interpret the fertility results. The mini-reports can be stored in the site binder.

6.0 ESTABLISHMENT AND ONGOING COSTS

The Soil Quality Benchmark Program establishment was initially expensive and time consuming. It took two years to identify, characterize and sample the 43 soil quality benchmark sites. These one time establishment costs for the benchmarks totaled $154,000 (Table 3).

Table 3. Establishment costs.

Establishment item	**Cost**
Characterization, by a pedologist	$72,000
Lab analyses, for soils and plants	$82,000
Field equipment	$4,000
GPS equipment and maintenance	$19,000
Total	**$154,000**

Other past and continuing in-kind benchmark costs include:

- Coordinator required to keep benchmark project organized, on time and on budget
- Sampling equipment, DGPS and GIS maintenance
- Annually, AESA Regional conservation staff contribute a total of 0.8 years sampling and maintenance of the benchmark sites
- Annual laboratory and equipment costs are $25,000

7.0 SUMMARY

Forty-three soil quality benchmark sites have been set up to monitor soil quality across Alberta landscapes. Approximately one third of the ecodistricts in the agricultural area are monitored. These sites were chosen to be representative of the soil-landscape patterns and agronomic practices within a given ecodistrict. Sites are within farmers' fields and no treatments are imposed. Both dryland and irrigated conditions are represented.

Sampling protocols have been established. The procedures are the same for all benchmark sites to minimize sample variations and allow for better monitoring of trends in soil test values and yield determinations over time. Grain and soil samples are archived for future sampling, if required.

The benchmarks provide a range of soil types and properties with a wealth of site information (soil classification, landuse, management practices) that has been collected. The farmer cooperators keep annual field management and rainfall records. This data can be used as input data for crop growth or soil degradation models.

Data from the 43 AESA Soil Quality benchmark sites has revealed significant differences in organic carbon in different agricultural ecoregions, depending on soil horizon and slope position. As well, differences in levels of nutrients were noted based on soil properties, slope position and agricultural ecoregion.

Results of the AESA Soil Quality Benchmark program have also caused interest in other groups and have allowed us to leverage our investments. For example, extra samples collected from the soil quality benchmarks were analyzed to determine phosphorus sorption by different soil to better understand how soils hold dissolved phosphorus. Another example on how the benchmark data has been used is a project being done to verify a nitrogen mineralization model for soil and work towards improved methodology for fertilizer recommendations.

The information collected from the benchmark sites will provide the following:

- detailed soil quality status on a range of soils across Alberta,
- landscape effects on soil quality and soil quality risk assessment,
- a cross validation data set across Alberta for soil quality modeling efforts,
- temporal changes in soil properties at constant sites across Alberta, and
- soil, yield and management relationships.

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9.0 APPENDICES

9.1 Ecodistrict characteristics used for site selection

Adapted from Table 4.1 in the AGRASID manual (CAESA-Soil Inventory Project Working Group 1998).

Eocdistrict	Ecodistrict Name	Landform	Texture	Soil types	Agroclimatic zone
242	YATES RIVER PLAIN	L	O(SiC)	O(GL)	4H
243	BUFFALO RIVER PLAIN	U(H)	O-CL	O-GL,BD	4H
244	HAY RIVER PLAIN	L(U)	C-O(CL)	GL-O(GY)	4H
245	RAINBOW LAKE PLAIN	U	CL-O	GL-O	4H
250	CAMERON SLOPE	U	CL(O)	GL(O)	4H
251	CAMERON HILLS UPLAND	U(L,M)	O(CL)	O(GL,BD)	5H
253	CARIBOU SLOPE	H(S)	CL	GL	4H
254	CARIBOU UPLAND	U(M)	O(CL)	O(GL,BD)	5H
263	URANIUM CITY UPLAND	H(U,M)	ROCK-(S)	ROCK(BD)	5H
330	LAKE ATHABASCA	Z	Z	Z	5H
331	ATHABASCA DUNES	U	O-S	O-BD	5H
338	CARSWELL PLAIN	H	S(O)	BD(O)	5H
574	SALT RIVER PLAIN	L-U	CL-S	GY-BE(sa)	4H
576	KNIGHT CREEK PLAIN	U(R)	S-O	BD-O	4H
577	ATHABASCA DELTA	U	L	RE-GY	4H
578	FOX LAKE PLAIN	U	O-S	O-BD(GL,GY)	4H
579	EMBARRAS PLAIN	U	S(O)	BD(O)	4H
580	BIRCH FANS	U-L	CL(C)	GY(GL,O)	4H
581	CHINCHAGA PLAIN	U(H)	CL,SiC-O	GL-O	4H
582	MILLIGAN UPLAND	H	CL(O)	GL(O)	5H
583	CLEAR HILLS UPLAND	H(S)	CL(O)	GL(O)	5H
584	NOTIKEWIN PLAIN	U(L)	C(O)	GL(O)	4H
586	HIGH LEVEL PLAIN	L(U)	C-L(O)	GL(SO,O)	3H(4H)
587	BOYER PLAIN	U(H)	SL(S,O)	GL(BE,O)	3HA
588	MANNING PLAIN	L	C	SO(GL-DG)	3H
589	CACHE PLAIN	U	S-SL(O)	BD-GL(O)	3H
590	GRIMSHAW PLAIN	U(L)	CL(L,O)	GL(SO,O)	3H
591	WORSLEY PLAIN	L(U)	C(L)	SO(GL,DG)	3H
592	MCLENNAN PLAIN	L(U)	CY(L)	SO(GL-DG)	3H
593	RYCROFT PLAIN	U-L(H)	C-L	SO-DG(GL)	2H
594	BLUEBERRY UPLAND	U	C(O)	GL(DG,O)	3H
595	FALHER PLAIN	L	C	SO(DG,GL)	2H
596	DUNVEGAN PLAIN	U(H)	L(S,O)	GL(BE,O)	2H(3H)
597	DEBOLT PLAIN	U(L)	C(L)	SO(GL,GY)	3H
598	BEAVERLODGE PLAIN	U(L)	C	SO(GL-DG)	3H
599	GRANDE PRAIRIE PLAIN	L(U)	C	BL-SO(DG)	2H
600	SMOKY PLAIN	U(H)	S(SL,O)	BD-GL(O)	3H
601	BUFFALO HEAD UPLAND	H(M,U)	CL(O)	GL(O)	5H(4H)
602	WADLIN UPLAND	U-M	CL(O)	GL(O)	5H
603	RUSSELL UPLAND	U-M	CL(O)	GL(O)	5H
604	PEERLESS UPLAND	H	CL(O,SL)	GL(O)	5H(4H)
605	BIRCH UPLAND	H(M,U)	CL(O)	GL(O)	5H
606	NORTH BIRCH UPLAND	U(M)	O(CL)	O(GL)	5H

Eocdistrict	Ecodistrict Name	Landform	Texture	Soil types	Agroclimatic zone
607	LOON LAKE PLAIN	L(U)	SiC-O(CL)	GL-O,GY	4H(3H)
608	MACKAY PLAIN	L-U	O-CL,SL	O-GL	4H
609	WABASCA PLAIN	L-U	O-S(CL)	O-BE,GL	4H(3H)
610	IOSEGUN PLAIN	U(M)	C(SL,O)	GL(SO,O)	4H
611	PUSKWASKA UPLAND	M-U(H)	CL(C,O)	GL(SO,O)	3H-4H
612	HEART RIVER UPLAND	H(U)	CL(O,SL)	GL(O)	4H
613	UTIKUMA PLAIN	U(H)	CL-O(SL)	GL-O	4H
614	PELICAN UPLAND	M(S)	CL-SL(O)	GL(O)	5H
615	CROSS LAKE UPLAND	H(U)	CL(O,SL)	GL(O)	4H
616	HONDO PLAIN	U-L	S-O(SL)	BE-O(GL)	4H
617	FREEMAN UPLAND	H(U)	CL(O,SL)	GL(O)	4H
618	SADDLE UPLAND	M(U)	CL(C,O)	GL(O)	4H
618	CUTBANK UPLAND	M(U)	CL(O)	GL(O)	5H
619	DRIFTPILE UPLAND	H-M	CL(O)	GL(O)	4H
620	SWAN HILLS	S-M	CL	GL	5H
621	BERLAND UPLAND	M-S	CL	GL(BD)	5H
622	BLUERIDGE UPLAND	H-U	CL	GL	5H(4H)
623	EDSON PLAIN	U(H)	SiC(L,O)	GL(O)	4H
624	MAYBERNE UPLAND	M-S	CL	GL(BE)	5H
625	OBED UPLAND	H-U	CL-L(O)	GL(O)	4H
626	CYNTHIA UPLAND	H(S,U)	CL(S,O)	GL(BD,O)	5H
627	WOLF LAKE UPLAND	H(S)	CL-L	GL	5H
628	RAM RIVER FOOTHILLS	M-S	L	GL	5H
629	O'CHIESE UPLAND	H-U	CL-L(O)	GL(O)	4H
630	WINFIELD UPLAND	H(U)	CL(O)	GL(O)	4H
631	BRAGG CREEK FOOTHILLS	M-S	L(S)	DG-BE	5H
632	HART LAKE PLAIN	U(H)	O-S(L)	O-BD(GL)	4H
633	FIREBAG HILLS	H(U,M)	S(O)	BD(O)	4H
634	MUSKEG UPLAND	U(H)	L-O(S)	GL-O(BD)	4H
635	STEEPBANK PLAIN	U(L)	O(S,L)	O(BD,CL)	4H
637	GARSON LAKE PLAIN	U(H)	SL,CL-O	GL-O(BD)	4H
638	STONY MTN UPLAND	M-U	SL(S,O,CL)	GL(O,BE)	4H
639	CROW LAKE PLAIN	U	O-SL	O-GL	4H
641	CHRISTINA PLAIN	U(H)	O-S	O-BE	4H
644	MOSTOOS UPLAND	U(H)	S-O	BE-O(BD)	4H
650	PINEHURST UPLAND	H(U)	CL(SL,O)	GL(O)	4H
678	ATHABASCA PLAIN	U(L)	L to CL(S,C)	GL(DG,O)	3H(4H)
679	WHITEFISH UPLAND	H(U)	CL(C)	GL(O)	4H
680	BEAVER RIVER PLAIN	U(H)	L to CL(SL)	GL(DG)	3H
681	WESTLOCK PLAIN	U	CL(C)	GL(DG,O)	3H
683	REDWATER PLAIN	U-H	SL(S,L)	DG	3H
684	LAC STE ANNE UPLAND	H(U)	SiL-CL	GL(DG,O)	3H
686	FROG LAKE UPLAND	H(U)	CL	GL(O)	4H
687	ONION LAKE PLAIN	U(H)	CL	DG(BL,GL)	3H
688	MYRNAM UPLAND	H	CL(C)	GL(DG)	3H
692	BRETON UPLAND	U-H	CL(C,O)	GL(O)	4H-3H
703	RIMBEY UPLAND	H-U	L to CL	GL-DG	3H
708	CAROLINE PLAIN	U(H)	L(SL)	GL	4H
727	LEDUC PLAIN	U(L,H)	L-C(S)	BL(SS)	2H
728	ANDREW PLAIN	U	L to CL	BL(SS)	2AH
729	LLOYDMINSTER PLAIN	U(H)	L to CL	BL	2AH

Eocdistrict	Ecodistrict Name	Landform	Texture	Soil types	Agroclimatic zone
730	VERMILION UPLAND	H(U,M)	L to CL	BL	2AH
731	DAYSLAND PLAIN	U	L to CL	SS-BL	2AH
732	COOKING LAKE UPLAND	H	L to CL	GL-DG	3H
737	RED DEER PLAIN	U(H)	L to CL(C,S)	BL-DG	3H
738	SEDGEWICK PLAIN	U	L to CL	BL(DB)	2AH
739	RIBSTONE PLAIN	H(U)	S(SL)	DB	2AH
740	BASHAW UPLAND	H(U)	L to CL	BL	2AH
743	PROVOST PLAIN	U(M)	SiL(SL)	DB	2AH
744	PINE LAKE UPLAND	H(M,U)	L to CL	BL(DG)	3H
746	OLDS PLAIN	U(M)	L to CL	BL	3H
750	BLACK DIAMOND UPLAND	M(U)	L to CL	BL-DG	4H(3H)
769	CASTOR PLAIN	U(L)	L to CL	SS(DB)	2AH
771	NEUTRAL HILLS	H(S,U)	L-CL	DB	2AH
777	SULLIVAN LAKE PLAIN	U	SL-L	SS(DB)	2AH
779	ENDIANG UPLAND	H(U)	L to CL(SL)	DB	2AH
781	DRUMHELLER PLAIN	U-M	C	DB	2AH
786	WINTERING HILLS	H(U)	L to CL	DB(BL)	2AH
787	MAJORVILLE UPLAND	H	L to CL	DB	2A
788	STANDARD PLAIN	U(M)	SiL-SiC	DB	2A
790	BLACKFOOT PLAIN	U	SL(L)	DB	2A
791	VULCAN PLAIN	U(M)	SiL	DB	2A
793	LETHBRIDGE PLAIN	U(L)	SiL(SiC)	DB	2A
797	MILK RIVER UPLAND	H(U)	CL(SL)	DB	2AH
798	DELACOUR PLAIN	U	SiL-CL	BL	2AH
799	WILLOW CREEK UPLAND	M-S	L to CL	BL	4H
800	CARDSTON PLAIN	U	U(H)	BL	2AH-3H
801	TWIN BUTTE FOOTHILLS	M-S	L to CL	BL	4H
802	DEL BONITA PLATEAU	H-U	SiL-CL	BL	2AH
804	SOUNDING CREEK PLAIN	U	SL-L	SS(BR)	3A
805	SIBBALD PLAIN	U	SiC-SiL	BR	3A
806	BERRY CREEK PLAIN	U	L to CL	SS(BR)	3A
809	OYEN UPLAND	H(U)	L to CL	BR(DB)	3A(2A)
811	ACADIA VALLEY PLAIN	U	C	BR	3A
812	BROOKS PLAIN	U	SiL-SL(S)	BR(SS)	3A
814	RAINY HILLS UPLAND	H(U)	L(SL)	BR	3A
815	BINDLOSS PLAIN	U(H)	S-L	BR	3A
818	BOW CITY PLAIN	U	L to CL	SS-BR	3A
821	SCHULER UPLAND	H-U	L to CL	BR	3A
823	VAUXHALL PLAIN	U	L(SL)	BR	3A
828	FOREMOST PLAIN	U(H)	L-SiL	BR	3A
829	PURPLE SPRINGS PLAIN	U	SL(S)	BR	3A
833	WILD HORSE PLAIN	H-U	CL-SL	BR-SS	3A
836	SWEETGRASS UPLAND	U-M	L-CL	DB	2AH
837	CYPRESS SLOPE	U-H	L to CL	DB	2A
838	CYPRESS HILLS	S(L)	L	DB-BL	2AH-3H
996	WILLMORE FOOTHILLS	M-S	L(S)	BD-BE(GL)	5H
997	JASPER MOUNTAINS	SM	R-L	R-BD,BE	5H
998	LUSCAR FOOTHILLS	M-S	L	GL-BE	5H
999	BANFF MOUNTAINS	SM	L-R	BE-R	5H
1000	ICEFIELD MOUNTAINS	SM	R(L,SNOW)	R(BD)	5H
1016	MORLEY FOOTHILLS	M(L)	L-SL	BL-BE	4H

Eocdistrict	Ecodistrict Name	Landform	Texture	Soil types	Agroclimatic zone
1017	CROWSNEST MOUNTAINS	SM	L(R)	BE-GL(R)	5H
1018	BLAIRMORE FOOTHILLS	H-S	L(CL)	BL-GL(BElit)	5H
1019	WATERTON MOUNTAINS	SM	L-R	BD,GL-R	5H

9.2 Soil and Plant Methods of Analysis

Analysis	Reference
Soils	
pH in water	McKeague 1978, section 3.13
pH in CaCl2	McKeague 1978, section 3.11
C.E.C.	McKeague 1978, section 3.32
Ammonium-N	McKeague 1978, section 4.35
Nitrate-N	McKeague 1978, section 4.35
EC-Saturated paste	McKeague 1978, section 3.21
Sodium adsorption ratio	McKeague 1978, section 3.26
CaCO3 equivalent	Communications in Soil Science and Plant Analysis, Vol 28, 1997
Particle size analysis	Gee and Bauder 1986,
Total N	Leco Manual
Total organic C	McKeague 1978, section 3.611
Nutrients	
P	McKeague 1978, section 4.47
K	McKeague 1978, section 4.51
SO4-S	McKeague 1978, section 4.47
Light fraction organic carbon	Gregorich and Ellert 1993
Hot KCl mineralizable N	Campbell et al. 1997.
Bulk Density	McKeague 1978, section 2.21
Plants	
Protein, Ca, P, Oil content	AAFRD Food Safety Division Agrifood Laboratories Branch SOP# SF-0166-01 (feed NIR diagnostics and scanning)

9.3 Topsoil Characteristics of Sampled Profiles.

Site ID	Transect Position	Soil Series	Soil Subgroup	Parent Material	Slope [Z] (%)	Horizon	Depth (cm)	Average Bulk Density (g/cm^3)	Texture (Lab)	pH in (H_20)	EC (dS/m)	CEC (meq/100g)	$CaCO_3$ (%)	ORGANIC CARBON (%)	TOTAL N (%)	C:N RATIO	TOTAL ORGANIC CARBON (Mg/ha)	CROP (Year)
Peace Lowlands Ecoregion																		
586	U	Judah	D. GL	L	-	Ap	0-15	1.09	CL	6.8	0.52	25.6	<0.7	3.50	0.30	12	57	canola (1999)
586	M	GlJudah	GLD. GL	L	1	Ap	0-14	1.23	SiCL	6.7	0.39	29.2	<0.7	4.30	0.30	14	74	canola (1999)
586	L	GlJudah	GLD. GL	L	-	Ap	0-14	1.27	SiCL	6.2	2.78	26.7	<0.7	3.00	0.20	15	46	canola (1999)
588	U	Kathleen	O. GL	L	-	Ap	0-15	1.50	C	8.4	0.82	27.5	0.9	2.30	0.20	12	52	canola (1999)
588	M	Judah	D. GL	L	4	Ap	0-15	1.43	SiCL	8.2	0.50	29.7	1.2	3.00	0.30	10	64	canola (1999)
588	L	GlJudah	GLD. GL	L	-	Ap	0-16	1.38	C	7.4	0.36	29.9	<0.7	2.80	0.40	7	62	canola (1999)
590	U	Berwyn	D. GL	M	-	Ap	0-13	1.32	L	6.8	0.65	20.7	<0.7	2.50	0.30	8	43	canola (1999)
590	M	Berwyn	D. GL	M	3	Ap	0-15	1.36	SiL	7.1	0.43	17.2	<0.7	1.90	0.20	9	37	canola (1999)
590	L	Berwyn	D. GL	M	-	Ap	0-15	1.47	L	6.8	0.33	19.2	<0.7	2.20	0.20	11	49	canola (1999)
591	U	Hamelin	O. DG	L	-	Ap	0-14	1.13	CL	6.7	0.22	28.7	<0.7	3.50	0.40	9	55	oats (1999)
591	M	Hamelin	O. DG	L	4	Ap	0-19	1.03	L	7.7	0.47	55.3	1.1	7.00	0.60	12	137	oats (1999)
591	L	Northstar	GL. DG	L	-	Ap	0-15	1.14	CL	6.8	0.30	32.3	<0.7	5.40	0.50	11	92	oats (1999)
592	U	glSpirit River	GL. BL	F	-	Ap	0-19	1.09	L	7.7	0.45	37.3	<0.7	4.60	0.50	9	95	barley (1999)
592	M	glSpirit River	GLE. BL	F	1	Ap	0-19	1.24	CL	7.7	0.46	37.9	<0.7	4.40	0.50	9	104	barley (1999)
592	L	glSpirit River	GL. BL	F	-	Ap	0-20	1.15	CL	7.6	1.32	40.2	<0.7	5.40	0.60	9	124	barley (1999)

Site ID	Transect Position	Soil Series	Soil Subgroup	Parent Material	Slope [Z] (%)	Horizon	Depth (cm)	Average Bulk Density (g/cm^3)	Texture (Lab)	pH in (H_20)	EC (dS/m)	CEC (meq/100g)	$CaCO_3$ (%)	ORGANIC CARBON (%)	TOTAL N (%)	C:N RATIO	TOTAL ORGANIC CARBON (T/ha)	CROP (Year)
Peace Lowlands Ecoregion, continued																		
593	U	Bluesky	SZ. DG	L	-	Ap	0-13	1.29	CL	7.2	0.27	32.6	<0.7	4.10	0.40	10	69	wheat (1999)
593	M	Bluesky	SZ. DG	L	1	Ap	0-12	1.50	C	8.0	0.34	28.2	<0.7	3.50	0.40	9	63	wheat (1999)
593	L	Bluesky	SZ. DG	L	-	Ap	0-14	1.29	C	7.2	0.21	26.5	<0.7	2.60	0.30	9	47	wheat (1999)
594	U	Woking	O. GL	M	-	Ap	0-20	1.42	CL	6.0	0.28	20.3	<0.7	1.30	0.20	7	37	canola (1999)
594	M	Woking	O. GL	M	5	Ap	0-20	1.49	CL	5.8	0.28	15.0	<0.7	1.40	0.20	7	42	canola (1999)
594	L	Donelly	GL. GL	M	-	Ap	0-20	1.41	CL	6.5	0.37	18.3	<0.7	2.40	0.20	12	68	canola (1999)
595	U	Dunvegan	O. DG	L	-	Ap	0-15	1.34	C	6.4	1.24	31.6	<0.7	3.60	0.40	9	72	wheat (1999)
595	M	Dunvegan	O. DG	L	2	Ap	0-17	1.30	CL	6.7	0.50	29.0	<0.7	3.60	0.40	9	80	wheat (1999)
595	L	Dunvegan	O. DG	L	-	Ap	0-15	1.20	CL	6.2	1.03	23.7	<0.7	3.00	0.30	10	54	wheat (1999)
598	U	Berwyn	D. GL	M	-	Ap	0-13	1.15	L	6.3	0.42	24.0	<0.7	3.60	0.40	9	54	oats (1999)
598	M	Berwyn	D. GL	M	3	Ap	0-20	1.27	CL	6.1	0.46	24.6	<0.7	3.50	0.40	9	89	oats (1999)
598	L	Berwyn	D. GL	M	-	Ap	0-21	1.16	CL	6.4	0.79	25.3	<0.7	3.60	0.40	9	88	oats (1999)
599	U	Landry	SZ. BL	M	-	Ap	0-20	1.25	C	6.6	0.44	40.6	<0.7	4.10	0.40	10	103	wheat (1999)
599	M	Landry	SZ. BL	M	2	Ap	0-15	1.30	C	6.6	0.53	35.4	<0.7	4.00	0.40	10	78	wheat (1999)
599	L	Landry	SZ. BL	M	-	Ap	0-12	1.41	C	6.4	0.46	34.4	<0.7	3.60	0.40	9	61	wheat (1999)

Site ID	Transect Position	Soil Series	Soil Subgroup	Parent Material	Slope [Z] (%)	Horizon	Depth (cm)	Average Bulk Density (g/cm^3)	Texture (Lab)	pH in (H_20)	EC (dS/m)	CEC (meq/100g)	$CaCO_3$ (%)	ORGANIC CARBON (%)	TOTAL N (%)	C:N RATIO	TOTAL ORGANIC CARBON (T/ha)	CROP (Year)
Mid Boreal Uplands Ecoregion																		
615	U	Athabasca	O. GL	M	-	Ap	0-15	1.21	SiL	7.4	0.94	21.5	-	6.29	0.37	17	115	oats (1998)
615	M	Athabasca	O. GL	M	2-3	Ap	0-18	1.36	L	6.1	0.73	12.7	-	1.93	0.12	16	47	oats (1998)
615	L	Bluet	HU. LG	M	-	Ap	0-18	0.58	L	7.9	0.86	27.5	3.2	5.69	0.37	15	60	oats (1998)
Boreal Transition Ecoregion																		
678	U	Grandin	O. GL	M	-	Ap	0-16	1.24	SiCL	5.8	0.39	20.7	-	2.34	0.24	10	47	wheat (1998)
678	M	Grandin	O. GL	M	3	Ap	0-22	1.06	SiCL	5.8	0.38	18.9	-	2.72	0.26	10	63	wheat (1998)
678	L	Venice	D. GL	M	-	Ap	0-17	0.95	SiCL	6.9	0.36	36.8	0.8	6.34	0.54	12	102	wheat (1998)
680	U	Spedden	D. GL	M	-	Ap	0-8	1.60	L	6.9	0.36	14.0	-	1.12	0.01	112	14	barley (1998)
680	M	Spedden	D. GL	M	5	Ap	0-18	1.27	SCL	6.8	0.46	17.3	-	2.80	0.16	18	64	barley (1998)
680	L	Kehiwin	O. DG	M	-	Ap	0-19	1.13	L	7.0	0.33	19.2	-	3.54	0.20	18	76	barley (1998)
681	U	Uncas	D. GL	FL/M	-	Ap	0-22	1.35	SL	6.7	0.52	14.3	-	1.92	0.17	11	57	canola (1998)
681	M	Uncas	D. GL	FL/M	2	Ap	0-22	1.51	SL	6.5	0.82	12.6	-	1.24	0.14	9	41	canola (1998)
681	L	glUncas	GLD. GL	FL/M	-	Ap	0-22	1.31	SCL	6.9	0.34	20.5	-	2.77	0.23	12	80	canola (1998)
684	U	Glory	O. GL	FL	-	Ap	0-12	1.57	L	5.9	0.24	11.6	-	0.59	0.11	5	11	barley (1998)
684	M	Carvel	D. GL	FL	9	Ap	0-16	1.44	SiL	6.1	0.54	13.5	-	1.35	0.14	10	39	barley (1998)
684	L	glWinterburn	GL. DG	FL	-	Ap	0-20	1.42	SiL	6.3	0.21	15.2	-	2.32	0.2	12	66	barley (1998)

Site ID	Transect Position	Soil Series	Soil Subgroup	Parent Material	Slope [Z] (%)	Horizon	Depth (cm)	Average Bulk Density (g/cm^3)	Texture (Lab)	pH in (H_20)	EC (dS/m)	CEC (meq/100g)	$CaCO_3$ (%)	ORGANIC CARBON (%)	TOTAL N (%)	C:N RATIO	TOTAL ORGANIC CARBON (T/ha)	CROP (Year)
Boreal Transition Ecoregion, continued																		
687	U	Gabriel	D. GL	Fv/M	-	Ap	0-12	1.51	SL	6.2	0.55	11.0	-	1.31	0.01	131	24	wheat (1998)
687	M	Redwater	O. DG	Fv/M	4	Ap	0-16	1.49	SL	6.5	0.61	12.3	-	1.22	0.01	122	29	wheat (1998)
687	L	Egremont	GL. DG	M	-	Ap	0-25	1.42	L	7.5	0.8	24.8	-	3.15	0.20	16	112	wheat (1998)
688	U	Redwater	O. DG	F	-	Ap	0-18	0.99	SiL	6.8	0.22	41.0	-	0.35	0.24	1	6	barley (1998)
688	M	Redwater	O. DG	Fb	5	Ap	0-23	1.08	L	6.3	0.24	38.8	-	5.27	0.27	20	130	barley (1998)
688	L	Redwater	O. DG	Fb	-	Ap	0-18	1.10	L	6.4	0.3	35.8	-	5.21	0.43	12	103	barley (1998)
692	U	Maywood	O. GL	L	-	Ap	0-15	0.93	C	6.0	0.16	39.2	-	1.65	0.24	7	23	oats (1998)
692	M	Maywood	O. GL	L	8	Ap	0-15	1.08	C	5.9	0.27	33.1	-	3.95	0.37	11	64	oats (1998)
692	L	glMacola	GLD. GL	L	-	Ap	0-24	1.02	C	5.9	0.21	38.5	-	4.54	0.43	11	111	oats (1998)
703	U	Benalto	D. GL	M	-	Ap	0-18	1.59	SCL	6.8	0.21	12.7	-	1.05	0.11	10	30	pasture (1998)
703	M	Benalto	D. GL	M	4	Ap	0-20	1.51	SL	6.3	0.14	11.2	-	1.10	0.12	9	33	pasture (1998)
703	L	Mapova	HU. LG	FL	-	Ap	0-19	0.56	L	8.0	0.49	65.1	-	16.3	1.02	16	174	pasture (1998)
Aspen Parkland Ecoregion																		
727	U	Angus Ridge	E. BL	M	-	Ap	0-28	1.08	SiCL	6.8	0.42	36.4	-	5.08	0.49	10	153	peas (1998)
727	M	Angus Ridge	E. BL	M	2	Ap	0-26	1.13	SiL	6.0	0.28	38.9	-	6.27	0.55	11	183	peas (1998)
727	L	Angus Ridge	E. BL	M	-	Ap	0-43	1.02	SiL	6.1	0.28	33.8	-	5.40	0.50	11	236	peas (1998)

Site ID	Transect Position	Soil Series	Soil Subgroup	Parent Material	Slope [Z] (%)	Horizon	Depth (cm)	Average Bulk Density (g/cm^3)	Texture (Lab)	pH in (H_20)	EC (dS/m)	CEC (meq/100g)	$CaCO_3$ (%)	ORGANIC CARBON (%)	TOTAL N (%)	C:N RATIO	TOTAL ORGANIC CARBON (T/ha)	CROP (Year)
Aspen Parkland Ecoregion, continued																		
728	U	Angus Ridge	E. BL	M	-	Ap	0-14	1.33	SL	5.9	0.63	17.2	-	3.70	0.23	16	69	wheat (1998)
728	M	Beaverhills	O. BL	M	4	Ap	0-33	1.11	L	6.2	0.69	23.0	-	5.40	0.12	45	197	wheat (1998)
728	L	glNorthern Valley	GLE. BL	Fv/M	-	Ap	0-36	1.05	L	6.5	0.95	28.4	-	0.67	0.01	67	25	wheat (1998)
730	U	Elonora	E. BL	M	-	Ap	0-7	1.53	SCL	6.9	0.73	15.7	-	1.45	0.10	15	16	wheat (1998)
730	M	Elonora	E. BL	M	16	Ap	0-13	1.37	SL	6.4	0.55	15.7	-	2.34	0.19	12	42	wheat (1998)
730	L	glElonora	GLE. BL	M	-	Ap	0-22	1.38	SL	7.0	1.26	19.9	-	3.38	0.27	13	103	wheat (1998)
738	U	Elonora	O. BL	M	-	Ap	0-16	1.38	L	6.0	0.36	18.5	-	0.57	0.20	3	13	barley (1998)
738	M	Elonora	O. BL	M	2	Ap	0-16	1.35	L	6.0	0.27	18.3	-	0.53	0.20	3	11	barley (1998)
738	L	Elonora	O. BL	M	-	Ap	0-15	1.37	L	6.2	0.30	20.6	-	0.25	0.25	1	5	barley (1998)
739	U	Irma	O. BL	F	-	Ap	0-20	1.44	L	7.0	0.22	15.2	<0.7	1.10	0.20	4	22	canola (1999)
739	M	Irma	O. BL	F	7	Ap	0-22	1.32	SL	6.8	0.14	12.2	<0.7	1.42	0.10	15	43	canola (1999)
739	L	Irma	O. BL	F	-	Ap	0-16	1.27	SL	6.4	0.83	14.8	<0.7	1.88	0.20	8	32	canola (1999)
740	U	Beaverhills	O. BL	M	-	Ap	0-11	1.38	SL		0.16	23.9	<0.7	2.19	0.30	7	33	barley (1999)
740	M	Beaverhills	O. BL	M	9	Ap	0-29	1.06	SL		0.21	28.4	<0.7	3.88	0.40	10	119	barley (1999)
740	L	Edburg	GLR. BL	M	-	Ap	0-20	1.11	L		1.52	41.8	1.1	5.01	0.60	8	111	barley (1999)

Site ID	Transect Position	Soil Series	Soil Subgroup	Parent Material	Slope [Z] (%)	Horizon	Depth (cm)	Average Bulk Density (g/cm^3)	Texture (Lab)	pH in (H_20)	EC (dS/m)	CEC (meq/100g)	$CaCO_3$ (%)	ORGANIC CARBON (%)	TOTAL N (%)	C:N RATIO	TOTAL ORGANIC CARBON (T/ha)	CROP (Year)
Aspen Parkland Ecoregion, continued																		
743	U	Hughenden	CA. DB	M	-	Ap	0-13	1.10	CL	-	0.60	27.6	<0.7	1.08	0.20	5	15	summerfallow (1999)
743	M	Hughenden	CA. DB	M	7	Ap	0-15	1.30	CL	-	0.68	26.3	<0.7	1.73	0.20	9	34	summerfallow (1999)
743	L	Hughenden	O. DB	M	-	Ap	0-17	1.06	CL	-	0.71	26.0	<0.7	2.39	0.30	8	43	summerfallow (1999)
744	U	Antler	O. BL	M	-	Ap	0-14	1.25	L	6.0	0.35	32.1	<0.7	3.95	0.37	11	69	barley (1999)
744	M	Cygnet	E. BL	F/M	7	Ap	0-24	1.06	L	6.9	0.17	27.6	<0.7	3.55	0.33	11	90	barley (1999)
744	L	glAntler	GL. BL	M	-	Ap	0-20	1.09	L	6.4	0.29	30.0	<0.7	4.94	0.43	11	108	barley (1999)
746	U	Antler	O. BL	M	-	Ap	0-19	1.19	L	7.2	0.71	26.9	-	4.38	0.33	13	99	barley (1998)
746	M	Antler	O. BL	M	10	Ap	0-15	1.10	L	7.0	0.27	29.1	-	4.93	0.39	13	81	barley (1998)
746	L	Antler	O. BL	M	-	Ap	0-21	1.13	L	6.7	0.28	15.9	-	6.29	0.47	13	149	barley (1998)
Moist Mixed Grassland Ecoregion																		
769	U	Hughenden	O. DB	M	-	Ap	0-13	1.30	SL	5.3	1.04	13.9	-	2.27	0.16	14	38	barley (1998)
769	M	Hughenden	O. DB	M	3	Ap	0-14	1.19	SL	5.5	0.57	16.3	-	2.76	0.22	13	46	barley (1998)
769	L	Hughenden	O. DB	M	-	Ap	0-19	1.27	SL	5.7	0.63	15.5	-	3.31	0.26	13	80	barley (1998)
781	U	Academy	O. BL	M	-	Ap	0-13	1.08	CL	5.6	0.8	24.6	-	4.08	0.3	14	57	wheat (1998)
781	M	Academy	O. BL	M	4	Ap	0-14	1.08	CL	6.0	0.58	25.5	-	4.46	0.36	12	67	wheat (1998)
781	L	Academy	O. BL	M	-	Ap	0-15	1.08	L	5.6	1.03	2.1	-	4.36	0.34	13	71	wheat (1998)

Site ID	Transect Position	Soil Series	Soil Subgroup	Parent Material	Slope [Z] (%)	Horizon	Depth (cm)	Average Bulk Density (g/cm^3)	Texture (Lab)	pH in (H_20)	EC (dS/m)	CEC (meq/100g)	$CaCO_3$ (%)	ORGANIC CARBON (%)	TOTAL N (%)	C:N RATIO	TOTAL ORGANIC CARBON (T/ha)	CROP (Year)
Moist Mixed Grassland Ecoregion, continued																		
786	U	Altario	R. DB	M	-	Ap	0-12	0.98	SL	7.1	0.93	25.5	-	5.48	0.44	12	64	barley (1998)
786	M	Metisko	O. DB	F/M	16	Ap	0-18	1.14	SL	6.9	0.68	14.0	-	1.82	0.16	11	37	barley (1998)
786	L	Metisko	O. DB	F	-	Ap	0-20	1.42	SL	6.5	0.56	10.3	-	1.74	0.13	13	49	barley (1998)
791	U	Readymade	O. DB	M	-	Ap	0-13	1.35	L	-	0.16	19.5	<0.7	2.64	0.30	9	46	wheat (1999)
791	M	Readymade	O. DB	M	6	Ap	0-10	1.35	L	-	0.28	21.8	<0.7	2.39	0.20	12	32	wheat (1999)
791	L	Readymade	O. DB	M	-	Ap	0-15	1.16	L	-	0.23	26.4	<0.7	2.64	0.30	9	46	wheat (1999)
793	U	Readymade	CA. DB	M	-	Ap	0-14	1.42	L	-	0.40	18.6	<0.7	2.36	0.20	12	47	wheat (1999)
793	M	Readymade	O. DB	M	2	Ap	0-14	1.42	L	-	0.39	19.1	<0.7	1.20	0.20	6	24	wheat (1999)
793	L	Readymade	O. DB	M	-	Ap	0-14	1.46	L	-	0.22	17.1	<0.7	1.55	0.20	8	32	wheat (1999)
Fescue Grassland Ecoregion																		
798	U	Academy	CA. BL	M	-	Ap	0-16	1.19	L	5.8	0.72	19.7	-	2.40	0.24	10	46	wheat (1998)
798	M	Delacour	O. BL	M	1	Ap	0-19	1.20	L	6.7	0.41	21.0	-	3.89	0.32	12	89	wheat (1998)
798	L	Delacour	O. BL	M	-	Ap	0-16	1.15	L	6.2	0.51	22.8	-	4.44	0.34	13	81	wheat (1998)
800	U	Cardston	O. BL	M	-	Ap	0-19	1.40	C	-	0.14	35.0	<0.7	3.83	0.30	13	102	barley (1999)
800	M	Cardston	O. BL	M	3	Ap	0-20	1.49	C	-	0.15	30.2	<0.7	2.23	0.20	11	66	barley (1999)
800	L	Cardston	O. BL	M	-	Ap	0-21	1.39	C	-	0.14	27.9	<0.7	2.48	0.20	12	72	barley (1999)

Site ID	Transect Position	Soil Series	Soil Subgroup	Parent Material	Slope [Z] (%)	Horizon	Depth (cm)	Average Bulk Density (g/cm^3)	Texture (Lab)	pH in (H_20)	EC (dS/m)	CEC (meq/100g)	$CaCO_3$ (%)	ORGANIC CARBON (%)	TOTAL N (%)	C:N RATIO	TOTAL ORGANIC CARBON (T/ha)	CROP (Year)
Mixed Grassland Ecoregion																		
804	U	Purescape	O. DB	M	-	Ap	0-16	1.35	SL	6.5	0.55	13.9	<0.7	1.38	0.20	7	30	summerfallow (1999)
804	M	Purescape	O. DB	M	4	Ap	0-16	1.20	SL	6.7	0.81	12.9	<0.7	1.26	0.20	6	24	summerfallow (1999)
804	L	Ronalaine	SZ. DB	M	-	Ap	0-15	1.18	L	6.4	0.39	16.9	<0.7	2.22	0.20	11	39	summerfallow (1999)
806	U	Maleb	O. B	M	-	Ap	0-11	1.47	L	7.2	0.42	15.6	<0.7	0.38	0.10	4	6	canola (1999)
806	M	Maleb	O. B	M	4	Ap	0-10	1.51	L	6.8	0.37	16.6	<0.7	0.86	0.10	9	13	canola (1999)
806	L	Maleb	O. B	M	-	Ap	0-13	1.25	L	6.4	0.25	17.1	<0.7	1.39	0.20	7	23	canola (1999)
809	U	Maleb	O. B	M	-	Ap	0-12	1.34	L	8.0	0.38	16.9	<0.7	0.95	0.10	10	15	canola (1999)
809	M	Maleb	O. B	M	4	Ap	0-13	1.48	L	7.5	0.17	14.5	<0.7	0.07	0.10	0.7	1.3	canola (1999)
809	L	Maleb	O. B	M	-	Ap	0-15	1.20	L	7.3	0.14	19.6	<0.7	1.39	0.20	7	25	canola (1999)
812	U	Travers	CA. B	M	-	Ap	0-21	1.36	L	-	0.89	19.3	4.0	0.81	0.10	8	23	wheat (1999)
812	M	Travers	CA. B	M	1	Ap	0-24	1.51	SCL	-	0.79	15.3	5.1	0.42	0.10	4	15	wheat (1999)
812	L	Travers	CA. B	M	-	Ap	0-22	1.35	CL	-	0.88	17.5	3.6	0.75	0.10	8	22	wheat (1999)
815	U	Travers	CA. B	M	-	Ap	0-15	1.46	SCL	-	0.38	14.5	1.5	0.79	0.10	8	17	wheat (1999)
815	M	Travers	CA. B	M	6	Ap	0-13	1.50	SL	-	0.42	14.4	<0.7	0.87	0.10	9	17	wheat (1999)
815	L	Maleb	E. B	M	-	Ap	0-15	1.15	L	-	0.22	16.8	<0.7	1.31	0.20	7	23	wheat (1999)

Site ID	Transect Position	Soil Series	Soil Subgroup	Parent Material	Slope [Z] (%)	Horizon	Depth (cm)	Average Bulk Density (g/cm^3)	Texture (Lab)	pH in (H_20)	EC (dS/m)	CEC (meq/100g)	$CaCO_3$ (%)	ORGANIC CARBON (%)	TOTAL N (%)	C:N RATIO	TOTAL ORGANIC CARBON (T/ha)	CROP (Year)
823	U	Antonio	CA. B	FL/M	-	Ap	0-22	1.30	CL	-	0.75	17.9	5.8	1.13	0.10	11	32	wheat (1999)
823	M	Antonio	O. B	FL/M	2	Ap	0-21	1.25	L	-	0.58	15.4	<0.7	1.06	0.10	11	28	wheat (1999)
823	L	Antonio	O. B	FL/M	-	Ap	0-23	1.17	L	-	0.52	16.5	<0.7	1.06	0.20	5	29	wheat (1999)
828A	U	Helmsdale	R. B	M	-	Ap	0-14	1.44	L	-	0.40	8.5	8.3	0.83	0.10	8	17	summerfallow (1999)
828A	M	Maleb	O. B	M	3	Ap	0-15	1.59	L	-	0.37	12.8	<0.7	0.69	0.10	7	16	summerfallow (1999)
828A	L	Maleb	O. B	M	-	Ap	0-15	1.36	L	-	0.43	15.9	<0.7	0.71	0.10	7	14	summerfallow (1999)
828B	U	Maleb	O. B	M	-	Ap	0-12		CL	-	0.34	19.2	0.7	1.09	0.10	11		irrigated corn (2000)
828B	M	Maleb	O. B	M	2	Ap	0-14		L	-	0.37	16.2	0.7	1.04	0.08	13		irrigated corn (2000)
828B	L	Maleb	O. B	M	-	Ap	0-15		L	-	0.50	19.1	0.8	1.05	0.09	12		irrigated corn (2000)

[Z] slope steepness refers to the mid slope position, the upper and lower slopes are often nearly level.
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9.4 Agronomic Practices Sheet

ALBERTA SOIL QUALITY BENCHMARK SITES - ANNUAL AGRONOMIC ACTIVITES

Site ID: Ecodistrict # --- (Sec-twp-range-mer) - Cooperator	
Activity	**2002 (include dates and type of equipment)**
Spring Tillage:	
Tillage #1, type, date	
Tillage #2, type, date	
Tillage #3, type, date	
Spring Herbicide:	
Form #1, rate, method, date	
Form #2, rate, method, date	
Form #3, rate, method, date	
Spring Fertilizer:	
Form #1, rate, method, date	
Form #2, rate, method, date	
Total rate (lbs/ac) or (kg/ha) - N	
P	
K	
S	
Micronutrients	
Manure Applications?	
Seeding: Date	
Method	
Crop & variety	
Rate	
Seed treatment	
Seeding Depth	
Row Spacing	

Site ID: Ecodistrict # --- (Sec-twp-range-mer) - Cooperator	
Activity	**2002 (include dates and type of equipment)**
Herbicides:	
Form #1, rate, method, date	
Form #1, rate, method, date	
Form #1, rate, method, date	
Other Pesticides:	
Form #1, rate, method, date	
Form #1, rate, method, date	
Form #1, rate, method, date	
Harvest:	
Swathed/cut	
Combined	
Yield	
Residue Management:	
Fall Tillage:	
Tillage #1, type, date	
Tillage #2, type, date	
Tillage #3, type, date	
Fall Herbicide:	
Form #1, rate, method, date	
Form #2, rate, method, date	
Form #3, rate, method, date	
Fall Fertilizer:	
Form #1, rate, method, date	
Form #2, rate, method, date	
Comments:	