Development of a Standard Methodology for Assessing the Suitability of Soils for Application of Hog Manure in the Prairie Ecozone

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Introduction

Environmentally sound planning is required for the expansion of the hog industry in the prairies. Available existing information can aid in providing answers to questions of appropriate land use. Often however, the expertise required to assess environmental concerns is not readily available, and there may be few or no guidelines for interpreting available resource information such as soils and geology. This project was under taken to provide an evaluation of soils and other resource information that can be used by initial planners. It provides a systematic approach to interpreting and displaying available information about the characteristics of the soils and geologic materials on a rural municipality or county scale. The methodology will facilitate initial screening of potential areas for locating intensive livestock operations. It will not however, be adequate for site approvals. This will require appropriate investigation procedures by provincial licensing or approval agencies.

Scope of the Project

How do we return this "resource" to the field to protect and sustain the long term quality of our soils and waters, and at the same time enhance the productivity of the soil? The timing, rate and quantity of manure applied to the soil must be based on the nutrient demand of the crop and the ability of the soil to store and retain nutrients. The current issue of sustainable manure management, specifically hog manure, will be addressed from a nutrient management and crop requirement, surface water protection and groundwater protection point of view.

This collaborative project between the Western Land Resource Group and PFRA is being undertaken to develop a standard methodology for evaluating the various soil types and landscapes in terms of management requirements for manure (nutrient loading) application.

Objectives

The project has been designed to develop a standard methodology (a decision support tool) to assess soil suitability for general development with specific reference to swine manure on prairie soils and landscapes. Specific objectives include:

1. To complete and standardize data bases for digital soils maps at 1:100,000 scale for project test areas.
2. To standardize the geological and hydrological data base for application of a Geological Materials Index (GMI) appropriate to a scale of 1:100,000 for the project test areas.
3. Organize climate data for probability analysis of extreme events for the early, mid and end of growing season in the prairie Ecozone.
4. Develop a standard protocol for integrating each of these data sets to define soil management groups (SMG). Each group will be defined by dominant factors to consider and offer appropriate management considerations for environmentally sustainable application of swine manure to agricultural prairie soils and landscapes.

Approach

In the broadest sense, the issue of sustainable manure application to land is dependant on matching the available land resources (soil, geology, climate), to appropriate management practices (application methods, rates and timing, and crops), in order to maximize use of manure nutrients in crop production and ensure nutrient losses do not adversely affect the environment.

This project evaluated and rated resource properties that influence the potential fate of manure nutrients. The potential fates of nutrients include soil retention and uptake by crops, loss in surface runoff and loss from the soil via leaching. It is recognized that nutrients (N) can be lost to the atmosphere. However, this was only indirectly addressed as atmospheric loss can be influenced by management practices.

Methodology

The methodology was developed using existing computer capabilities, hardware and software available in the Land Resource Units, PFRA and Natural Resources Canada.

Selection of Study Areas

Three study areas were selected having a range of soils, geology and climate conditions. One area was located in each of the prairie provinces.

Alberta

The selected area was the County of Red Deer, west and south from the city of Red Deer. The 20 township area is: Twp: 34 - 38, Rge: 28 W4th - 3 W5th. The area is primarily in the Thick Black soil zone, grading to Dark Gray along the western edge.

Saskatchewan

The selected study area consisted of two rural municipalities in the southwest part of the province including the Rural Municipalities of Grassy Creek, RM 78, and Bone Creek, RM 108. The project is within a slightly more arid Brown-Dark Brown transitional soil zone.

Manitoba

The selected study area consisted of the rural municipality of South Norfolk located in the moist Black Soil zone of southern Manitoba.

Database components

The primary database that was used was the provincial soil inventory data. The common scale of soil information across the prairies is 1:100 000 and is available in digital format primarily on a Rural Municipality or county basis. The digital information includes the soil polygon lines and associated information on soil map composition and soil and landscape properties.

The geological data base consists of the drill log information collated and maintained by the respective provincial groundwater hydrology groups. This database was obtained for test areas in Alberta and Manitoba. In Saskatchewan this data analysis is pending evaluation of the data for the Alberta and Manitoba test areas. Use and interpretation of this database was done in collaboration with provincial groundwater specialists, and geotechnical staff in PFRA and Natural Resources Canada.

Climate analysis was based on the hydrology records of PFRA, and was evaluated in terms of likelihood of extreme events that would affect the risk for surface runoff. Aridity indices were derived from CanSIS (Canadian Soil Information System) databases.

A database of common manure management practices on the prairies, including pertinent information from provincial guidelines and management considerations for manure application was developed.

Development of Indices from Database Components

Use of the above data bases to assist with resource suitability evaluations for ILO planning, requires that the technical information contained in these databases be transformed into terms and factors useful to planners. The algorithm relating (integration and overlay techniques) database components is the essence of this decision support technology. The rational for the use and development of specific indices for each data base are discussed in the following section.

The Nutrient Factor

An important goal in applying manure to land is to increase the productivity of a soil. The actual rate at which manure is applied should be based on knowledge of the soil nutrient status, the nutrients required by a crop and nutrient content of the manure. Since this varies temporally and with previous management it was deemed that for a broad scale evaluation, a relative rating of inherent soil productivity was required. For this index a modification was made to the Land Suitability Rating System (Agronomic Interpretations Working Group 1995), which is a system similar in form to the Canada Land Inventory for Agricultural Capability Rating system but that can be calculated based on soil, landscape and climate information available in databases. The soils component was assessed with this system and the seven classes were regrouped into three

classes, namely - high productivity (classes 1-3), moderate productivity (classes 4-5) and low productivity (classes 6-7).

Surface Water Factor

The surface water factor describes the physical landscape conditions conducive to surface water ponding and runoff. The three factors used in the development of this index, (K- soil erodibility, L - slope length, S- slope steepness), were taken from the Universal Soil Loss Equation (Wischmeier and Smith 1965), as nutrients are likely to be included in surface runoff or associated with eroded material. The surface water factor was calculated for each soil polygon within the designated pilot areas, using the K factor for each of the indicated soil components and the median value of the indicated slope length and steepness class assigned to each soil. The values were then grouped into three categories High, Medium and Low.

Groundwater Factor

The groundwater factor is primarily concerned with the relative potential for nutrients to leach through the soils, move through the underlying materials and enter the shallowest aquifer. To define the capacity of the soil to retain nutrients, we considered the capacity of the soils to hold water and expressed it in terms of a root zone leaching index. The second consideration was the capacity for the underlying materials to transmit nutrients from below the root zone to the closest underlying aquifer. We expressed this capacity in terms of a geologic material index. The final rating for the groundwater factor was derived from the integration of these two indices.

Soil Root Zone Leaching Index

The root zone leaching index rates the potential for water movement below the rooting depth of common crops (assumed to be 1m) by comparing an estimate of water available for leaching, based on precipitation minus potential evapotranspiration (P-PE) data, to the available water holding capacity of the soil. Since most groundwater recharge occurs with spring snowmelt, the over winter P-PE data was used to estimate the water available to enter the soil. The available water holding capacity of each soil component was calculated based on volumetric moisture contents at 1/3 and 15 atmospheres moisture tension and soil layer thickness summed to a depth of 1m. Each soil component was rated as High, Moderate or Low based on the amount of water in excess or deficit of the available water holding capacity.

Geological Materials Index

For the present project, the Geological Materials Index (GMI) has is been calculated for the Manitoba and Alberta test areas only with the Saskatchewan data pending evaluation of these test areas. The GMI is meant to provide a regional overview of relative risk to groundwater related to geological materials across an area without specifically identifying aquifers. Locations with shallow pervious materials (or potential aquifers) are deemed much more at risk than locations with pervious materials covered by thick layers of impervious materials. The GMI is based on the thickness of each geological layer above the uppermost potential aquifer and the estimated vertical hydraulic conductivity of each geologic layer based on material composition or lithology

as described in groundwater well drill logs. Use and interpretation of this data was done in collaboration with provincial groundwater specialists, and geotechnical staff in PFRA and Natural Resources Canada. The GMI was calculated and rated as High, Moderate and Low and was applied to the soil polygons with a GIS overlay.

Integration of Nutrient, Surface Water, and Groundwater Factors into Soil Management Groups (SMG).

This project integrates available resource information to provide decision support tools for land managers. The Nutrient, Surface Water, and Groundwater factors, as described above, each represent individual pathways for potential manure-nutrient loss from agro-ecosystems. Although each factor can be evaluated independently for any soil landscape area, it was considered more practical to integrate the ratings into a smaller number of significant groups for land management decision making. Soil Management Groups (SMGs) define soil landscape areas with relatively similar manure-nutrient use characteristics. Each SMG represents one or more of the unique risk factor combinations. Management practices can then be selected to address the environmental sensitivities for the area, facilitating optimum sustainable manure-nutrient use, while minimizing the potential for nutrient losses due to leaching or surface runoff.

Decision Support System - automating access to resource and management information.

The development of standardized data bases for basic resource information on soils, landscapes and surficial geology was one of the initial objectives of the project. Classifying, categorizing and grouping this resource information for soil specialists and agronomists was also an important consideration. Future developments for this technology involves automating accessibility to this geographic information and linking it to provincial farming standards, guidelines and regulatory requirements.

It is proposed that access to this resource information for a municipality would be through a menu driven, interactive GIS facility. Users would be able to select resource information such as the SMG for an area, identify the major factors to consider for manure application or manure management information, such as provincial guidelines and regulations, setbacks, properties of manures, methods of application etc. Specialists would be able to interrogate the resource data bases, obtain relevant resource and management information and compile preliminary reports evaluating the suitability of the land base for manure applications.

The next immediate steps for this project are to assess the acceptability of this technology to provincial specialists in each province as a tool for screening and general planning for specific land use issues and proposals and to further test and evaluate the methodology at the regional or municipal level.

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