Landscape Sensitive Soil Quality Benchmark Sites in Alberta, Canada

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ABSTRACT

The AESA (Alberta Environmentally Sustainable Agriculture) Soil Quality Program was established in 1997 to determine the state of soil quality across Alberta and to determine the risk of change in soil quality with various management practices. Considering limited resources, a diverse farming area of 233,839 km^2, and time required to observe measured changes in soil parameters, we realized that modeling would need to be employed. Soil quality modeling and the subsequent extrapolation of site-specific data to regional levels require good quality data on climate, soils, land use and management practices.

There is a need for a monitoring network of sites to provide the data to test and validate these models. The AESA Soil Quality Benchmark Program was thus established in 1998. Forty-three sites, located in 42 ecodistricts within the agricultural area of Alberta, represent the soil-landscape patterns and agronomic practices central to each ecodistrict. Soil topographic sequences (upper, mid and lower slope positions) are monitored at each site. We will introduce the Soil Quality Benchmarks and look at several soil quality parameters based on landscapes and ecostratification.

INTRODUCTION

Increasing awareness of the environment and our use of natural resources has led to an Alberta Environmentally Sustainable Agriculture (AESA) Soil Quality Monitoring Program to determine the state of the soil quality across Alberta, the risk of change in soil quality with various management practices, and how soil quality integrates into environmental sustainability. Soil quality is difficult to define, measure and explain. Soil quality varies in time and space due to external factors such as land use, management and environmental interactions. We will address these concerns through soil quality measurements and estimations.

- Soil Quality is being measured through a system of benchmarks and landscape research.
- We realized that with limited resources, a large diverse farming area of 233,839 km2 and time required to observe measured changes in soil parameters that modeling would have to be used. Modeling soil quality requires the use of a range of state of-the-art models and good quality databases.
- Modeling efforts should be sensitive to the range of conditions found within landscapes.

MATERIALS AND METHODS

One database that is being monitored and developed is a network of benchmarks on farm fields across Alberta. The main objectives of this benchmark sampling across Alberta are to provide baseline soil information, provide a data set to test and validate simulation models (crop growth, wind erosion, water erosion), monitor changes in soil quality over time for typical field practices, and provide data on the landscape effects upon soil properties.

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In January 1998, a Soil Quality Workshop was held to provide advice for development of the AESA Soil Quality Benchmarks. Workshop attendees, involved in soil quality research and initiatives, were invited from the University of Alberta, Agriculture Canada, private industry, PFRA, Alberta Research Council, University of British Columbia, University of Michigan, University of Saskatchewan, USDA-ARS, USDA-NRSC and other 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.

The Soil Quality Workshop participants felt that an annual field sampling should occur at the ecodistrict level and that sampling should occur every year. It was decided to spatially stratify the benchmarks in accordance with the national ecostratification network 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. About 1/3 of the 100 ecodistricts in the agricultural area should be monitored and distributed geographically across the province. 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 should be as little as possible interference to the farmer during the growing season.

Criteria were developed by the AESA Soil Quality Committee to guide the selection of the benchmark sites and potential sites were selected in 1998 and 1999. The same pedoloist team established all sites. Benchmarks were central to each ecodistrict and representative of typical farming practices. Each profile was classified and sampled by horizon. AGRASID was used to ensure that the soils at the site were representative of the ecodistrict.

Locations of the benchmark sites were located with DGPS to permit positioning in subsequent sampling years (Figure 1). In addition to the legal description, a general description and air-photo showing the approximate location of the sampling points were documented.

RESULTS

Features of the Benchmark Sites (Figures 2 and 3)

- 43 sites, representing 42 ecodistricts chosen within the agricultural area of Alberta Agriculture
- sites are representative of the soil landscape patterns and agricultural practices within a given ecodistrict
- at each site, sampling occurs at three landform elements within a catena (upper, mid and lower slope positions)
- annual sampling occurs for soils and crops
- annual agronomic practices are recorded

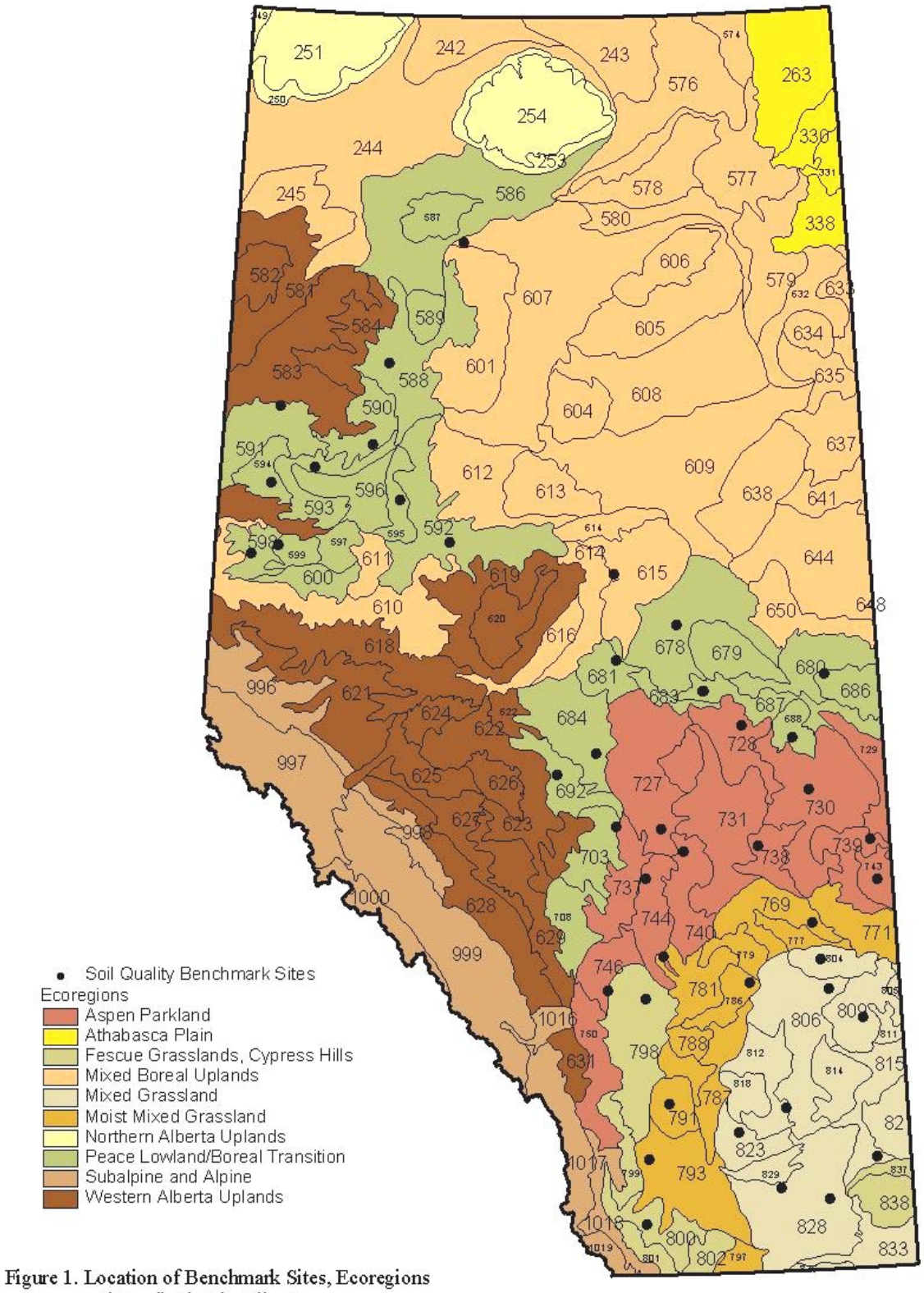

Figure 1. Location of Benchmark Sites, Ecoregions and Ecodistricts in Alberta.

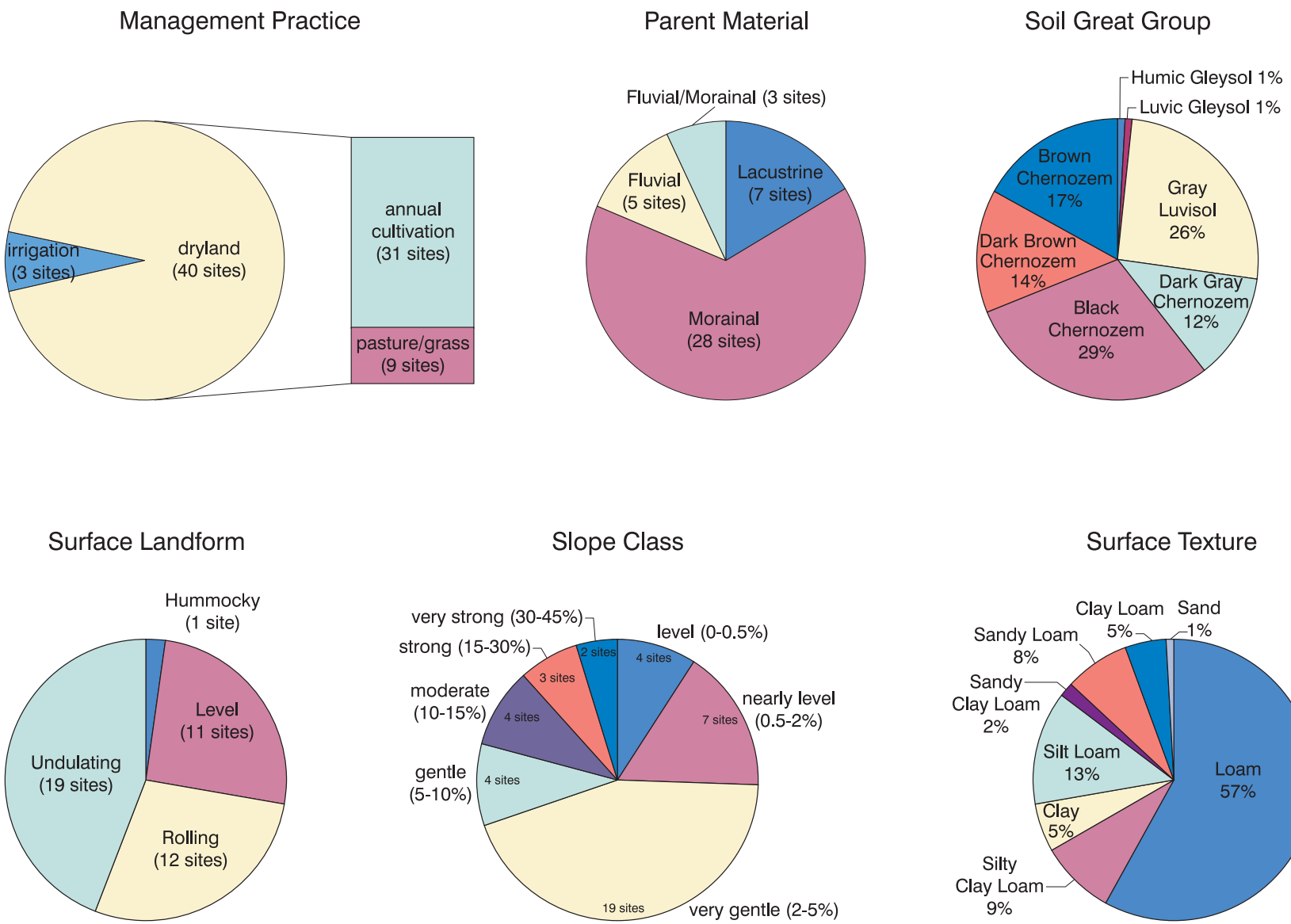

Figure 2. Characteristics of the AESA Soil Quality Benchmarks.

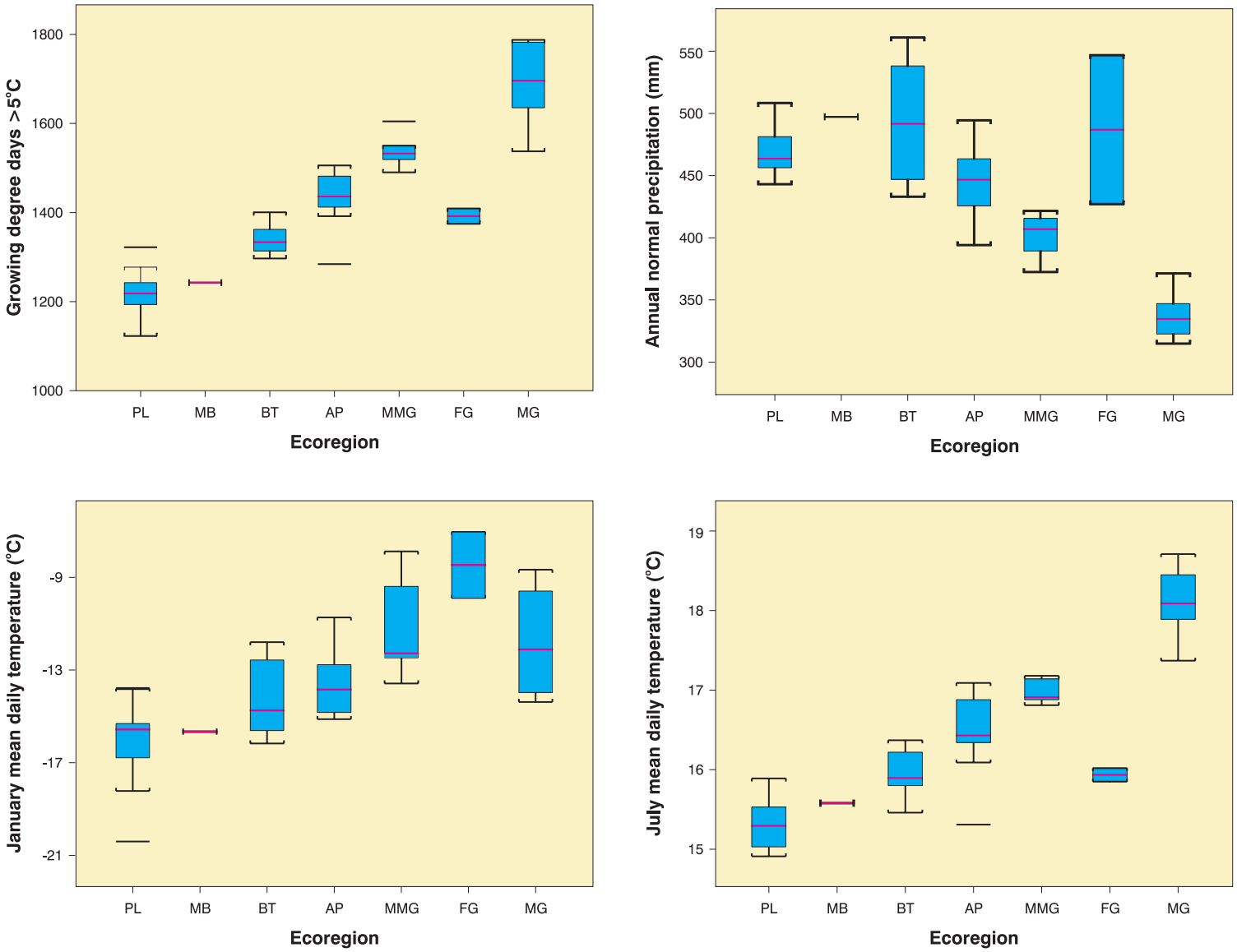

Figure 3. Climatic characteristics of the AESA Soil Quality Benchmarks.

Graphs show upper extreme values, upper quartile, median, lower quartile, and lower extreme values. Outliers are identified when they occur.

Annual Yield and Soil Sampling
Biomass and yield samples are collected at harvest time annually. Soil sampling also occurs every year after harvest. Soil analyses for the fertility samples collected include fertility, pH in water and CaCl2, EC, SAR if Ec >4), mineralizable N, light fraction C and bulk density. Yield samples are sent to the lab for analyses of protein, Ca and P. Oilseed crops were also analyzed for oil content.

Annual Agronomic History
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),
- harvest methods, and
- an indication of crop yields

Establishment and Ongoing Costs
Databases development is expensive and takes time and planning. Ongoing costs for the Benchmark Program include sampling equipment, lab analyses, GPS, GIS maintenance. Regional staff contribute a total of 0.8 years annually for sampling and maintenance of the benchmark sites. A coordinator is required to keep the benchmark project organized, on time and on budget.

Establishment costs (including site selection, characterization and lab analyses) for the benchmarks totaled $154,000 for a cultivated area of 10,986,702 ha or $0.014 per cultivated ha. Ongoing annual laboratory and equipment costs are $25,000 or $0.0023 per cultivated ha.

SUMMARY

It is difficult to quantify the state of soil quality and the rate at which soil quality could change under different management scenarios. Benchmarks document the complexity in soils and management across the agricultural area of Alberta. Because of the diverse nature of agricultural systems across Alberta, modeling will have to be used to estimate changes in soil parameters. Benchmarks provide a cost effective cross validation dataset for model verification and good visibility of soil quality issues and concerns.

ACKNOWLEDGEMENT

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