A METHODOLOGY FOR ASSESSING PRE-MINE AGRICULTURAL PRODUCTIVITY

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ABSTRACT

Current requirements set out by the Alberta Government state that the goal of reclamation is to return mined land to a capability that is equivalent or better than that which existed prior to mining. In preparation for coal strip-mine activity in the Lake Wabamun area, Monenco Ltd. has been conducting agricultural field studies for TransAlta Utilities Corporation since 1977. These studies are conducted to quantify land productivity as a general indicator of land capability prior to mining for comparison to productivity on reclaimed land. A close association with rural community groups and land holders is maintained to ensure success and reduce interference with local farm activities.

Agricultural land is generally differentiated into major crop and soil types with the use of maps, aerial photographs and field surveys. Field sites are selected for monitoring in relative proportion to the occurance of the major crop and soil types within the study area. Potential field sites are assessed on the basis of land use, uniformity of soil type and slope, and accessability.

Sampling methodologies for major crop types such as pasture, hay and grain have been adapted over time to reduce variability encountered during field programs. A review of past research has been undertaken to develop a statistically valid methodology for measuring productivity, with specific emphasis on pastureland monitoring.

INTRODUCTION

Coal strip-mine activity by TransAlta Utilities Corporation in the Lake Wabamun, Alberta area has been conducted for the production of electrical power since 1962. The mine area is located approximately 80 km west of Edmonton, with mine activity occurring both north and south of Wabamun Lake. The area north of the lake includes the Whitewood Mine permit area and Wabamun thermal power plant, encompassing 4700 ha of land (TransAlta Utilities Corporation, 1983). The area south of the lake includes the Highvale-north mine permit area and Sundance thermal power plant, encompassing 6475 ha, and the Highvale-south mine permit area and Keephills thermal power plant, encompassing 5787 ha of land (Montreal Engineering Company Limited, 1979b).

Mining is currently in progress within both the Whitewood and Highvale-north mine areas and is expected to begin in the Highvale-south mine area within the next ten to twenty years. Current government Development and Reclamation requirements state that the goal of reclamation is to return mined land to a capability that is equivalent or better than that which existed prior to mining. Monenco Limited has been conducting agricultural field studies for TransAlta Utilities Corporation since 1977 in order to quantify productivity of land used for agriculture. These measurements of pre-mine land productivity, which are a general indicator of land capability, are part of the approach that TransAlta uses to document the success of its reclamation efforts.

METHODOLOGY

BACKGROUND

The methodology presently used for the determination of agricultural productivity is the result of a continuous review of related research in conjunction with an adaptable field program to help reduce variability encountered in the area. This adaptation occurred over the years to develop a statistically valid methodology for measuring agricultural productivity without creating unnecessary interference with current farming activities. Additionally, the methodology is designed to be as cost effective as possible. A cooperative association has been maintained with the local landholders and rural community groups to ensure that the project objectives were well understood. Results of soil analysis and crop yields have also been made available to the local land holders to assist in their field management activities. The yearly field management activities of each field involved in the study are documented on questionnaire handouts delivered in the spring of each year. The farmers are requested to supply information regarding seeding, fertilizing, crop rotation and other field related activities. Since the inputs of farm management have an affect on productivity, it is important to qualitatively monitor the influence of this factor.

LAND EVALUATION

Agricultural land within each mine permit area was assessed by reviewing available information from previous soil and vegetation surveys, soil maps, and aerial photographs. The crop type and soil characteristics were considered to be major factors in the determination of land productivity, so the dominant crop and soil types were differentiated from this information. This differentiation was completed so that similar crop and soil conditions could be identified on reclaimed land and compared to pre-mine agricultural productivities.

The relative proportion of each soil subgroup was determined by planimetering the area covered by each subgroup in the study area on a soil survey map. The proportion of major crop types found in the area was determined in a similar manner, using recent color aerial photographs from the study area. Vegetation observed in the study area was easily differentiated into agricultural land and wildland, but a field survey was often required to differentiate the area into more specific crop types such as coarse grains, hay, tame pasture and wild pasture. In order to ground-truth these unidentifiable crop types within the study area, observations were made from municipal roadways and crop types were noted on color mosaic maps of aerial photographs. The relative proportion of each major crop type was then determined.

SAMPLE SIZE ESTIMATION

The number of field sites selected to monitor the study area was influenced by the number of major soil and crop types noted in the area. In the Highvale-south mine permit area, for example, the proportion of major crop types were determined to be 50% tame pasture, 25% hay and 25% coarse grains, while the major soil types were determined to be 60% Luvisol, 20% Gleyed Luvisol and 20% Gleysol. With this in mind, it was concluded that the field sites selected for monitoring the study area should represent a sampling range of similar proportion. A total of ten field sites were considered a suitable number to study the area, including five field sites on pasture and five field sites on hay or grain. The field sites located on hay or grain rotate as crop rotations progress. Similarily, of the ten field sites selected to study the area, six field sites were located on Luvisol soils, two field sites on Gleyed Luvisol soils and two field sites on Gleysol soils.

An analysis of data collected in a similar program was completed to determine the number of samples required to monitor each individual field site, as well as determine if field sites with similar crop and soil types could be considered replicates of each other (Monenco 1983a).

The analysis indicated that ten samples collected from each individual field site could be used to accurately monitor productivity with a confidence limit of at least 90% and an allowable error of ±20%.

FIELD SITE SELECTION

Potential field sites were identified during a late fall and early spring field survey. The survey was conducted from municipal roadways to identify potential sites on the basis of land use, uniformity of soil type and slope, and accessibility. Municiple roadways were used to locate most of the field sites to ensure access throughout the growing season and to help reduce crop disturbance created by repeated trips to the field sites. The determination of specific crop type was completed in the fall when hay and grain harvests were in progress. Consideration was also given to the consistency of slope position to help reduce variability encountered between north-facing slopes south-facing slopes and relatively flat areas. The spring field survey was used to confirm soil types identified on soil maps or in previous soil surveys. Since fields were still either un-seeded or crops very small at this time, access was not difficult to arrange. Soil samples were collected from random locations across each potential field site with a Dutch soil auger. Relevant soil characteristics from the major horizons, such as color, texture, mottling and gleying, were used to confirm the identity of the soils.

From the overall list of potential field sites, ten final selections were made. Land holders were contacted to relay the objectives of the program, to determine their interest in participating in the program and to inquire about their long term land use plans. Alternate field sites were selected when farmers declined participation in the monitoring program.

VEGETATION SAMPLING PROGRAM

The sampling methodology is based on sampling procedures previously completed in the Lake Wabamun area (Montreal Engineering Company, Limited 1979b, Monenco Limited 1982a, 1983b, 1983c, 1984). The methodology was finalized after a review of literature on statistical sample size estimation (Webster 1979, Little and Hills 1978, Payandeh and Beilhartz 1979, Freese 1967), sampling procedures for measuring productivity (Nevens and Khulman 1935, Mott et al. 1962, Cooke 1969, Bjorge 1976, Mueggler 1976, Agriculture Canada 1981, Ahmed et al. 1983, Kondra 1983, Lopitinsky 1983, Waddington 1983), experimental variability factors (Van Dyne et al. 1963, Warren and Mendez 1982, Deshmukh and Baig 1983), the effect, use and design of pastureland monitoring cages (Williams 1951, Cowlishaw 1951, Green et al. 1952, Linehan 1952, Campbell and Lodge 1955) and the effects of grazing on pasture fields Pitt and Heady 1979, Hofmann et al. 1981).

PASTURELAND MONITORING

Estimates of productivity on pastureland are determined by measuring plant matter produced on selected field sites over each growing season. Small prismatic wire cages, each measuring 2 meters long, 1.5 meters wide at the base, and 1 meter high, are utilized to protect small areas of pasture grass within each field so that measurements of plant growth can be made. The cages are constructed of 5 x 5 cm, 9 gauge galvanized wire mesh, strong enough to withstand cattle activities, and are secured to the ground with metal pegs. A total of 10 cages are randomly placed to sample within the boundaries of each 1 ha field site. Pasture grass under each cage is cut three times during the growing season with a sickle-bar mower. The first harvest date coincides with the entry of cattle onto the pastures, the second occurres before the grass heads out in July, and the final cut occurs by mid-September.

A bulk sample from a 1 x 2 m area is cut at approximately 5 cm from the ground and collected from the cages during each harvest. Borders of 0.25 m along the sloped sides of each cage are not included in the sample to reduce any effects created by cattle grazing along the edges. Each sample is raked, placed in a paper bag, and weighed to the nearest gram on a triple-beam balance. A small grab sample is collected from every second bulk sample, weighed to the nearest gram and sent to the laboratory for drying and dry weight measurement. The fresh weight/dry weight ratio from these selected grab samples is used to determine the dry weights for all the bulk samples. Measurements obtained during the three harvests at each cage are combined, and an average measurement for each field determined and reported in g/m^2 and tons/acre.

In the earlier years of pasture land monitoring, a permanent fenced exclosure was used to monitor each field site. This system, however, did not have the advantage of mobility that the present cage monitoring system has. Over time, changes in the plant community within the permanent exclosure were occurring. The lack of normal grazing pressure by cattle was affecting productivity. In addition, the permanent exclosures were more susceptible to cattle damage than the cages. Therefore, the cage monitoring system applies a more reliable and consistant sampling technique, and allows replicated sampling across the entire field site. A "direct" sampling method, which measures the grass produced under each cage for the entire growing season, is utilized for this monitoring program. A "difference" sampling method, which measures growth, both inside and outside of each cage, would be required if measurements of grass consumption by cattle were being monitored.

HAYLAND MONITORING

Estimates of productivity on hayland are determined by measuring plant matter produced on selected field sites over each growing season, prior to the summer (1st cut) and fall (2nd cut) harvest. Ten hay samples are collected from each field site, with a 25 m interval between each sample and a total field site area measuring 50 m wide x 125 m long. A pre-determined sampling interval, rather than a completely random selection of sample locations, is used in an effort to minimize crop disturbance and assist in re-locating sample sites. A hay sample from a 1 m^2 area is cut from each sample location at approximately 5 cm from the ground with hand-operated hedge clippers and is forwarded to the laboratory for determination of fresh weight/dry weight ratios.

In the spring, when hay growth is short, each of the ten sample locations are identified with a 1 m high white stake. After the first sampling program is completed, the stakes are removed and each sample location is marked with a small amount of colored flagging tape. After the field is swathed and baled, the sample locations are reidentified, and the flagging is replaced by 1 m high white stakes. This process allows the same locations to be easily identified for the second sampling program. Measurements obtained during the first and second sampling program from each sample location are combined. An average measurement for each field is determined and reported in g/m^2 and ton/acre. The plant composition of each hayfield is determined by estimating the occurrence of different plant species at each of the 10 sample locations using the point-intercept method (Mueller-Dombois and Ellenberg, 1974).

An attempt at an alternative sampling method was conducted for one season, but it proved highly variable and inconvenient. Fresh weight samples were collected directly from farmer swaths as soon as possible after the hay was cut. The coordination of this sampling method was made difficult by the fluctuating schedules of both the researcher and the farmer. There was also a problem with accuracy of the measurement, considering all hay crops are not cut at a consistent height, width, or time. The present sampling methodology allows for much more control by the researcher, thereby eliminating a large percentage of the variability.

GRAINLAND MONITORING

Estimates of productivity on grainland are determined by measuring plant matter produced on selected field sites over each growing season, prior to fall swathing and combining. The sampling procedure is the same as the Hayland sampling program discussed previously. When dry, each sample is weighed to determine total weight of grain and straw, threshed on a portable threshing machine and the grain collected in a paper bag and weighed. This provides a dry weight measurement for both grain and straw at each sample location.

In the spring, after seeding is complete, each of the ten sample locations are identified with a 1 m high white stake. This allows quick and easily identification of sample locations without unnecessary disturbance of the mature crop.

An average measurement for grain and straw is determined for each field. Grain samples are sent to the laboratory for determination of moisture content. Field conditions, such as grain lodging and weed problems, are noted when samples are collected.

Large 15 m x 15 m permanent plots had previously been used to monitor coarse grains, but these were found extremely inconvenient for the farmer to identify and cut around.

SOIL SAMPLING PROGRAM

The identification of individual field site soil characteristics plays an important role in the assessment of baseline conditions associated with each crop and soil type. Where no previous soil survey information is available, a soil pit is dug in a central location within each field site after the fall harvest. The timing helps minimize any effects on that years crop, yet provides time to re-seed the surface for next seasons growth. The soil from each major horizon ($\geq$ 5 cm) is identified, described and sampled (McKeague 1978). Samples are sent to the laboratory for chemical and physical analysis.

When more in-depth sampling is required, composite hand auger samples are collected in the spring in addition to the fall soil pit. Samples from ten random locations at three depths in each field site (0-15 cm, 15-30 cm and below 30 cm) are collected, placed in labelled plastic bags and sent to the laboratory for chemical analysis. Information regarding available nutrients from the spring and fall soil analysis are made available to the farmer associated with each field site.

CONCLUSION

Although methods for sampling soil and vegetation can be quite specific, a certain degree of flexibility was maintained to develop this monitoring program. A mixture of recognized sampling techniques, practicality, and field experience are used to adapt the program within a variety of conditions. The program utilizes crop yield to measure productivity on the dominant soil types in the area. This information is supplemented by farm management data provided by farmers. The process of undertaking the surveys includes land evaluation, sample size estimation, site selection combined with public participation, soil sampling and vegetation sampling. The information collected will provide an accurate measurement of pre-mine land productivity and a useful indication of land capability.

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RECLAMATION IN MOUNTAINS, FOOTHILLS AND PLAINS: DOING IT RIGHT!

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