TECHNOLOGY EVALUATION AND DEVELOPMENT SUB-PROGRAM

MANAGEMENT OF FARM FIELD VARIABILITY IV. CROP YIELD, TILLAGE SYSTEM, AND SOIL LANDFORM RELATIONSHIPS

FINAL REPORT

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EXECUTIVE SUMMARY

This report documents the last two objectives of the SWEEP/TED project "Management of Farm Field Variability". The objectives of this part of the project were to determine crop yield response to different tillage systems, at different landscape positions, and relate the variations in crop yield response to soil and landform properties. The possibility of implementing variable management was examined by quantifying the stability of the yield response pattern over a number of years.

The study was carried out in cooperation with the provincial Tillage-2000 project, which is a cooperative project of the Ontario Ministry of Agriculture and Food (OMAF), the Dept. of Land Resource Science (Univ. of Guelph), and cooperating farmers. Details of the study are given in the annual reports of the project, which are available from OMAF.

Field sites were selected from the existing Tillage-2000 sites for detailed examination of the relationships between landform, soil properties, soil loss, tillage management, and crop yield. At each fieldsite, two tillage systems (conventional, conservation) had been established and permanent benchmark monitoring locations selected. The conservation system was defined as any tillage system which should decrease the loss of soil from the field by erosion. The tillage system were classified as no-till if no primary or secondary tillage was completed, minimum till systems if no inversion tillage (moldboard plough) system was used and moldboard if a moldboard plough was used to invert the soil.

Landform at each benchmark was characterised by carrying out a detailed elevation survey using a laser theodolite, and calculating parameters based on a digital elevation model and classification system. The landform classification is based on the slope gradient and change in slope gradient with distance (curvature) at a location. A concave surface with low slope is classified as a footslope, while a convex surface with low slope is a crest/shoulder position. In addition the cross-slope curvature can be causing water to

converge (concave cross-slope) or diverge (convex cross-slope) at a point and landforms are further divided by this classification.

Relative soil loss was obtained from relative changes in ^{137}Cs content (a naturally occurring soil tracer) measurements. Soil properties were obtained from a 1.0 m soil core taken at each site using a hydraulic soil sampler. Yield measurements collected as part of the Tillage-2000 program were entered into the data base containing all of the other information. Soil sampling for soil fertility analysis was also completed. Indices for plant available water and air filled porosity were calculated from soil profile data. The objective of the sampling program was to obtain as complete a database as possible. A copy of the database accompanies this report.

The 5 year (1986-1990) average grain corn, soybean, and small grain yields in the paired conservation and conventional tillage systems were not significantly different. In addition, field by field, and year to year differences in yield were equally variable in the conservation and conventional systems. The paired moldboard and minimum tillage sites suggested a slight yield advantage to the moldboard system. Average relative crop yields across all crop types were higher in the moldboard system for all years except 1988. A total of 23 out 36 plot years had higher yields on the moldboard system compared to the minimum tillage system.

The paired no-till and moldboard tillage sites indicated no significant difference in yield for any of the crop types. A total of 14 out of 23 plot years had a higher yield in the no-till system than in the moldboard system. Average relative yield across all crops was higher in 1987 and 1988 in the no-till compared to moldboard, but lower in the other three years.

The paired no-till and minimum tillage sites indicated a slight yield advantage to the no-till system. The average no-till yield was significantly higher than minimum tillage yield (0.1 probability for both the soybeans and small grain crops.

Conservation tillage systems, both overall and in the paired tillage comparisons, did relatively better than conventional systems in 1988 (a drought stress year) than in any other year. This suggests that conservation tillage systems are more buffered against adverse crop growth conditions than conventional systems.

Soil texture (Ap horizon) class and tillage X texture class interactions were significant (0.001 probability) in explaining the variations in yield of all crop types. Landform class was significant for corn and soybeans, but not small grains. A regression of the ratio of no-till yield/conventional tillage yield against % sand content of the Ap horizon was significant (0.05 probability). The regression indicated that for % sand contents greater than 36 % the no-till yield would on average be higher than the conventional tillage system. The no-till yield for finer textured soils would on average be lower than conventional tillage systems. The interaction of tillage and texture is suggested as the reason for little overall differences in tillage system on crop yield, across all farm sites.

Landform classification criteria as proposed by Pennock and de Jong (1987) are not sensitive enough at the elevation measurement scale used in this study (i.e. 10 m grid). The criteria for backslope versus level class (6.5 % slope) resulted in an unacceptably large number of level class designations. The criteria was changed to 3 % slope gradient.

A general analysis of covariance confirmed the presence of significant covariance between the major soil properties. The 7 unit landform classification system was not very useful in explaining variations in soil properties. This was partly attributed to the high variability of texture within the landform classes, and the covariance of texture and other soil properties.

A sub-classification by upper, middle, and lower slope position within each of the original landform classes explained a significant (0.05 probability) amount of the variability of almost all soil properties, especially those related to soil loss. The conceptual model of the slope location of the original landform classes was correct for approximately 60-70 %

of the benchmarks. However, a significant number of benchmarks were found at slope positions not conforming to the conceptual model. The poor success of the original 7 landform classes in explaining the spatial variations of soil properties was attributed to the conflicting patterns that water flow and tillage translocation would have on soil properties.

Solum depth was significantly related to soil texture class, but ^{137}Cs content was not related to texture. This suggests that the amount of soil loss is not related to texture, and the increased solum depths in the sandy soils are related to pedogenic processes. The independence of soil loss on soil texture, and the higher cesium loss on upper slope comparedto middle slope positions are contrary to water erosion theory, but consistent with tillage translocation theory.

The difference between the highest and lowest yielding areas in a field, across all years and all sites was 40 % of the mean field yield. Tillage system did not significantly affect the within field variations in yields. The lowest, highest, and range, of relative yield difference weresimilar in the paired tillage comparisons. The standard deviation of relative yield difference was slightly higher (0.05 probability) in the minimum compared to no-till system.

The percentage of within field variation of yield remained constant from year to year was on average 52 % and 56 % (significantly different at 0.10 probability), for the conventional and conservation tillage systems respectively. Approximately 3 % of the benchmarks had an average yield which was at least 30 % less than the average field yield. Another 5 % of the benchmarks were between 20 % and 30 % lower than the field average yield. A total of 15 %, and 4 % of the benchmarks had an average yield which was greater than 10 %, and greater than 20 % of the field average yield respectively. The relative ranking of the benchmarks with respect to relative yield was independent of the measurement year, but the year did affect the magnitude in all yield classes. The drought stress year (1988) resulted in much greater relative within field variations of crop yield.

A paired benchmark analysis on crop response on stress (low yielding) and non-stress (high yielding) benchmarks, in stress and non-stress growing conditions was carried out. It indicated that conservation tillage systems may be more buffered against adverse climatic growing conditions than conventional tillage systems. High yielding areas under conservation tillage dropped only 13.8 % in yield during a stress year, compared to 16.5 % decrease in the conventional system. Low yielding areas in the conservation system decreased 24 % in yield in the stress year, compared to a 31.1 % decrease in the conventional system. This benchmark data supported the paired field yield data, which indicated that the ratio of conservation yield/conventional yield was the highest in 1988 the drought stress year.

The 7 unit landform classification explained a significant amount ofthe within field benchmark yield data. Converging landforms had on average 8.5 %, 7.8 %, and 5.5 % higher yields of corn, soybeans, and smallgrains respectively, compared to diverging landforms. Across all crop types the average difference between converging and diverging landforms was 7.3 % (significant at 0.05 probability level). The diverging shoulderand backslope position had significantly lower corn and soybean yields, than the other landform units.

There was a significant interaction of soil texture class and soilloss, on relative crop yield losses. Benchmarks were separated on the basis of %sand in the Ap horizon and yield response correlated against cesium content in each texture class. Yield response to soil loss was predicted from these correlations. Severely eroded soils with a % sand content greater than 70 % had an average predicted yield loss of 37 % of the field average yield. The same severely eroded soils had a predicted yield loss of only 8.0 %, 4.7 %, and 0.7 % for Ap horizons with 50-70 %, 40-50 %, and 30-40 % sand content. The yield loss in all texture groupings increased during the 1988 growing season indicating soil loss was affecting available water, but more so in the sandier soils. The available water index of

McBride and Mackintosh (1984) was significantly related to cesium content in the >70 % sand content group, but not in theother groups. The benchmarks with 20-30 %, and <20 % sand content had a predicted relative yield decrease of 4.3 % and 8.0 % respectively. Thus, the benchmarks in the medium texture classes had much less predicted yield loss from soil loss, than benchmarks with lighter or finer soil textures. This is consistent with the higher available water holding capabilities ofmedium textured soils compared to other textures.

The data in this project, and in the Tillage-2000 project indicate that it should be possible to implement a conservation tillage system with no loss in yield productivity. This is especially true for sandy texturedsoils where increases in yield are likely under conservation tillage.

For the range in soil and landform conditions in this report, thereseems to be little benefit to adopting a minimum tillage system. No-till yields were equal or better than minimum till and the minimum till was slightly lower yielding than the moldboard tillage. In addition, the work on tillage translocation suggests that secondary tillage, which can sometimes be more intensive under minimum tillage, can result in significant soil loss off of shoulder/crest slope positions. The criteria of 20 % or 30 % residue cover to control water erosion is meaningless with regards to tillage translocation. Thus, unless a management procedure can be devised to control tillage translocation, minimum tillage can not be viewed as a viable alternative to a moldboard system in a sustainable production system. The minimum till system may control water and soil loss by water erosion, but it will not be stopping the decline in soil quality and crop productivity in the upland regions.

The study indicates that the sandy soils (>70 % sand) are the most fragile of all of the soil types. Soil loss in upper convex slope positions has already resulted in yield losses of 30-40 % of the average field yield. The productivity losses are even more severe in years of climatic stress. However, since on average these soils had a higher yield in no-till than in any other tillage system, there seems little reason for farmers not to adopt the no-till system immediately. The main mechanism of soil loss is tillage translocation, and water erosion is likely to be minimal considering the high infiltration capacities of sandy soils.

Conservation tillage systems appear to be increasing the soils buffering capacity against adverse climatic conditions, particularly drought stress. This is encouraging considering the possibility of increased frequencies of drought stress due to global warming trends. The full extent of the remediating capabilities of no-till is not very well understood and should be the subject of future studies. The remediation may appear to be faster than expected because the massive soil loss from tillage translocation has been stopped in the no-till, but continued in the conventional tillage system. Thus, even if the yield productivity of severely degraded areas is stabilized, it would appear that they have undergone an increase because of the continued decline in productivity of the conventional system. The actual rate of remediation, and degree to which it is possible to remediate these areas is unknown, and beyond the scope of this study.

A considerable amount of research activity is currently underway regarding variable management. A symposium on this subject will be held at the annual American Society of Agronomy meeting. Other symposia havebeen held the past few years by the American Society of Agricultural Engineers (ASAE). Most of the activity has centered on development of spatial location sensors, and variable application technology. There seems to be little doubt that the technical ability to vary management within the field will be present, the important missing link is the knowledge base to decide what kind of management should be done at each point in the field. The yield data indicates that reasonably consistent pattern of yield are present year after year. Thus, variable management from a cost benefit point of view is necessary. Technology for automaticmeasurement and recording of yield patterns is available, but more accurate equipment is needed.

The consistent yield differences in the benchmarks from year to year is encouraging, and it is clear that many of the differences are related to soil loss or the effects of soil loss. The sites with very large yieldlosses are diverging shoulder slope/crest positions as indicated by Battiston et *al.* (1987). This problem can be attributed almost entirely totillage translocation. The obvious solution is not to till the fields. However, it may be possible to change the pattern of tillage. The necessity of at least alternating the direction of all tillage, including secondary tillage cannot be overstated. The net soil losses from alternating tillage directions is still very large, but much smaller thanthe loss from a single direction.

Without an accurate method of predicting the soil redistribution from tillage translocation, there does not appear to be much hope in explaining any more than about 40-50 % of the spatial variations of soil properties. The same constraint exists for predicting variations in yieldresponse using only landform classification. The alternative is to measure and map yield response directly from year to year and identify sensitive areas from changes in yield from year to year especially during climatic stress conditions. While it is possible to predict that the areas of high yield loss will likely be the shoulder slope positions, it is not true that all shoulder slope positions have been eroded and thus will have yield reductions.

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1.0 INTRODUCTION

This report documents the work on the last two objectives of the SWEEP/TED project "Management of Farm Field Variability". The first report of this project (Kachanoski et al., 1991a) gave the overall justification, objectives, and general methodology of the project, which will not be repeated here.

2.0 OBJECTIVES

The objectives of this part of the project were:

1. To determine crop yield response to different tillage systems, at different landscape positions.
2. To relate the variations in crop yield response to soil and landscape properties.

3.0 METHODOLOGY

This part of the study was carried out in cooperation with the Tillage-2000 project, which is a cooperative project of the Ontario Ministry of Agriculture and Food (OMAF), the Dept. of Land Resource Science (Univ. of Guelph), Joint Program Conservation Authorities, the Ont. Soil and Crop Improvement Assoc., and cooperating farmers. Details of the Tillage-2000 project have been given in the annual reports of the project (Aspinall et al., 1986-1990).

In the Tillage-2000 project approximately 40 farm sites were selected. A paired sampling design was established on each of the field scale sites. Each study site had at least 2 field scale treatments, a conservation and conventional system. The long axis of each plot was orientated so that the major soil landscape units in the field would be split (paired) by the 2 tillage systems. Within each major soil landscape unit, permanent paired benchmark plots were established for collection of crop, soil, and topographic information. Three or four different landscape units were chosen at each site, each replicated 3 or 4 times. Thus, at each site there were a total of approximately 18 to 32 benchmarks. Each benchmark consisted of a 6 m by 6 m square sampling area which was permanently marked with an electronic marking sond (3M manufacturers). The individual benchmark crop yield data was collected by the OMAF Soil Conservation Advisors, with help from staff of cooperating Conservation Authorities, and this project. The yield samples were taken by hand within each benchmark sampling area. The sub-area for yield sampling within each benchmark was chosen immediately after planting but before emergence, to eliminate bias. The specific type of sampling depended on crop type.

For corn, 2 adjacent rows each 6 m long were chosen. The corn cobs were sampled, weighed, and counted in the field. A sub sample of 10 cobs was selected for determination of moisture percentage, and cob versus kernel weight. This was used as a conversion for the field weights. Soybeans yield sampling also consisted of adjacent rows, but the entire plants were cut off and run through a hand thresher. Small grain sampling was on 2 m by 2 m sub-areas, with the plants once again taken and put through a hand thresher.

The basic soil survey data was collected by Doug Aspinall, again with help from project staff. An undisturbed soil core was taken to a depth of approximately lm within the benchmark sampling area, using a hydraulic soil coring unit. Soil analysis for texture, pH, and $CaCO_3$ were carried out by the Ont. Institute of Pedology Lab. Additional soil sampling was carried out by project staff for ^{137}Cs analysis (described in an earlier report) and soil fertility testing. Soil analysis were completed by the Analytical Service of the Dept. of Land Resource Science, Univ. of Guelph, under the supervision of E. Gagnon, or by project staff.

The soil data from the undisturbed soil cores was used to estimate indices of available water and air-filled porosity using the methods outlined by McBride and Mackintosh (1984).

Elevation measurements were made at the selected set of sites using a laser transit and prism (total station). A grid (approximately 10 m by 10 m) of elevation measurements were taken over the entire field site. The landform parameters; elevation, gradient, aspect, profile (downslope) curvature, plan (cross-slope) curvature, were calculated at each benchmark using the surrounding point elevation measurements and a fitted least squares quadratic surface (Kachanoski et al., 1991a).

Once the individual landform parameters were calculated, the benchmarks were classified into similar groups. Each group defined distinct landform elements or hillslope zones with specific ranges of surface morphological attributes. A classification system using this concept has been proposed by Pennock and de Jong (1987) and is given in Table 3.1. The results from the first report of this project (the detailed Brant site and the tillage translocation of soil, Kachanoski et al,. 1991a) indicated that a major landform classification parameter related to soil loss should be curvature.

The results were analysed using a variety of statistical methods depending on the objective of the data analysis. The yield data was summarized by year, crop, and tillage system using both paired and unpaired analysis. In the unpaired analysis the average yield was calculated from all sites that had a particular treatment. The paired analysis compares yields from only those sites where both treatments being compared are on each of the fields included in the average. Statistical comparisons are made using standard analysis of variance and paired student's t-test using the SAS (Univ. of North Carolina, USA) statistical analysis programs.

The tillage treatments were first grouped into conservation versus conventional systems. The conventional system is the system the Tillage-2000 farm cooperator normally uses on the farm. The conservation system is the additional treatment added to the Tillage-2000 field which reduces tillage intensity, increases surface residue, and hopefully decreases the loss of soil and phosphorus by erosion and runoff. If the normal tillage system was **a** fall moldboard plough with spring secondary tillage, then the conservation system could be either a no-till system, or a non-inversion minimum tillage system. Tillage systems were also classified into three groups; Moldboard (MB), Minimum (MIN), and No-till (NTL). The no-till treatments had no primary or secondary tillage, with planting occurring directly into the previous years crop residue. The moldboard tillage system consisted of a primary moldboard tillage where the soil is inverted, and subsequent secondary tillage. The minimum tillage group was all of the remaining tillage systems and usually involved a non-inversion tillage treatment such as discing or chisel plowing, which may or may not have been followed by secondary tillage. The three tillage groups can bethought of as maximum (moldboard), moderate (minimum), and slight (no-till) soil disturbance systems. The measured surface residue on the tillage systems as reported in the annual Tillage-2000 reports supports the grouping of the tillage systems in this manner. For the year following a corn crop, surface residue levels were on average 5-10 %, 25-35 %, and 50-80 % for the moldboard, minimum, and no-till systems respectfully (Tillage-2000 annual reports, Aspinall et al., 1986-1990).

Additional data analysis were carried out to examine the influence of soil landscape on yield patterns. Again the specific analysis depended on the specific objective of the data analysis. If the existence of within field variability is to be exploited, then it has to be possible to identify regions or trends within a field that stay reasonably consistent from year to *year* with regards to yield response. If a particular region within a field has lower than average yield in one year but not in another year, then variable management becomes difficult. Thus, methods of assessing the consistency of the yield pattern within a field from year to year were used.

The consistency of the yield pattern from year to year was checked using; simple correlation analysis, principal components analysis, and the calculation of the mean relative difference Dy. The correlation analysis was straight forward. If the individual benchmark yields within a field have the same relative difference to each other then the linear correlation (r) between benchmark yields from different years will be high. The coefficient of determination (r^2) will give the percentage of within field variation that can be explained by the benchmark locations, from year to year. This is the consistent part of the yield pattern that can possibly be exploited by changing management.

Principal components analysis is slightly more complicated, but accomplishes approximately the same thing as the correlation analysis. Readers are referred to detailed descriptions of the method in Statgraphics, (1987). The method identifies a series of components which combine linearly to give your original data set, under the condition that the different series of components are linearly independent of one another. If the yield pattern within a field stays relatively consistent from year to year, then the first principal component series obtained from the analysis will explain a majority of the yield variability across all years. The series also gives you the underlying linear time stable pattern.

In addition to principal components analysis, the relative yield pattern was also estimated by calculating the average relative difference in yield Dy given by:

$$\mathbf{Dy} = \mathbf{Et\ [\ (Yi - E[Yi])\ /\ E\ [Yi]\ ]} \qquad \mathbf{[1]}$$

where, Yi is the yield at a benchmark for a particular year, E(Yi] is the field averaged yield for that year, and Et [:] is the average across all years for a particular benchmark. Thus, Dy gives you an estimate of the relative difference in yield at a benchmark compared to the mean field yield that can be expected on average over a number of years.

The type of statistical analysis used will be stated for each section of data discussed, along with additional comments on why the analysis was used. The crop, soil, and landform measurements for each individual benchmark and tillage system are given in Appendix V. The database has been put on a computer disc which accompanies this report. All subsequent analysis and data summaries were completed from this database.

4.0 TILLAGE SYSTEMS AND CROP YIELD

4.1 Yearly Averaged Yields

The average yearly yields for corn, soybeans, and small grains (wheat, barley, oats) for unpaired benchmarks across all tillage treatments are given in Table 4.1, along with the number of benchmarks for each crop and year. A standard analysis of variance indicated that the measurement year had a significant effect on average yield for each of the three crop types (probability < 0.001).

The highest yield in corn was in 1987 with a very high average of 9169 (kg ha^{-1}). The lowest yield was in 1988 due to the severe drought conditions that prevailed during July and August. Drought in the spring of 1989 is also probably the reason for the second lowest yield of corn.

The 1988 drought conditions had less of an effect on soybean yields and little effect on small grain yields. In fact the small grain yield in 1988 is the second highest of the 5 years (Table 4.1). This is probably because the drought was in July and August, which is when small grains are ripening not filling. The lowest soybean and small grain yields were in 1989, which again is attributed to an early season drought.

The previous discussion on yield/crop/year is important for subsequent discussions involving the effects of different tillage systems during crop stress or non-stress conditions. It also indicates that an overall paired analysis is necessary since an uneven number of benchmarks of a particular tillage system in a good or bad year could significantly affect the overall calculated average.

4.2 Conventional Versus Conservation Tillage

The comparison of conventional versus conservation systems is essentially a paired comparison, since each Tillage-2000 field had both systems. Thus, it is possible to compare averages over all 5 years. Table 4.2 gives the 5 year field yield averages of corn, soybeans, and small grains, for the two systems. An analysis of variance indicated no significant differences between systems for any of the crops. This is obvious from the similarity of the average yields given in Table 4.2. For example, the 5 year average paired yield of corn was 7855 kg ha^{-1} and 7858 kg ha^{-1} for the conventional and conservation systems respectfully. Although certainly not statistically significant, it is interesting that the average for each crop type is larger in the conservation tillage system.

The lack of a statistical difference between conventional and conservation systems, and the fact that the average yields were actually higher in the conservation system is very important. It indicates that the Tillage-2000 program was able to implement conserving tillage system, which did not reduce overall crop productivity. There is certainly no evidence in the data to suggest that adoption of a conservation tillage system will on average reduce crop yield. In addition, the standard deviation of field yields given in Table 4.2 indicate that the range (variability) in yield response over the 5 years and all sites is essentially equal. Thus, field by field and year to year differences in yield were not more variable under conservation systems. For economic risk models this translates into equal production risks for the two systems.

The average crop yields for each year for the conventional and conservation tillage systems are given in Table 4.3. As mentioned earlier an overall analysis of variance indicated no significant difference between tillage systems and no tillage X year interaction.

4.3 Moldboard Versus Minimum Tillage

The average corn yield for the paired moldboard and minimum tillage sites is given in Table 4.4. The moldboard treatment had a slightly higher average yield of 8274 kg ha^{-1} compared to the minimum tillage average of 7961 kg ha^{-1}. The difference was not statistically significant, but the data suggest a slight yield advantage for the moldboard system with 11 out of the 18 sites having a higher yield on the moldboard system. The high variability of the yield differences is not attributable to only differences between farms, since within farm variability is quite high. For example, in 1986 at the Q. Martin site (Mart86) the minimum till had a yield 1771 kg ha^{-1} less than the moldboard system. However, in 1987 this difference was 600 kg ha^{-1} in favour of the moldboard and in 1990 the minimum till out yielded the moldboard by 689 kg ha^{-1}. The data set also contains some explainable differences, such as the large 2354 kg ha^{-1} yield difference in favour of the moldboard system for the Anthony site in 1987 (Anth87). This was the first year of trying the minimum tillage system for the cooperator, and verbal discussions indicated that the tillage was done under too wet conditions and the planter wasn't set properly for the increased residue level. In 1990 the minimum till at the Anthony site (Anth90) had a yield 330 kg ha^{-1} higher than the moldboard system. For some sites, such as the Dykstra site, the minimum till yield was always lower than the moldboard.

The average soybean and small grain yields are given in Tables 4.5 and 4.6 respectively, for the paired minimum and moldboard tillage systems. The yield differences were not significant for the soybeans, but once again the moldboard out yielded the minimum till system in 5 out of 7 plot years. The moldboard also had a higher average small grain yield of 207 kg ha^{-1} which was significant at the 0.10 probability level.

For all crop types the moldboard system had higher yields on 23 out of the 36 plot years. This and the fact that the average yield was higher for the moldboard for each crop type suggest a slight yield advantage to the moldboard system over the minimum tillage system.

4.4 Moldboard Versus No-till

The average corn yields for the paired moldboard and no-till sites are given in Table 4.7. On average the no-till had a higher yield of 401 kg ha^{-1}, which is almost significant at the 0.1 probability level. A total of 8 out of the 12 plot years had a higher yield on the no-till treatment. The difference would have been statistically significant except for the large 1773 kg ha' difference in favour of the moldboard system at the 1988 Templeman site. The very low no-till yield at this site/year was attributed to this being the first year of no-till at the site and the cooperator used a surface application of urea for Nitrogen fertilizer, which is not recommended. The corn had classic Nitrogen deficiency symptoms in the no-till plot. The next plot year at this site (1990, Temp90), the no-till had a 107 kg ha^{-1} higher yield than the moldboard system.

The average yield for soybeans and small grains are given in Tables 4.8 and 4.9 respectively, for the paired moldboard and no-till sites. The average no-till soybean yield was 52 kg ha^{-1} higher than the moldboard yield, but again the difference was not statistically significant. There were only 2 small grain site/years which is not enough to complete any statistical analysis, however both plot/years had higher yields on the no-till sites.

In total, 14 out of the 23 plot years had higher yields on the no-till treatment and there was almost a statistically significant difference in corn yield in favour of the no-till. This indicates that at the very least, there is no evidence in the data to suggest that changing to a no-till system would have resulted in an overall yield decrease.

4.5 Minimum Versus No-till

The field averaged corn yields for the paired minimum and no-till sites are given in Table 4.10. The average no-till corn yield was 169 kg ha^{-1} higher than the minimum till yield, but this was not statistically significant. The yield differences were highly dependent on the site, with the Chipps site having very large differences in favour of no-till, while the Pottruff site had large differences in favour of minimum tillage.

The field average soybean and small grain yields are given in Tables 4.11 and 4.12, for the paired minimum and no-till sites. The average no-till yield was significantly (0.1 probability level) higher for both the soybeans and the small grains. In total, 14 out of 25 no-till plot years had higher yield than the minimum till treatment. This combined with a significantly higher yield in the no-till for soybeans and small grains indicates that there may be a slight yield advantage to the no-till system.

The paired site data indicated that both the moldboard and no-till systems had a slight yield advantage over the minimum till system, and the no-till system was equal or slightly better than the moldboard system. These trends can be summarized across all crops and years by comparing yield ratios (yield from one treatment divided by the yield from the paired site under a different tillage treatment). This data is summarized in Table 4.13. Across all benchmarks, fields, crops and years the conservation tillage system had a 2 % (yield ratio = 1.02) greater yield than the paired conventional system. The paired moldboard and minimum till sites indicated a 3.5 % higher yield for the moldboard system (significant at the 0.10 probability level). The paired minimum tillage and no-till sites indicated an 8 % higher yield for the no-till treatment (significant at the 0.10 probability level). The paired moldboard and no-till sites indicated a 3 % higher yield in the no-till, but this was not significant.

The comparisons which included the no-till system tended to be very site dependent, with yield differences being either positive or negative across all years. The data clearly do not support the hypothesis that no-till will always result in lower crop yields. While this was true in some sites it was clearly not true in other sites, and on average a yield gain was measured for the no-till sites. Out of a total of 48 paired plot/year measurements with no-till as one of the treatments, 28 (58 %) had a higher yield in the no-till. Out of a total of 23 paired moldboard and no-till plot/year measurements, 12 (57 %) had a higher yield in the no-till. For small grains 6 out of 7 paired plot year comparisons had the highest yield in the no-till system.

The data in Table 4.13 also indicate that the conservation tillage systems, both overall and in the paired tillage comparisons, did relatively better in 1988 (a stress year) than any other year. Thus, while absolute yields declined in 1988 from the drought conditions, the yield decline was relatively less in the conservation tillage systems than in the conventional systems. This suggest that the conservation systems have more of a buffer against adverse conditions than conventional systems.

The average differences between moldboard, minimum, and no-till are very small with differences significant at only the 0.1 probability level for some crops, years, and tillage pairs. Thus, there appears to be justification to combining the tillage treatments into a single database for examining the influences of topographic position, and soil properties on general yield response. This will be done, but the influence of soil and topography on yield will also be given for individual tillage comparisons to examine specific questions about the interaction of tillage system and soil conditions on yield response.

4.6 Tillage System, Soil, and Yield

The purpose of this section is examine the influence of soil conditions on the crop yield response under different tillage. The emphasis will be on comparing systems in this section rather than on how soil conditions influence yield within a field. The latter topic will be covered in detail in Section 6.0.

A summary of the analysis of variance of crop yield against soil properties and other major independent variables is given in Table 4.14, Table 4.15, and Table 4.16 for corn, soybean, and small grain crops respectively. The tillage source of variance indicated the same information as discussed in the previous section (Section 4.3 to 4.5), except for the significant tillage term for corn yield (Table 4.14). The high significance level for tillage and corn yield is a result of the non-pairing of the sites in this analysis, and the significantly lower yields for the no-till-minimum paired sites (Table 4.10) compared to the other paired sites (Table 4.4, Table 4.7). The analysis is left unpaired in this section to examine variations of yield as a function of soil variables across all sites. A better indication of the significance of tillage system on crop yield is the previous paired analysis where the significance was at the 0.10 probability level.

Texture class and tillage X texture interactions were significant (0.001 probability) for all crops, but the interaction was only significant at the 0.15 probability level for soybeans. Landform class was significant for corn and soybeans, but not small grains. However, drainage class was only significant for small grain yield. Cesium classes (1987 sampling) were only significant at the 0.1 to 0.2 probability level for all three crops. As will be shown later, this is a result of a significant interaction between the influence of soil loss on yield and texture. Unfortunately, because of the large number of variables it was not possible to examine every combination of interactions. The tillage x landform interaction was not significant for any of the crops.

To better quantify the interaction between tillage system and texture on crop yield response a regression analysis was carried out on the paired field averaged yields. Since the interaction term was significant for all of the crops, the ratio of yields obtained from paired comparisons was used in an analysis across all crop types. This allowed more observations for each tillage comparison.

The ratio (R) of the no-till yield/conventional tillage yield, calculated for each plot year, across all crops and years was significantly correlated ($r^2 = 0.61$, significant at the 0.05 probability level) to the average % sand content of the Ap horizon. The regression equation obtained was:

$$\mathbf{R1 = 0.95 + 0.0022 \times (\%\ sand\ content\ in\ Ap\ horizon)} \qquad [2]$$

where, R1 = no-till yield/conventional tillage yield. The conventional till yield was either moldboard or minimum tillage depending on the paired system at each field. At a % sand content of approximately 25 %, the calculated R1 value in the above equation equals 1.0. The value of R1 will be greater than 1.0 for % sand contents greater than 36 % respectively. Thus, on average the yield data suggests that no-till yields will be greater than other tillage systems in sandy (>36 %) soils. This consistent with the generally held belief by most farmers, that no-till is more successful on lighter textured soils. A more detailed examination of yield response and texture classes is given in Section 6.0.

The ratio of minimum tillage yield/moldboard tillage yield was not significantly correlated to % sand. However, when all data was combined to calculate a ratio R2, of conservation tillage yield/conventional tillage yield, the regression against % sand content (Ap horizon) was significant (0.05 probability) with an equation given by:

$$\mathbf{R2 = 0.94 + 0.0016 \times (\%\ sand\ content\ in\ Ap\ horizon)} \qquad [3]$$

When % sand is equal or greater than 36 % then R2 is greater than 1.0 and the conservation system would have a greater predicted yield than the conventional system.

The interaction of tillage system and texture is probably the reason that little overall differences in tillage systems were found in the general analysis of variance (Sections 4.2

to 4.5). The conservation tillage systems generally did better in the lighter textured soils, while the conventional system on average did better on in the heavier textured soils. Thus, across all sites, tillage was only slightly significant. As will be subsequently shown, some fields had tremendous within field texture variations and these will be used to examine the question of differential tillage response to texture in more detail. Examining within field variations paired by tillage is an efficient method of analysis because the tillage systems have the same management and manager, crop variety, and climate.

5.0 SOIL AND LANDFORM RELATIONSHIPS

5.1 Introduction

As indicated in the literature review of the first report (Kachanoski et al., 1991a), the detrimental effects of erosion on crop productivity in many past studies have been confounded with landscape positional effects. Our goal was to try and separate differences in crop yield caused from past soil loss, from inherent yield differences caused by pedogenic soil differences, and landscape position. The main technical problem related to data analysis is that soil properties and landform shape have a large spatial covariance. The lower concave footslope positions tend to receive more runoff water (from upper slope positions),and thus may in general be less prone to drought stress. These same locations may also have more organic matter, greater solum depths, etc., which by themselves also help in alleviating drought stress by increasing available water holding capability. Soil loss on these locations may have little effect on crop yield because of both soil and landform properties.

The need to understand why a location responds in a particular manner is important if management options are to be implemented which can capitalize on that behaviour. It is importance to understand the spatial covariance between the soil and landform properties in a data set, before interpreting site specific yield responses. The relationship between soil and landform are examined in this section. Subsequent sections will then give the yield response relationships.

5.2 Landform Classification

The benchmarks were originally classified according to the criteria outlined in Table 3.1 (Pennock and de Jong, 1987). The criteria are based on three parameters; (1) landform curvature in the direction of maximum elevation gradient (sometimes referred to as downslope or profile curvature), (2) landform curvature perpendicular to the direction of maximum elevation gradient (cross slope or plan curvature), and (3) maximum elevation gradient.

Downslope curvature is used to separate out the convex crest/shoulder positions (positive curvature), footslope positions (negative curvature), and positions with little curvature (backslope and level sites). These landscape elements are illustrated conceptually in Figure 5.1. The locations with little downslope curvature are separated further by positions with an elevation gradient (backslope) and no gradient (level). The selection of how much gradient (slope) is needed before a location is classified as level or as a backslope is subjective. Pennock and de Jong (1987) chose greater than 3 degrees slope as a necessary requirement to be classified as a backslope. In more familiar units this is greater than 5.2 % slope. They also chose 0.1º/m (positive or negative) as the minimum downslope curvature necessary for classification as a shoulder or footslope.

The landform is further classified into converging (shoulder, backslope, or footslope) units with negative cross slope curvature and diverging (shoulder, backslope, footslope) units with positive cross slope curvature. The classification units were based largely on how water will move through the landscape, since this is assumed to be the main mechanism of interaction between spatial locations, and because the system was developed for identifying areas of different water erosion potential and yield response (both dependent on water movement).

Initial benchmark classifications were carried out with the original criteria of Pennock and de Jong (1987). However, after the analysis it became clear that the criteria classified over 60 % of the benchmarks as Level, and few backslope positions were identified. This was in retrospect not surprising considering the large (5.2 %) slope needed to be classified as not-level. A more realistic criteria of 3 % was subsequently used. The 3 % slope criteria has been used in soil surveys as well. The downslope criteria was also altered to 0.04 °/m for similar reasons. Pennock and de Jong (personal communications) are also changing criteria limits because of similar concerns with large numbers of Level classifications. They believe (but have no data to justify) that different criteria are necessary in different climatic regions.

5.3 Results and Discussion

A summary of the analysis of variance on the influence of the landform classification, soil texture class (Ap horizon), and the interaction between texture class and landform, on the variability of major soil properties is given in Table 5.1. Texture class explained a significant (0.001 probability level) amount of the differences in solum depth between benchmark locations. Landform class was only significant at the 0.14 probability level and the interaction of landform class and texture was not significant with respect to solum depth variations. In total, landform class and texture can account for 18 % of the total solum depth variations among the different benchmarks, with most of the variation explained by texture class. The same amount of the variability (18 %) of organic matter (Ap) was explained by texture class and landform (both significant at the 0.001 probability level).

Landform and texture class explained 34 % and 27 % of the variability of soil teat P and K respectively, with texture the dominant variable (significant at 0.0001 probability level). The interaction of texture and landform class was almost significant at the 0.10 level for soil test phosphorus. Texture class was also significant (0.0002 probability) in explaining over 20 % of the variation in pH of the Ap horizon.

Over 25 % of the variation of the Available Water (AW) index (McBride and Mackintosh, 1984) was explained by landform class, texture, and their interaction. The Water Availability Index is an estimate of the amount of water stored in the soil profile, which should be available for crop use the coming year. It is based in texture and bulk density measurements and regressions of these parameters with available water.

The interaction of landform class and texture on AW was significant at the 0.0008 probability level. About 20 % of the variation of ^{137}Cs and the change in ^{137}Cs between 1987 and 1990 was accounted for by the landform and texture classes. However, landform was only slightly significant (0.10 probability level) with respect to the change in ^{137}Cs. Variations in surface carbonate (%) were not significantly explained by either landform or texture class.

The general analysis of variance (Table 5.1) confirms the presence of covariance between the major soil properties. Solum depth is affected by texture class, but so is ^{137}Cs (and by inference soil loss). Thus the relationship between solum depth and soil loss (^{137}Cs loss) must be examined within specific texture classes. The significant effects of both landform, texture class, and their interaction on the AW index indicates yield relationship to AW must also be interpreted carefully. In general, the relationships between the various parameters were expected and are given here as background for subsequent discussions on yield response, and as justification for classification of benchmarks on the basis of the Ap horizon texture. The significant effect of landform class on ^{137}Cs and other important variables such as the AW index, organic matter, and to some extent solum depth, is encouraging. However, the total amount of variance explained by the topographic classification is not large.

The average values of the major soil variables for the different landform classes are given in Table 5.2. Average solum depth was approximately 50 cm in all of the landform classes, except for the Converging footslope CFS, which was 61 cm. As indicated in Table 5.1 the influence of landform class was only significant at the 0.14 probability level, which was largely related to the increased average solum depth in the CFS class. In general, although some significant soil property differences exist between the landform classes, the differences are not particularly large. The ^{137}Cs (1987) values also do not show as much difference as expected between the landforms. The converging landforms are always higher (significant at 0.05 probability) than the diverging landforms, but the shoulder slope class is not lower than the footslope as would be expected according to the study by Battiston et al. (1987), and the Brant site study given in the first report of this project (Kachanoskiet al., 1991a).

The previous analysis suggests that the 7 unit landform classification with no modification is not very useful with regards to explaining the variations in soil properties. While some of this can be explained by the significant influence of soil texture on average soil properties and the distribution of more than one texture class in each landform class, more influence of landform class was expected. One landform parameter which was not included in the analysis is contributing area. Contributing area is an index of how much area upslope from a location is possibly contributing runoff water to that location. Unfortunately, it is necessary to have a closed basin or watershed as your study area to do this calculation. The cross slope curvature is a partial index of the contributing area, since it indicates whether upslope runoff flow lines are converging on a particular spot, or diverging away from a location.

A location with a high contributing area will usually have a negative (converging) cross slope curvature. The significant effect of converging versus diverging landforms on ^{137}Cs values (Table 5.2) suggests contributing area may be important. The Tillage-2000 sites were set up on a farm field basis to match management scales and not by basin or sub-basins.

To further refine the landform classification, a further subdivision was made on the basis of relative slope position (upper U, middle M, and lower L) within each field. This is partially equivalent to defining three contributing area classes (U = low contributing area, M = medium, L= high), without having to calculate a value for contributing area. However, it also separates out tillage soil loss areas, since these tend to occur on upper slope areas. The number of benchmarks in the original landform classes in each of the U, M and L slope positions are summarized in Table 5.3. In the shoulder slope class 53 %, 28 %, and 19 % of the benchmarks were in the U, M, and L slope positions respectively. The fact that almost 20 % of the shoulder slope class is found in lower slope positions is contrary to the conceptual notion of that landform class as illustrated earlier in Figure 5.1. However, the designation of "shoulderslope class" is based only on the presence of a convex downslope curvature. Thus, the conceptual model of the shoulder slope class in Figure 5.1 is the ideal situation. It is possible (and probable as indicated by the data in Table 5.3) that the lower portions of some slopes also have a convex curvature, especially at the local scale (10 m) of the elevation data base. Most (53 %) of the shoulder slope class corresponds to the ideal conception and is in the upper slope position (Table 5.3). The same is true for the backslope class with the majority (70 %) being located in the middle slope position, and the footslope class with 61 % located in the lower slope position. Thus, on average the digital designation works. However, a reasonably large number of benchmarks do not correspond to these ideal slope positions and this, in addition to texture interactions, may be why average soil properties such as solum depth, ^{137}Cs, and others are not as different between the original landform classes as expected. It appears that complex topography is justly named, and any ideal conceptualization will only hold true on average.

The average values of the major soil properties for the landform classes further subdivided by U, M, and L slope position have been summarized in Table *5.3,* Table 5.4, and Table 5.5. The classification by slope position (U, M, L) was significant at greater than the 0.05 probability level for almost all soil properties. The properties related to past soil loss were especially sensitive to the classification of slope position. For example, the average solum depth in the entire backslope class was approximately *51* cm, which was not significantly different than the other landform classes (Table 5.2). However, the lower (L) slope positions of the backslope class had an average solum depth of 90 cm, while the middle slope position (the conceptually ideal position) had a solum depth of only 44 cm (Table 5.4). Of particular significance is the partitioning of the variance of % $CaCO_3$ (Ap horizon). The original landform classes were not significant in explaining the differences of surface carbonate content (Table 5.2), which has generally been thought of as a good indicator of severe soil loss. The designation by U,M, and L slope positions explained a lot of the differences. For example, the backslope class had an average of 5 %, 1.7 %, and 0.0 % for the U, M, and L slope positions respectively (Table 5.5). On average the upper slope positions had 4.1 % which was significantly (0.05 probability level) higher than the M(1.3 %), and L(0.8 %) slope positions. The average pH (Ap horizon) values are also now significantly distributed among the landforms, which is to be expected since they should be related to the distribution of surface carbonates (Table 5.3).

The values for ^{137}Cs in the U, M, and L slope positions are consistent with the concept of increased soil loss on upper slope positions, with the distinction between U, M, and L more important than classification by downslope curvature (Table 5.5). Even the

Level class had a significant difference in cesium levels in the U, M, and L slope positions. The distribution of cesium among the landform classes now corresponds with the changes in average solum depth, %$CaCO_3$, and pH. The interaction of all of these variables with texture class was also significant, so this effectis still imbedded in the data and needs to be examined. However, the landform classification with additional slope position designations appears to do a reasonably good job of separating areas of significantly different soil properties and soil loss.

One final comment should be made on the ability to separate out areas of different soil loss using the landform classification method outlined above. The entire rational for the designation criteria is basedon those landform properties which control the movement and accumulation of runoff water in the landscape. The downslope curvature is calculated as the curvature in elevation along the direction of maximum slope gradient. The rational being that this is the direction that surface runoff and soil loss processes will be occurring. This reasoning is validif the major process of soil loss is water runoff. As indicated in the first report the major soil loss on upper shoulder/crest slope positions has been attributed to tillage translocation and not water runoff (Kachanoski et al., 1991a). In addition, the translocation and lateral mixing process caused by tillage translocation is so severe that it would also be affecting the cesium concentrations in the middle backslope areas. The tillage translocation process will be controlled by the landform shape in the direction of tillage, which may or may not be in the same direction as the maximum slope gradient. In complex topography it is clear that thedirection of tillage translocation could not possibly be always in the same direction as water flow. This simple fact may be why it is difficult to obtain a good relationship between soil properties and landform shape.

The soil would have the imprint of the water flow pattern from the 10, 000 years of soil development superimposed on a severe soil redistribution pattern related only to the direction of tillage which is controlled by existing or past fence lines. The result would be a semi-random pattern/covariance of soil and landform, which is exactly what Battiston et al. (1987) and others have found.

The average values of the major soil properties, classified into groups based on % sand content of the Ap horizon are given in Table 5.6.

As indicated, the numbers of benchmarks were evenly distributed across a wide range in sand contents (5 % to 90 %). Despite this wide range in sand content, %clay only varied from 5 % to about 35 % with mostof the sand content variation being matched by silt content variation. The lack of a large number of benchmarks with high clay content is a limitation, but is probably similar to the texture range found in the upland regions of Ontario with complex topography. Most of the high clay content soils of Ontario are found in the lowlands which were not a focusof this project.

Solum depth was significantly related to texture class (0.001 probability level), which is primarily related to the greater solum depthsfor soil with sand contents greater than 70 % (Table 5.6). These very sandy soils also have the lowest pH, organic matter, %$CaCO_3$, and soil test Mg. Surprisingly, the available water AW index is very similar to the other %sand classes, except the lowest (<15 %) %sand class. The <15 %sand class also has the greatest Ap depth, highest %organic matter, highest soil tests (P, K, Mg), highest AW index, and lowest air-filled porosity index. Thus, while the two extremes in texture class have a number of significantly different soil properties, the middle classes have averagevalues which are somewhat similar. Only the air-filled porosity index seems to change progressively across the texture range. Average ^{137}Cs content does not appear to be dependent on %sand class and the analysis ofvariance also indicated that texture was not significant in explaining cesium variations. This suggests that the amount of past soil loss is notdependent on texture class. This is contrary to what would generally be predicted on the basis of water erosion theory. The lower cesium on upperversus middle slope positions (Table 5.5) is also contrary to water erosion theory.

The benchmarks were also classified according to solum depth classesto examine how other soil properties may be changing as solum depth changes. This analysis is given in Table 5.7. The benchmarks had a wide range in measured solum depth with 12 % of the benchmarks having a depthof less than 15 cm, and 10 % were greater than 90 cm. The other benchmarks were evenly distributed among the other depth classes. The average Ap thickness is positively correlated to solum depth.

The cesium values show some relationship with the solum depth classes with the lowest and highest average cesium corresponding with the smallest and greatest solum depth classes. The <15 cm depth class did nothave as low a value of cesium as expected based on the assumption that this class has had a lot of soil loss. The solum depth in the data base was allowed in some cases to be less than the Ap depth, which is technically incorrect. If the %$CaCO_3$ was greater than 3 % in the Ap horizon and the soil core showed no soil development below the plough layer the solum depth was set to zero (0). This was purposely done to identify those sites with parent material at the surface. However, there are difficulties in deciding why an Ap horizon has a high carbonate level. In the Brant site (Kachanoski et al., 1991a), a number of profiles whichwere in depositional areas had high surface carbonates. This was attributed to the deposition of upper slope soil from severely eroded areas composed of parent material. Also, some soil types have naturally high values of carbonates (pedogenic) and should not be classified as eroded. Unfortunately, exclusion or inclusion of a site as eroded or noteroded would then require examination of other soil properties, which would defeat the purpose of trying to use the carbonate level as an index to classify benchmarks for soil loss or other soil properties. The net effect is that this class may have erroneously classified benchmarks, which the authors would like to remove, but cannot. As will be shown later, a classification based on cesium (soil loss) avoids this problem and results in low solum depths for severely eroded sites.

The AW index shows some dependency to solum depth class, increasingsystematically as solum depth increases. Air filled porosity, however, does not change dramatically from class to class. The pH and texture (% sand, % silt, % clay) all change systematically with solum depth.

6.0 BENCHMARK YIELD, SOIL, AND LANDFORM RELATIONSHIPS

6.1 Introduction

The purpose of this section of the report is to examine the influence of landform, soil, and management (tillage) on crop yield. The effects of soil loss on yield response is also examined, which is related to soil and landform interactions. Finally, the consistency of yield response within a field (i.e. the within field variability of yield) from year to year will be assessed to determine the feasibility of implementingvarying management within a field. The effect of tillage system on the consistency of yield response will also be examined.

Much of the data analysis was carried out using relative crop yield values rather than absolute values, although the absolute values were alsoused when appropriate. The use of relative crop yield analysis allows data from different crops to be combined, and yield relationships obtained for general within field management, which is not crop specific. A limitation to this approach is that different crops may respond differently to the stress variations in the field. However, it is unlikely that variable management (within field) will be adopted if radically different systems have to be devised for each crop type, at least at this stage of the technology development. If it is possible to identify consistent within field variations across all crops, then the first step towards making variable management a reality has occurred. A detailed analysis of how much of the within field yield variations remain constant from year to year was completed. This is also an indicator of whether the different crops grown each year respond in a similar manner. Calculating the relative yield difference can therefore be viewed as a normalization process allowing trends in the data to be identified independent of cropor tillage system. Absolute yields were also used in the analysis especially when comparing the interaction of tillage and soil on yield response.

The convention for the benchmark numbering is, first digit corresponds to Treatment, second and third digits to Benchmark position (ie. 213 corresponds to Treatment 2, Benchmark 13).

6.2 Field Yield Patterns

A summary of parameters of the within field variations (averaged over all growing seasons) of the relative yield difference (%) is given in Table 6.1 for the paired tillage treatments. The average difference between the lowest and the highest yielding areas (within a field) was 40 % of the mean field yield. This range in yield difference was the same in both the conventional and conservation tillage systems. The lowest yielding areas were on average 20.3 % and 19.1 % lower than the average field yield for the conventional and conservation tillages respectively, which was not significantly different. The high yielding areas were on average 19.1 % and 17.7 % higher than the field yield, for the conventional and conservation systems respectively. Again there was no significant difference between tillage systems. The average standard deviation of the within field difference was also the same for the two tillage systems (Table 6.1).

Pairing the tillage systems did not result in any significant differences in any of the relative difference parameters, except for the within field standard deviation which was significantly (0.05 probability) larger in the minimum tillage compared to no-till system.

Thus, the data on within field variations does not support the hypothesis that yields aremore variable under a conservation tillage system. This is consistent with the similarity of the standard deviation of field averaged yields for the different tillage systems (Section 4.0).

The percent (%) of the within field variations of yield which remained constant from year to year is given in Table 6.1 for the different fields and tillage systems. The consistency of within field yield variations was on average 56 % and 52 % (significantly different at 0.10 probability) for the conventional and conservation systems respectively. The paired tillage comparisons indicated a significant difference between the no-till (60 %) and the minimum till systems (54 %), but the other tillage pairs had no significant differences. On average across all sites 54 % of within field variations of yield remained constant from year to year (over the 5 years of measurement). This is encouraging with regards to variable management because the 5 years of measurement include severe drought conditions (1988, 1989) as well as excellent growing conditions (1987) with record yields in many areas. The data also suggest that regardless of tillage system the same magnitudes ofyield variations were present and the consistency of the yield patterns from year to year will remain essentially the same.

The influence of tillage system on within field variations of cropyield response can be examined in more detail by selecting paired benchmarks with the lowest (stress benchmark) and highest (non-stress benchmark) relative yield from each paired tillage comparison. Selecting paired benchmarks (a low yielding pair and high yielding pair) minimized any differences in soil and landform conditions between tillage systems.The next step was to pick a stress year and non-stress year (climatic conditions) where the same crop was grown each year on the benchmarks. For example, the 1987 and 1988 years would be picked for a non-stress year and stress year respectively for corn. The average relative yields for the best and worst soil benchmarks for a stress and a non-stress growing conditions and the paired conservation and conventional tillage systems are given in Table 6.3. The data are based on absolute yields, but are expressed as relative yield with the non-stress benchmark in the non-stress year of the conventional tillage system having a yield of 1.0.

For the non-stress year, the best benchmarks of the conservation system had a 1.7 % higher yield than the best benchmarks of the conventional system (Table 6.3). During the stress year the yield in both tillage treatments decreased by about 15 %, but it dropped less in the conservation system than in the conventional system. Thus in the stress year, the best benchmark locations in the conservation tillage were now 4.4 % higher than the conventional system. In the non-stress year, the worst benchmarks had a yield of approximately 77 % of the best benchmarks,with the conservation system having a slightly lower yield (0.9 %) than the conventional system. However, in the stress year the worst benchmarks had a substantial yield decrease, but once again the decrease was greater in the conventional system than in the conservation system. Thus the worst benchmarks in the conservation system during the stress year have a yield 6.2 % higher than the conventional tillage system. This analysis suggests that conservation tillage systems are more buffered against climatic stress than conventional systems. Certainly, there is no evidence to suggest that conservation tillage systems result in larger yield decreases during stress conditions.

The relative yield differences for each measurement year are given in Figure 6.1, Figure 6.2, and Figure 6.3 for the Strathmere, D. Lobb, andAnthony sites. These represent the largest (91 %), average (52 %), and smallest (39.5 %) time stable variances in the data set, respectively. The Strathroy site (Figure 6.1) shows a consistent relative yield pattern for each of the 5 years of measurements. There is fluctuation in the magnitude of the extreme (largest, smallest) values, but a yield response pattern is obviously present. The crop rotation on this site was corn (1986), soybeans (1987), winter wheat (1988), corn (1989), and corn (1990). So the relative yield pattern remained the same regardless of the three different crops grown.

The pattern for the D. Lobb site is less consistent from year to year, but areas of different yield response are still evident. Benchmark #1 always has a higher relative yield, while the last two benchmarks (#8, #9) are always low. The field averaged pattern for this site is given in Figure 6.4. The field had alternate corn and soybean crops. The high yield at the first benchmark was caused by a high water table, and high N soil test (Kachanoski et al., 1991b). The lower yield at the back of the field was caused by a change in texture from sandy loam to silty clay loam.

The lowest time stable pattern was found in the Anthony site (Figure 6.4), but even it has an identifiable pattern with yield generally increased from the first benchmark to the last benchmark. The field average pattern is given in Figure 6.4, indicating the higher average yields in the last three benchmarks and the overall trend. The Anthony site had corn (1987), winter wheat (1988), soybeans (1989), and corn (1990). The winter wheat pattern looks more variable, but it was a very dry year in 1988.

Overall the yield patterns seem quite consistent and the main reason for changes in patterns seems to be changes in the degree of response of the extreme values. However, low yielding areas were still always generally lower than the average, and high areas always higher. The influence of crop type on the relative pattern does not appear to be particularly significant.

To examine the consistency of the pattern in more detail, the benchmarks were classified according to the average relative yield difference (i.e. the average across all measurement years). The yearly average relative differences were then calculated for each class and the ranking of the yearly values examined. The values are given in Table 6.2.

Approximately 3 % of the benchmarks had an average (across all measurement years) yield which was at least 30 % less than the average field yield. These same benchmarks had the lowest relative yield in 4 out of 5 of the years, and was the second lowest on the fifth year. The magnitude of the yield difference varied considerably, from only -14 % (1987) to -52 % (1990). Approximately 4 % of the benchmarks had an average yield which was at least 20 % greater than the average field yield. This group of benchmarks always had the highest average yield (1986-1990), but the magnitude also varied considerably from 17.6 % (1986) to 51.1 % (1989). The value of the relative yield differences in each class are obviously dependent on the year, but the ranking of the yield classes (lowest to highest) is very stable and independent of the year. It is also evident from the data (Table 6.2) that the drought stress years (1988, 1989) resulted in much greater relative differences in yields between benchmarks.

A summary of average soil properties in each of the relative yield classes is given in Table 6.2. The data is given to determine if any obvious soil differences are present in each class. Solum depth, cesium, and available water index tend to increase as the relative yield difference increases. Average cross slope curvature for all yield classes less than the field average yield were positive (diverging landforms), while yield classes greater than the average had negative (converging landforms) cross slope curvature. The %sand (Ap horizon) was higher in both the smallest and largest relative yield classes.

The soil property distributions suggest that soil loss and solum depth are related to the relative yield variations, but that texture difference are imbedded in the data and the influence of soil loss on yield variation will have to be done within texture classes. The average relative yield differences for benchmarks classified by %sand content classes and solum depth classes have been given in Table 5.6 and Table 5.7 respectively, along with all the soil properties. The highest sand content class (>70 % sand) had the lowest average relative yield difference (-6 %), but the highest average solum depth (68 cm). However, the largest solum depth class (0.90 cm) had the highest average relative yield difference. These data indicate a differential response of solum depth and yield response depending on the texture class.

The data in Table 6.2 suggests that cross slope curvature is relatedto average yield differences. The average measured yields for the seven land form classes are given in Table 6.4, for all three crop types. Converging landforms had on average 8.5 %, 7.8 %, and 5.5 % higher yieldsof corn, soybeans, and small grains respectively, than diverging landforms. Across all crop types the average difference between converging and diverging landforms was 7.3 % (significant at 0.05 probability). The diverging shoulder and backslope positions had significantly lower corn and soybean yields than the other landform classes, which is consistent with the study by Battiston et al. (1987).

The previous data analysis suggests that it is necessary to separateout texture effects on the influence of soil loss and solum depth relationships to crop yield. The study by Battiston et al. (1987) also suggested that relative yield loss as a function of soil loss was soil dependent, particularly in the way soil loss affects available water. In order to separate out texture and soil loss interactions, the benchmarkswere first classified according to %sand of the Ap horizon, and then a regression of relative yield difference Dy versus cesium content was carried out separately to obtain the regression parameters of the equation:

$$\mathbf{Dy = A + B \times Cesium\ content\ (Bq\ m^{-2})} \qquad \mathbf{[4]}$$

The values of the regression, intercept (A) and slope (B) for the various%sand content classes are given in Table 6.5, for both the average relative yield difference across all years) and for 1988 the drought stress year.

The intercept (A) values in Table 6.5 can be interpreted as the relative yield loss under the most severe soil loss conditions (i.e. cesium content approaches zero). The data in Table 6.5 indicate a very strong dependence of the predicted relative yield loss due to soil loss, and %sand class. Severely eroded soils with more than 70 % sand content had an average predicted yield loss of 37 % of the field yield, and this increased to a 43 % loss during the 1988 drought year. The data suggest a dramatically decreasing influence of soil loss on yield loss as %sand (Ap horizon) decreases. However, the effects of the drought in 1988 were present in all texture classes. Since the average yield of a crop is alsolikely to decrease during a drought year especially in sandy soils, the data suggest that sandy soils are the most susceptible to yield losses from soil loss. Interestingly, the intercept (A) starts to decrease againas the %sand decreases below 30 %. This suggest that the soils in the medium texture classes (30-40 % sand class) are the least susceptible to soil loss effects. It is well known that the medium textured soils tend to have the highest available water content and thus should be less prone to drought stress or soil loss effects which would decrease available water (Battiston et al., 1987, McBride and Macintosh, 1984). The data in Table 6.5 would support this hypothesis. The regression slope values in Table 6.5 show the same relationship to cesium (soil) loss as the intercept values.

The benchmarks with %sand greater than 70 % were examined in more detail by classifying them according to cesium content. The average soil properties of the benchmarks (>70 % sand) in the different cesium content classes are summarized in Table 6.6, along with the year by year average relative yield differences. The yield data in Table 6.6 show the dramatic interaction of yield response, soil loss, and drought stress. The benchmarks in the two lowest cesium classes had a large decrease in relative yield in 1988 and 1989, the drought stress years. The average Available water content AW index was correlated (0.05 probability) to the average cesium content levels in the different classes and decreased significantly as cesium content decreased. The benchmarks with the lowest cesium (highest soil loss) had a very high (positive) downslope and cross slope curvature indicating they are diverging shoulder slopes. Once again this is consistent with the study by Battiston et al. (1987). Soil test values did not appear to be affected by the cesium class. The data suggests that available water was the major limiting factor controlling yield loss in these sandy benchmarks and that the amount of available water was significantly affected by past soil loss.

By comparison to the greater than 70 % sand class, the average values of the 40-50 % sand class are given in Table 6.7. The relative yield in the lowest cesium class indicated a greater relative yield loss in the two drought years (1988, 1989, than in the other years, but the decrease in nowhere as dramatic as in the >70 % sand class. The available water index was not related to the cesium level suggesting that the yield was not as sensitive to soil (cesium) loss because the soil loss has not yet affected available water. Soil test P is somewhat lower in the low cesium level classes indicating that soil fertility problems may because of some of the changes in yield values.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The 5 year (1986-1990) average grain corn, soybean, and small grain yields in the paired conservation and conventional tillage systems were not significantly different. In addition, field by field, and year to year differences in yield equally variable in the conservation and conventional systems.

The paired moldboard and minimum tillage sites suggested a slight yield advantage to the moldboard system. Average relative crop yields across all crop types were higher in the moldboard system for all years except 1988. A total of 23 out 36 plot years had higher yields on the moldboard system compared to the minimum tillage system.

The paired no-till and moldboard tillage sites indicated no significant difference in yield for any of the crop types. A total of 14 out of 23 plot years had a higher yield in the no-till system than in the moldboard system. Average relative yield across all crops was higher in 1987 and 1988 in the no-till compared to moldboard, but lower in the other three years.

The paired no-till and minimum tillage sites indicated a slight yield advantage to the no-till system. The average no-till yield was significantly higher than minimum tillage yield (0.1 probability for boththe soybeans and small grain crops.

Conservation tillage systems, both overall and in the paired tillagecomparisons, did relatively better than conventional systems in 1988 (a drought stress year) than in any other year. This suggest that conservation tillage systems are more buffered against adverse crop growthconditions than conventional systems.

Soil texture (Ap horizon) class and tillage X texture class interactions were significant (0.001 probability) in explaining the variations in yield of all crop types. Landform class was significant forcorn and soybeans, but not small grains. A regression of the ratio of no-till yield/conventional tillage yield against %sand content of the Ap horizon was significant (0.05 probability). The regression indicated that for %sand contents greater than 36 % the no-till yield would on average behigher than the conventional tillage system. The no-till yield for finer textured soils would on average be lower than conventional tillage systems. The interaction of tillage and texture is suggested as the reason for little overall differences in tillage system on crop yield, across all farm sites.

Landform classificatlon criteria as proposed by Pennock and de Jong (1987) are not sensitive enough at the elevation measurement scale used in this study (i.e. 10 m by 10 x 10 m grid). The criteria for backslope versus level class (6.5 % slope) resulted in an unacceptably large number of level class designations. The criteria was changed to 3 % slope gradient.

A general analysis of covariance confirmed the presence of significant covariance between the major soil properties. The 7 unit landform classification system was not very useful in explaining variations in soil properties. This was partly attributed to the high variability of texture within the landform classes, and the covariance of texture and other soil properties.

A sub-classification by upper, middle, and lower slope position within each of the original landform classes explained a significant (0.05 probability) amount of the variability of for almost all soil properties, especially those related to soil loss. The conceptual model of the slopelocation of the original landform classes was correct for approximately 60-70 % of the benchmarks. However, a significant number of benchmarks were found at slope positions not conforming to the conceptual model. The poor success of the original 7 landform classes in explaining the spatial variations of soil properties was attributed to the conflicting patternsthat water flow and tillage translocation would have on soil properties.

Solum depth was significantly related to soil texture class, but ^{137}Cs content was not related to texture. This suggests that the amount of soil loss is not related to texture, and the increased solum depths in the sandy soils are related to pedogenic processes. The independence of soil loss on soil texture, and the higher cesium loss on upper slope comparedto middle slope positions are contrary to water erosion theory, but consistent with tillage translocation theory.

The difference between the highest and lowest yielding areas in a field, across all years and all sites was 40 % of the mean field yield. Tillage system did not significantly affect the within field variations in yields. The lowest, highest, and range, of relative yield difference were similar in the paired tillage comparisons. The standard deviation of relative yield difference was slightly higher (0.05 probability) in the minimum compared to no-till system.

The percentage of within field variation of yield remained constantfrom year to year and was on average 52 % and 56 % (significantly different at 0.10 probability), for the conventional and conservation tillage systems respectively. Approximately 3 % of the benchmarks had an average yield which was at least 30 % less than the average field yield. Another 5 % of the benchmarks were between 20 % and 30 % lower than the field average yield. A total of 15 %, and 4 % of the benchmarks had an average yield which was greater than 10 %, and greater than 20 % of the field average yield respectively. The relative ranking of the benchmarks with respect to relative yield was independent of the measurement year, but the year did affect the magnitude in all yield classes. The drought stress year (1988) resulted in much greater relative within field variations of crop yield.

A paired benchmark analysis on crop response on stress (low yielding) and non-stress (high yielding) benchmarks, in stress and non-stress growing conditions was carried out. It indicated that conservation tillage systems may be more buffered against adverse climatic growing conditions than conventional tillage systems. High yielding areas under conservation tillage dropped only 13.8 % in yield during a stress year, compared to 16.5 % decrease in the conventional system. Low yielding areas in the conservation system decreased 24 % in yield in the stress year, compared to a 31.1 % decrease in the conventional system. This benchmark data supported the paired field yield data, which indicated that the ratio of conservation yield/conventional yield was the highest in 1988 the drought stress year.

The 7 unit landform classification explained a significant amount of the within field benchmark yield data. Converging landforms had on average 8.5 %, 7.8 %, and 5.5 % higher yields of corn, soybeans, and small grains respectively, compared to diverging landforms. Across all crop types the average difference between converging and diverging landforms was 7.3 % (significant at 0.05 probability level). The diverging shoulder and backslope position had significantly lower corn and soybean yields, than the other landform units.

There was a significant interaction of soil texture class and soil loss, on relative crop yield losses. Benchmarks were separated on the basis of %sand in the Ap horizon and yield response correlated against cesium content in each texture class. Severely eroded soils with a %sand content greater than 70 % had an average predicted yield loss of 37 % of the field average yield. The same severely eroded soils had a predicted yield loss of only 8.0 %, 4.7 %, and 0.7 % for Ap horizons with 50-70 %, 40-50 %, and 30-40 % sand content. The yield loss in all texture groupings increased during the 1988 growing season indicating soil loss was affecting available water, but more so in the sandier soils. The available water index of McBride and Mackintosh (1984) was significantly related to cesium content in the >70 % sand content group, but not in the other groups. The benchmarks with 20-30 %, and <20 % sand content had a predicted relative yield decrease of 4.3 % and 8.0 % respectively. Thus, the benchmarks in the medium texture classes had much less predicted yield loss from soil loss, than benchmarks with lighter or finer soil textures. This is consistent with the higher available water holding capabilities of medium textured soils compared to other textures.

The data in this project, and in the Tillage-2000 project indicate that it should be possible to implement a conservation tillage system with no loss in yield productivity. This is especially true for sandy textured soils where increases in yield are likely under conservation tillage.

For the range in soil and landform conditions in this report, there seems to be little benefit to adopting a minimum tillage system. No-till yields were equal or better than minimum till and the minimum till was slightly lower yielding than the moldboard tillage. In addition, the workon tillage translocation suggests that secondary tillage, which can sometimes be more intensive under minimum tillage, can result in significant soil loss off of shoulder/crest slope positions. The criteria of 20 % or 30 % residue cover to control water erosion is meaningless with regards to tillage translocation. Thus, unless a management procedure can be devised to control tillage translocation, minimum tillage can not be viewed as a viable alternative to a moldboard system in a sustainable production system. The minimum till system may control water and soil loss by water erosion, but it will not be stopping the decline in soil quality and crop productivity in the upland regions.

The study indicates that the sandy soils (>70 % sand) are the mostfragile of all of the soil types. Soil loss in upper convex slope positions has already resulted in yield losses of 30-40 % of the average field yield. The productivity losses are even more severe in years of climatic stress. However, since on average these soils had a higher yield in no-till than in any other tillage system, there seems little reason for farmers not to adopt the no-till system immediately. The reasons for adopting the no-till system are primarily crop productivity and efficiency gains, not environmental. The main mechanism of soil loss is tillage translocation, and water erosion is likely to be minimal considering the high infiltration capacities of sandy soils.

Conservation tillage systems appear to be increasing the soils buffering capacity against adverse climatic conditions, particularly drought stress. This is encouraging considering the possibility of increased frequencies of drought stress due to global warming trends. The full extent of the remediating capabilities of no-till is not very well understood and should be the subject of future studies. The remediation may appear to be faster than expected because the massive soil loss from tillage translocation has been stopped in the no-till, but continued in the conventional tillage system. Thus, even if the yield productivity of severely degraded areas is stabilized, it would appear that they have undergone an increase because of the continued decline in productivity of the conventional system. The actual rate of remediation, and degree to which it is possible to remediate these areas is unknown, and beyond the scope of this study.

A considerable amount of research activity is currently underway regarding variable management. A symposium on this subject will be held at the annual American Society of Agronomy meeting. Other symposia have been held the past few years by the American

Society of Agricultural Engineers (ASAE). Most of the activity has centered on development of spatial location sensors, and variable application technology. There seems to be little doubt that the technical ability to vary management within the field will be present, the important missing link is the knowledge base to decide what kind of management should be done at each point in the field. The yield data indicates that reasonably consistent pattern of yield are present year after year. Thus, variable management from a cost benefit point of view is necessary. Technology for automatic measurement and recording of yield patterns are available, but more accurate equipment is needed.

The consistent yield differences in the benchmarks from year to year is encouraging, and it is clear that many of the differences are related to soil loss or the effects of soil loss. The sites with very large yieldlosses are diverging shoulder slope/crest positions as indicated by Battiston et al. (1987). This problem can be attributed almost entirely totillage translocation. The obvious solution is not to till the fields. However, it may be possible to change the pattern of tillage. The necessity of at least alternating the direction of all tillage, including secondary tillage cannot be overstated. The net soil losses from alternating tillage directions is still very large, but much smaller thanthe loss from a single direction.

Without an accurate method of predicting the soil redistribution from tillage translocation, there does not appear to be much hope in explaining any more than about 40-50 % of the spatial variations of soil properties. The same constraint exists for predicting variations in yield response using only landform classification. The alternative is to measure and map yield response directly from year to year and identify sensitive areas from changes in yield from year to year especially duringclimatic stress conditions. While it is possible to predict that the areas of high yield loss will likely be the shoulder slope positions, itis not true that all shoulder slope positions have been eroded and thus will have yield reductions.

8.0 REFERENCES

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Table 3.1: Description and Classification of Landform Elements (Pennock and de Jong, 1988)

Landform element	Description	Criteria *	Morphology
DSH	Diverging water flow,	PROF > .100º/m	Convex
	Shoulder	CCURV > 0.00º/m	Convex
CSH	Converging water flow,	PROF >.100º/m	Convex
	Shoulder	CCURV <0.00º/m	Concave
DBS	Diverging water flow,	PROF >-.100 º/m, <.100 º/m	Linear
	Backslope	GRAD >3.00º	High slope
		CCURV >0.00 º/m	Convex
CBS	Converging water flow,	PROF >-.100 º/m, <.100 º/m	Linear
	Backslope	GRAD >3.00 º	High slope
		CCURV <0.00 º/m	concave
LBS	Level Back Slope		
DFS	Diverging water flow,	PROF <-.100 º/m	Concave
	Footslopes	CCURV >0.00 º/m	Convex
CFS	Converging water flow,	PROF <-.100 º/m	Concave
	Footslopes	CCURV <0.00 º/m	Concave
L	Level, water flow	PROF >-100 º/m, <.100 º/m	Linear
	negligible	GRAD <3.00 º	Low slope

* Note: PROF = profile curvature, CCURV = plan curvature, GRAD = slope gradient

Table 4.1: Average Systems Crop Yields for the Different Years Across All Tillage Systems

	CROP YIELD (kg ha^{-1})		
YEAR	CORN	SOYBEANS	SMALL GRAINS
1986	7615 (136)^{BC*}	2414 (30)^{C}	3326 (48)^{B}
1987	9169 (204)^{A}	3140 (72)^{A}	2450 (32)^{C}
1988	7283 (137)	2527 (66)^{BC}	3184 (120)^{B}
1989	7429 (98)^{B}	2366 (131)	2385 (46)^{C}
1990	7772 (119)^{B}	2698 (100)^{B}	4076 (58)^{A}

* Values in the same columns with the same letters are not significantly different at the 0.05 probability level.

Values inside brackets ( ) are the number of benchmarks.

Table 4.2: Average Conventional and Conservation Tillage Yields for Paired Tillage-2000 Sites

	YIELD (kg ha^{-1})		
CROP	CONV TILLAGE	CONS TILLAGE	#PLOT YEARS
CORN	7855 (1572)*	7858 (1572)	43
SOYBEANS	2613 (667)	2695 (670)	23
SMALL GRAINS	2961 (1165)	2972 (1065)	17

Values in brackets are standard deviations (field). Note: significant differences between tillage systems.

Table 4.3: Average Crop Yields by Year for Conventional and Conservation Tillage Systems

	CORN		SOYBEANS		SMALL GRAIN	
YEAR	CONV	CONS	CONV	CONS	CONV	CONS
1986	7631	7778	2115	2713	3287	3365
1987	7774	8534	3264	3022	2507	2367
1988	6968	6646	2654	2400	3068	3310
1989	6828	6889	2292	2451	2303	2483
1990	7658	7687	2685	2714	4220	3960

Note: significant differences between tillage systems after the effect of year on yield was removed. Also no tillage X year interaction.

Table 4.4: Field Averaged Corn Yields for the Paired Moldboard and Minimum Till Sites

	CORN YIELD (kg ha^{-1})			
SITE	YEAR	MOLD	MIN	DIFF
TEL86	1986	7262	7380	-118
DYKS86	1986	7756	7057	699
MURR86	1986	7873	7139	734
MART86	1986	12456	10685	1771
CHIPP86	1986	8512	8261	251
BEE86	1986	6932	8079	-1147
TEL87	1987	8952	8323	629
MART87	1987	9082	8482	600
NEWC87	1987	10958	11267	-309
ANTH87	1987	8173	5819	2354
CHIPP87	1987	7362	6821	541
DYKS87	1987	9478	8047	1431
CHIPP88	1988	4709	5990	-1281
NEWC88	1988	8480	10568	-2088
NEWC90	1990	9043	8100	943
ANTH90	1990	7705	8036	-331
DYKS90	1990	6214	4581	1633
MART90	1990	7989	8678	-689
	AVG	8274	7961	312*
	STD	1656	1653	1122

[*] Difference is not statistically significant at the 0.05 probability level.

Note: DIFF is the difference between MOLD and MIN; AVG is the column average; STD is the column standard deviation.

Table 4.5: Field Averaged Soybean Yields for the Paired Moldboard and Minimum Till Sites

SITE	SOYBEAN YIELD (kg ha^{-1})			
	YEAR	MOLD	MIN	DIFF
ANTH89	1989	1652	1155	497
BEE87	1987	3957	3738	219
CHIPP90	1990	3277	2968	309
MART88	1988	2596	2449	147
MART89	1989	1878	2181	-303
MURR87	1987	3443	4401	-958
NEWC89	1989	3351	2822	529
	AVG	2879	2816	62*
	STD	797	977	488

* Difference is not significantly at 0.05 probability level.

Note: DIFF is the difference between MOLD and MIN; AVG is the column average; STD is the column standard deviation.

Table 4.6: Field Averaged Small Grain Yields for the Paired Moldboard and Minimum Till Sites

	SMALL GRAIN YIELD (kg ha^{-1})			
SITE	YEAR	MOLD	MIN	DIFF
ANTH88	1988	2635	2300	335
DYKS89	1989	3445	3146	299
DYKS88	1988	2070	1851	219
MURR88	1988	6601	5337	1264
MURR90	1990	3854	4106	-252
SCHAL86	1986	2113	2198	-85
SCHAL87	1987	2652	2527	125
TEL88	1988	2196	2216	-20
TEL89	1989	2865	2657	208
TEL90	1990	2273	2296	-23
	AVG	3070	2863	207*
	STD	1301	1021	393

* Difference is significant at 0.10 probability level.

Note: DIFF is the difference between MOLD and MIN; AVG is the column average; STD is the column standard deviation.

Table 4.7: Field Averaged Corn Yields for the Paired Moldboard and No-till Sites

		CORN YIELD (kg ha^{-1})		
SITE	YEAR	MOLD	NTILL	DIFF
CHIPP86	1986	8512	7903	609
DLOBB 87	1987	9664	9540	124
CHIPP87	1987	7362	9034	-1672
RIDD87	1987	10912	11497	-585
MLOBB88	1988	7697	9010	-1313
TEMP88	1988	7635	5862	1773
CHIPP88	1988	4709	7111	-2402
RIDD89	1989	8977	9257	-280
BEE89	1989	9003	8902	101
DLOBB89	1989	6580	6725	-145
TEMP90	1990	6315	6422	-107
MLOBB90	1990	8007	8929	-922
	AVG	7947	8349	-401*
	STD	1574	1526	1048

[*] Difference is not statistically significant at 0.05 probability level.

Note: DIFF is the difference between MOLD and NTILL; AVG is the column average; STD is the column standard deviation.

Table 4.8: Field Averaged Soybean Yields for the Paired Moldboard and No-till Sites

SITE	YEAR	MOLD	NTILL	DIFF
BEE90	1990	2458	2827	-369
CHIPP90	1990	3277	3488	-211
DLOBB88	1988	1760	2180	-420
DLOBB90	1990	2478	2265	213
RIDD88	1988	2569	3040	-471
RIDD90	1990	2498	2267	111
TEMP89	1989	3098	2987	111
STEW89	1989	2501	2381	120
STEW90	1990	2781	2457	324
	AVG	2602	2654	-52 *
	STD	408	424	295

* Difference is not statistically significant at 0.05 probability level.

Note: DIFF is the difference between MOLD and NTILL; AVG is the column average;STD is the column standard deviation.

Table 4.9: Field Averaged Small Grain Yields for the Paired Moldboard and No-till Sites

SITE	YEAR	MOLD	NTILL	DIFF
RIDD86	1986	3990	4066	-76
STEW88	1988	2156	2457	-301
	AVG	3073	3261	-188*
	STD	917	804	112

* Too few sites for statistical analysis.

Note: DIFF is the difference between MOLD and NTILL; AVG is the column average; STD is the column standard deviation.

Table 4.10: Field Averaged Corn Yields for the Paired Minimum and No-till Sites

SITE	YEAR	MIN	NTILL	DIFF
GHENT86	1986	4666	4613	53
POTT86	1986	7124	6798	326
STRATH86	1986	8816	9032	-216
CHIPP86	1986	8261	7903	358
CHIPP87	1987	6821	9034	-2213
POTT87	1987	8850	8172	678
POTT88	1988	7599	7157	442
CHIPP88	1988	5990	7111	1121
JOHN88	1988	6584	6626	-42
JOHN89	1989	6022	5889	133
STRATH89	1989	6668	7764	-1096
STRATH90	1990	8005	8570	-565
POTT90	1990	8059	7002	1057
	AVG	7189	7359	169*
	STD	1179	1208	849

* Difference is not statistically different at the 0.05 probability level.

Note: DIFF is the difference between MIN and NTILL; AVG is the column average; STD is the standard deviation.

Table 4.11: Field Averaged Soybean Yields for the Paired Minimum and No-till Sites

SITE	SOYBEAN YIELD (ka ha^{-1}) YEAR	MIN	NTILL	DIFF
CHIPP90	1990	2968	3488	-520
JOHN86	1986	2115	2712	-597
JOHN87	1987	2510	2716	-206
JOHN90	1990	820	1820	-1000
NEWC89	1989	2822	2719	103
POTT89	1989	2367	2003	364
STRATH87	1987	2926	2919	7
	AVG	2361	2625	-264*
	STD	692	519	434

* Difference is statistically significant at the 0.10 probability level.

Note: DIFF is the difference between MIN and NTILL; AVG is the column average;STD is the standard deviation.

Table 4.12: Field Averaged Small Grain Yields for the Paired Minium and No-till Sites

SITE	SMALL GRAIN YIELD (kg ha-^{1}) YEAR	MIN	NTILL	DIFF
GHENT87	1987	2376	2123	253
GHENT88	1988	3246	4553	-1307
GHENT89	1989	1104	1251	-147
BEE88	1988	3570	3721	-151
STRATH88	1988	3196	3719	-523
	AVG	2698	3073	-375 *
	STD	889	1204	526

* Difference is statistically significant at the 0.10 probability level.

Note: DIFF is the difference between MIN and NTILL; AVG is the column average; STD is the standard deviation.

Table 4.13: **Average Yield Ratios for Paired Tillage Comparisons Across All Crop Types**

YEAR	YIELD RATIO CONS CONV	 MIN MOLD	 NTILL MOLD	 NTILL MIN
1986	1.00 (.106) **	0.98 (.096)	0.97 (.045)	1.04 (.123)
1987	1.01 (.146)	0.95 (.14)	1.096 (.088)	1.05 (.142)
1988	1.09 (.192)	1.01 (.17)	1.15 (.206)	1.11 (.165)
1989	0.95 (.128)	0.886 (.146)	0.962 (.073)	1.02 (.117)
1990	1.04 (.11)	0.96 (.115)	0.967 (.111)	1.24 (.50)
AVG	1.02 (.105)	0.967* (.069)	1.03 (.078)	1.089*(.131)

* Significantly different than 1.0 at the 0.10 probability level.

** Values in brackets are the standard deviations.

Table 4.14: **Analysis of Variance for Benchmark Corn Yield and Tillage, Year, Landform, and Texture**

SOURCE	**ANALYSIS OF VARIANCE** DF	 F	 Pr > F
Tillage	2	5.12	0.0002
Year	4	32.8	0.0001
Landform	6	1.9	0.08
Texture	10	6.4	0.0001
Available Water	7	1.1	0.40
Tillage X Texture	16	1.9	0.02
Soil Test P	6	0.7	0.64
Drainage	4	0.51	0.73
Cesium 1987	3	1.5	0.20

Total observations = 693

DF = Degrees of freedom

F = F statistic (analysis of variance)

Table 4.15: Analysis of Variance for Benchmark Soybean Yield and Tillage, Year, Landform, Texture, and Available Water

	ANALYSIS OF VARIANCE		
SOURCE	DF	F	Pr>F
Tillage	2	0.7	0.41
Year	4	14.9	0.0001
Landform	6	2.8	0.013
Texture	10	3.0	0.001
Available Water	7	2.6	0.012
Tillage X Texture	**6**	1.7	0.15
Soil Test P	5	3.0	0.01
Drainage	5	1.1	0.35
Cesium 1987	3	1.9	0.13

Total observations = 398
DF = Degrees of freedom
F = F statistic (analysis of variance)

Table 4.16: Analysis of Variance for Benchmark Small Grain Yield and Tillage, Year, Landform, Texture, and Available Water

	ANALYSIS OF VARIANCE		
SOURCE	DF	F	Pr>F
Tillage	2	1.26	0.26
Year	4	15.66	0.0001
Landform	4	1.77	0.33
Texture	8	9.8	0.0001
Available Water	6	3.3	0.004
Tillage X Texture	8	2.1	0.04
Soil Test P	5	1.1	0.40
Drainage	3	3.1	0.04
Cesium 1987	2	2.0	0.14

Total observations = 303
DF = Degrees of freedom
F = F statistic (analysis of variance)

Table 5.1: Analysis of Variance for Landform Units and Soil Property

SOIL PROPERTY	SOURCE OF VARIANCE: LANDFORM (L) F	Pr>F	TEXTURE (T) F	Pr>F	INTERACTION (L)x(T) F	Pr>F	r^2
Solum Depth	1.63	0.14	3.11	0.001	1.03	0.43	0.18**
O.M.C.	3.96	0.0008	3.48	0.0002	0.48	0.99	0.18**
Soil Test P	1.5	0.17	6.8	0.0001	1.35	0.12	0.34****
soil Test K	0.8	0.60	4.8	0.0001	0.98	0.50	0.27***
pH (Ap)	1.2	0.29	3.7	0.0002	0.62	0.92	0.22*
Available Water	2.5	0.02	2.8	0.002	2.2	0.0008	0.25**
Cesium 1987	2.2	0.04	2.55	0.006	0.9	0.61	0.19**
Cesium (87-90)	1.8	0.11	1.30	0.23	1.14	0.31	0.19**
%$CaC0_3$	1.1	0.37	0.50	0.84	0.61	0.94	0.06

* Significant at 0.05 probability

** Significant at 0.01 probability

*** Significant at 0.001 probability

**** Significant at 0.0001 probability

Table 5.2: Soil Property Values at Different Landform Units

	LANDFORM UNIT						
SOIL	SHOULDER/CREST		BACKSLOPE		FOOTSLOPE		LEVEL
PROPERTY	CONVERG	DIVERG	CONVERG	DIVERG	CONVERG	DIVERG	
Solum Depth (cm)	51.3^{A}	51.0^{A}	53.1^{A}	49.1^{A}	61.1^{B}	49.8^{A}	49.8^{A}
% O.M.C.	3.06^{AB}	3.21^{AB}	2.58^{A}	3.07^{AB}	3.27^{AB}	3.50^{BC}	4.08^{BC}
Soil Test P (ppm)	28.2^{B}	25.8^{AB}	21.0^{A}	26.5^{A}	25.0^{A}	25.6^{A}	25.7^{A}
pH (Ap)	6.6^{AB}	6.8^{B}	6.3^{A}	6.5^{AB}	6.5^{AB}	6.6^{AB}	6.7^{B}
Available Water (cm)	19.9^{A}	19.6^{A}	18.6^{A}	19.7^{A}	22.0^{A}	21.8^{A}	22.5^{A}
Cesium 1987 (Bq m^{-2})	2256^{AB}	2208^{AB}	2409^{A}	2262^{A}	2495^{A}	2193^{B}	2195^{B}
% $CaCO_3$ (Ap)	2.13^{A}	1.39^{A}	0.88^{A}	3.22^{A}	1.69^{A}	2.57^{A}	1.36^{A}

Note: significance level from landform versus soil properties is given in Table 5.1.

Note: values of the same soil property with different capitol letters are significantly different at the 0.10.

Table 5.3: Number of Benchmarks and pH Values at Different Landform Properties and Slope Position

	SOIL PROPERTY						
LANDFORM	pH(Ap)			#BENCHMARK			
UNIT	U	M	L	U	M	L	TOTAL
Shoulder Converg	6.7	6.6	6.4	17	12	6	35
Diverg	6.7	7.2	6.4	29	12	10	51
AVG	6.7	6.9	6.4	46**	24**	16**	86**
Backslope Converg	6.1	6.6	5.1	5	16	3	24
Diverg	6.3	6.7	5.4	6	19	3	26
AVG	6.2	6.65	5.25	9**	35**	6**	50**
Footslope Converg	6.9	6.5	6.5	7	16	32	55
Diverg	7.0	6.4	6.5	6	3	15	22
AVG	6.95	6.65	6.5	11**	19**	47**	77**
Level	6.9	6.9	6.5	56	35	72	161
AVG	6.7^{A}*	6.7^{A}	6.1^{B}	120**	113**	141**	374

* Average soil properties with different letters are significantly different at the 0.05 probability level.

** Total benchmark number not average.

Table 5.4: Solum and Ap Depths for Different Landform Properties and Slope Positions

LANDFORM UNIT	SOIL PROPERTY					
	SOLUM DEPTH (cm)			Ap DEPTH (cm)		
	U	M	L	U	M	L
Shoulder Converg	39.0	64.6	57.0	24.4	21.2	25.8
Diverg	49.9	36.5	66.9	27.8	23.5	23.7
AVG	44.5	50.5	62.0	26.1	22.4	24.8
Backslope Converg	50.5	45.4	98.5	24.2	25.2	35.8
Diverg	50.5	43.9	81.0	25.0	25.5	22.5
AVG	50.3	44.7	89.8	24.6	25.4	29.2
Footslope Converg	53.1	60.6	63.1	23.6	28.4	30.3
Diverg	45.0	72.7	46.5	31.9	27.3	24.8
AVG	49.1	66.7	54.8	27.8	27.9	27.6
Level	46.5	47.2	55.8	24.1	24.6	27.1
AVG	47.7^{A*}	53.0^{A**}	67.0^{B**}	25.9^{A}	25.1^{A}	27.1^{A}

[*] Average soil properties with different letters are significantly different at the 0.05 probability level

[**] Average values are significantly different at the 0.1 probability level.

Table 5.5: Cesium and % CaCO$_3$ Values for Different Landform Properties and Slope Position

LANDFORM UNIT	SOIL PROPERTY					
	% CaCO$_3$ (Ap)			Cesium 1987 (Bq m^{-2})		
	U	M	L	U	M	L
Shoulder Converg	3.86	0.39	1.03	2133	2075	2848
Diverg	1.74	1.43	0.4	2292	2122	2093
AVG	2.8	0.91	0.72	2212	2099	2471
Backslope Converg	1.26	0.93	0.00	2110	2250	3138
Diverg	8.83	2.54	0.00	2007	2265	2576
AVG	5.04	1.74	0.00	2059	2258	2857
Footslope Converg	3.03	1.09	1.74	2004	2465	2642
Diverg	8.09	0.83	1.40	2187	2188	2195
AVG	5.56	0.96	1.57	2096	2327	2419
Level	2.08	1.60	1.08	1969	2116	2404
AVG	4.13^{A*}	1.26^{B}	0.81^{B}	2100	2212^{A}	2557^{B}

[*] Average soil properties with different letters are significantly different at the 0.05 probability level.

Table 5.6: Average Benchmark Properties Classified by %Sand in the Ap Horizon

	%SAND CONTENT OF THE Ap HORIZON						
YIELD/SOIL PARAMETER	<15	15-20	20-30	30-40	40-50	50-70	70-90
% Benchmarks	9.0	7.1	18.5	19.8	17.7	14.7	13.2
%Clay	-	-	22.5	18.2	12.5	10.3	7.3
Depth (Ap cm)	30.2	26.2	24.2	24.2	24.5	24.0	26.7
Solum (cm)	54.0	44.2	42.3	57.8	56.6	50.7	67.9
pH (Ap)	6.8	7.0	6.8	6.5	6.7	6.8	6.1
% $CaCO_3$ (Ap)	1.1	2.2	3.9	2.3	1.0	1.6	0.64
% O.M.C. (Ap)	5.1	4.4	3.9	3.6	2.9	3.1	2.8
Soil Test P (ppm)	46.8	33	22	22	20	23	28
Soil Test Mg (ppm)	330	277	270	219	194	183	106
Soil Test K (ppm)	156	154	130	100	90	108	208
Air filled porosity (%)	6.6	11.2	8.2	10.9	13.3	18.2	23.3
Available water (cm)	25.5	20.8	20.2	21.6	20.3	20.3	22.4
Cesium 1987 (Bq m^{-2})	N/A	2264	2062	2395	2291	2291	2231
Cesium 1990 (Bq m^{-2})	N/A	2139	2137	2299	2269	2045	2254
% Rel. Yield Diff.							
1986	-0.2	0.2	-1.8	-0.2	2.1	3.0	-2.0
1987	2.0	0.9	1.4	-2.0	1.6	4.8	-4.8
1988	2.5	2.5	-3.2	0.3	5.2	1.9	-7.1
1989	0.0	-7.3	2.2	5.1	1.7	4.0	-14.9
1990	-1.1	3.7	-1.8	-1.4	5.4	-2.8	-1.7
AVG	-0.6	0.0	10.6	0.4	3.2	2.2	-6.1

% Rel. Yield Difference using Eq. (1).

Table 5.7: Average Benchmark Properties Classified by Solum Depth

	SOLUM DEPTH (cm)						
YIELD/SOIL PARAMETER	0-15	15-30	30-45	45-60	60-75	75-90	>90
%Benchmarks	12.0	10.3	14.2	20.1	18.4	15.3	9.7
Depth (Ap cm)	23.5	22.7	25.3	25.0	25.6	27.8	28.3
%Gravel (Ap)	5.2	1.8	1.6	2.0	1.5	1.9	1.5
%Sand (Ap)	35.6	36.9	36.5	38.2	42.0	45.2	51.1
%Silt (Ap)	45.1	46.0	45.6	45.2	41.9	42.5	37.4
%Clay (Ap)	19.2	17.0	17.8	16.5	16.1	12.2	11.3
pH (Ap)	7.2	7.0	6.9	6.8	6.6	6.1	5.9
% $CaC0_3$ (Ap)	7.6	2.2	1.6	0.9	0.75	0.27	0.21
Air filled porosity (%)	13.6	13.0	12.8	13.1	13.1	14.5	13.2
Available Water (cm)	18.01	20.3	19.7	20.8	22.4	22.5	25.6
Cesium 1987 (Bq m^{-2})	2066	2309	2184	2140	2267	2349	2332
Cesium 1990 (Bq m^{-2})	1781	2211	2221	2130	2195	2167	2283
% Rel. Yield Diff.							
1986	3.8	3.5	-1.9	-0.1	-1.0	0.4	-0.9
1987	-1.1	3.1	-4.1	-1.0	2.4	2.4	5.4
1988	-10.5	-8.1	2.0	1.1	2.9	0.9	7.9
1989	-8.4	-8.8	-2.6	-3.9	7.5	10.0	11.4
1990	2.2	1.6	-3.7	1.8	8.8	0.3	-4.8
AVG	-2.0	-1.7	-2.1	4.1	2.9	2.8	3.8

% Relative Yield Difference using Eq. (1).

Table 6.1: Summary of Within Field Variations in Average Relative Yield Difference

TILLAGE		AVERAGE RELATIVE YIELD DIFFERENCE										
		CONV TILLAGE				CONS TILLAGE				TIME STABLE VARIANCE (%)		
COMPARISON	SITE	LOW	HIGH	RANGE	STD	LOW	HIGH	RANGE	STD	CONV	CONS	AVG
MB vs. MIN	Anthony	-18.3	26.0	44.0	14.6	-18.4	19.5	37.9	10.3	38.7	40.3	39.5
	Bee	-19.4	7.6	27.0	11.2	- 7.0	6.6	13.6	5.6	75.0	70.7	72.9
	Chipp	-11.2	11.0	22.2	8.4	-31.8	17.7	49.5	14.8	39.1	50.6	44.9
	DYK	-11.7	17.1	28.8	7.7	-15.6	16.6	32.2	11.09	40.0	52.0	46.0
	Martin	-28.1	12.7	40.8	11.1	-36.6	20.7	57.3	17.7	49.6	55.8	52.7
	Murrel	-11.1	6.8	17.9	6.1	-9.3	10.0	19.3	7.1	53.1	46.6	49.9
	Newc	-21.4	16.6	38.0	13.0	-14.2	10.0	24.2	7.2	62.7	47.4	55.2
	Schal	-15.5	28.3	43.8	15.4	-35.7	28.5	64.2	16.8	51.0	77.8	64.4
	Teledale	-20.5	12.1	32.6	12.3	-26.2	15.2	41.4	14.3	45.2	56.7	51.0
	AVG	-17.5^{A}	15.4^{A}	32.9^{A}	11.1^{A}	-21.6^{A}	16.1^{A}	37.7^{A}	11.7^{A}	50.5^{A}	53.5^{A}	52.0
MB vs. NT	Chipp	-11.2	11.0	22.2	8.4	-13.0	10.1	23.1	7.2	39.1	55.2	47.2
	D Lobb	-31.4	37.8	69.2	19.6	-26.2	31.2	57.4	19.0	55.9	47.5	51.7
	Ridd	-17.9	11.2	29.1	7.6	-15.6	14.9	30.5	7.3	52.0	29.0	40.5
	Templ	-13.9	16.5	30.4	8.4	-19.7	19.0	38.7	11.7	64.9	78.9	71.9
	Steward	-20.8	17.3	38.1	10.3	- 8.6	15.0	24.1	9.1	57.4	57.0	57.2
	AVG	-19.0^{A}	18.8^{A}	37.8^{A}	10.9^{A}	-16.6^{A}	18.0^{A}	34.6^{A}	10.9^{A}	53.9^{A}	53.5^{A}	53.7
MIN vs. NT	Chipp	-31.8	17.7	49.5	14.8	-13.0	10.1	23.1	7.2	50.6	55.2	52.9
	Ghent	-21.0	26.3	47.3	15.1	-33.3	21.1	54.4	17.1	39.6	48.0	43.8
	Johns	-33.5	23.4	56.5	16.3	-33.1	14.8	47.9	13.4	42.0	49.5	45.8
	Pottruff	-23.0	18.7	41.7	10.8	-30.7	18.5	49.2	12.4	46.2	54.1	50.2
	Strath	-24.1	44.7	68.8	26.0	-26.6	36.4	63.0	21.4	89.9	92.7	91.3
	AVG	-26.7^{A}	26.2^{A}	52.9^{A}	16.6^{A}	-27.3^{A}	20.2^{B}	47.2^{A}	14.3^{B*}	53.7^{A}	59.9^{B}	56.8
OVERALL	AVG	29.3^{A}	19.1^{A}	39.4^{A}	12.5^{A}	19.1^{A}	17.7^{A}	39.5^{A}	12.1^{A}	52.2^{A*}	56.1^{B*}	54.2

values of the same index with different letters are significantly different at the 0.05 probability level.

Significant at the 0.10 probability level.

Table 6.2: Temporal Stability of Relative Yield Differences Across all Sites and Associated Soil Properties

	AVERAGE WITHIN FIELD RELATIVE YIELD DIFFERENCE								
YIELD/SOIL	% LESS THAN AVERAGE					% GREATER THAN AVERAGE			
PARAMETER	>30	0-20	20-10	10-5	5-0	0-5	5-10	10-20	>20
%BENCHMARKS	2.8	4.5	12.8	12.0	15.4	17.3	15.9	15.1	4.2
<u>% REL. YIELD</u>									
1986	-24.6	-8.4	-8.3	-3.5	-0.27	-0.47	2.84	8.7	17.6
1987	-14.1	-18.9	-5.4	-7.5	-1.28	2.98	3.60	8.5	19.1
1988	-43.3	-38.8	-17.4	-7.2	-4.93	3.09	10.7	20.8	27.6
1989	-52.2	-36.6	-25.0	-10.9	-2.80	6.91	11.9	19.3	51.1
1990	-35.2	-10.9	-16.6	-10.2	-2.90	0.80	8.9	15.2	27.9
<u>SOIL PROPERTIES</u>									
Depth Solum (cm)	45.5	35.9	46.1	57.8	56.4	50.7	56.0	60.7	52.4
Depth Ap (cm)	20.3	22.3	23.2	26.4	26.8	26.7	25.2	26.4	23.7
Cesium 1987 (Bq m^2)	1977	1949	2106	2325	2361	2249	2275	2432	2530
Cross Curvature	1.1	2.8	0.2	0.1	0.0	-1.3	0.9	-2.1	-1.0
%Sand	51.0	54.2	44.9	37.2	37.3	36.2	40.4	41.9	46.3
%Clay	16.8	13.2	16.1	16.1	15.7	16.7	15.6	15.0	13.8
Avail. Water (cm)	18.3	17.1	21.1	22.6	20.9	22.0	21.0	22.2	22.8
pH (Ap)	6.9	6.8	6.8	6.6	6.7	6.6	6.6	6.6	6.5

Table 6.3: Summary of Stress-Yield Relationships.

	RELATIVE CROP YIELD **			
	BEST SOIL LANDFORMS		WORST SOIL LANDFORMS	
	CONV	CONS	CONV	CONS
Non-Stress	1.00*	1.017	0.779	0.770
Year		(0.171)	(.235)	(.212)
Stress	0.835	0.879	0.468	0.530
Year	(.114)	(0.18)	(.203)	(.241)

* Crop yield at CONV best landscape locations during non-stress year are equal to 1.0.

** 13 farms x 2 tillages x 2 locations/tillage x 2 years.

Values in brackets are standard deviations.

Table 6.4: Average Yield for the Different Crop Types at Different Landform Positions

		YIELD (kg ha^{-1})			
CROP TYPE	LANDFORM UNIT	DOWNSLOPE CURVATURE			DIFF(%)
		CONVERGING	DIVERGING		
Corn	Shoulder/Crest	8450^{A**}	7594^{B}		11.3
	Backslope	8231^{A}	7404^{B}		11.2
	Footslope	8078^{AB}	7852^{AB}		2.9
	Level	8038^{AB}			
				AVG	8.5
Soybean	Shoulder/Crest	2458^{AB}	2369^{B}		3.8
	Backslope	3048^{A}	2360^{B}		29.2
	Footslope	2636^{AB}	2914^{A}		-9.5
	Level	2655^{AB}			
				AVG	7.8
Small Grain	Shoulder/Crest	2970^{AB}	2821^{B}		5.3
	Footslope	3521^{C}	3328^{AC}		5.8
	Level	3186^{ABC}		AVG	5.5
			overall	AVG	7.3*

* Statistically significant at 0.05 probability level.

** Values from the same crop with different letters are statistically different at the 0.10 probability level.

Table 6.5: Regression Parameters for Relative Yield Difference Versus Cesium Content for Benchmarks Classified into Different Classes Based on %sand of Ap Horizon

Ap		Ap texture	Regression Parameters *			
			Slope (x 10^{-5}) **		Intercept	
Sand Range	% Sand	%Clay	Mean	1988	Mean	1988
<20 %	11.0	24.0	3.44	2.97	-0.080	-0.018
20-30 %	25.0	22.5	1.62	1.07	-0.043	-0.069
30-40 %	34.2	18.2	1.31	0.67	-0.018	-0.080
40-50 %	45.8	12.5	3.32	5.14	-0.047	-0.07
50-70 %	60.0	10.3	4.77	7.7	-0.080	-0.14
>70 %	76.1	7.3	5.01	16.8	-0.370	-0.43

** Regression of relative yield difference on cesium content (Bq m^{-2})

* Multiply slope values by 10^{-5}

Table 6.6: Soil, Yield, and Landform Parameter for Cesium (Erosion)Classes for Benchmarks with Greater than 70 % Sand.

	CESIUM RANGES (Bq m^{-2})					
SOIL YIELD PARAMETER	< 1800	18 - 1900	1900-2000	2000-2300	2300-2500	>2500
Rel. Yield (%) 1986	-5.3	-1.2	-4.2	-4.2	-2.0	2.2
Rel. Yield (%) 1987	-13.1	-10.1	-19.5	1.8	3.5	2.2
Rel. Yield (%) 1988	-42.2	-33.9	7.0	-2.0	-11.8	15.9
Rel. Yield (%) 1989	-33.4	-43.1	-0.3	-0.3	0.2	59.2
Rel. Yield (%) 1990	9.0	-10.5	2.2	-1.0	1.9	1.4
AVG	-20.6	-13.9	-6.1	-1.5	-1.9	6.4
Cesium 1987 (Bq m^{-2})	1650	1843	1944	2188	2407	2670
Cesium 1990 (Bq m^{-2})	1590	2028	2110	2301	2365	2551
Available Water (cm)	14.9	15.2	21.9	25.7	20.8	30.6
Air filled porosity (%)	24.4	30.9	24.0	20.2	25.7	17.7
Soil Test P (ppm)	28	27	34	21	30	28
Soil Test K (ppm)	195	209	135	266	274	158
Soil Test Mg (ppm)	169	108	70	93	142	104
Bulk density (g m^{-3})	1.4	1.3	1.4	1.3	1.4	1.3
Dry matter (%)	2.2	2.9	2.2	3.2	3.0	3.3
%$CaCO_3$	1.03	0.1	2.1	0.0	0.6	0.3
pH	6.7	6.1	6.6	5.3	6.1	5.8
%Sand	76.1	85.6	82.1	81.1	82.0	81.6
%Silt	16.7	10.3	12.3	13.4	12.5	13.1
%Clay	7.3	5.1	5.3	5.5	5.5	5.5
Solum depth (cm)	48.9	85.1	51.0	80.3	70.0	73.4
Ap depth (cm)	21.9	29.0	22.5	26.6	28.4	29.4
Cross curvature (^{o}/m)	6.5	-0.2	7.5	-1.3	1.1	-0.2
Down curvature ($^{o}/_{m}$)	0.09	-0.01	0.08	-0.03	0.03	0.02
Slope (^{o})	0.6	0.90	0.90	0.5	1.0	0.8
# Benchmarks	4	5	6	8	9	11

Table 6.7: Soil, Yield, Topography Parameters for Cesium (Soil Loss) Classes for Benchmarks with

	CESIUM RANGES (Bq m^{-2})						
SOIL/YIELD PARAMETER	>3000	2500-3000	2200-2500	1900-2200	1750-1900	1500-1750	<1500
Rel.Yield (%) 1986	4.3	-1.7	3.3	6.3	-1.3	0.0	-2.7
Rel.Yield (%) 1987	17.9	3.5	-7.4	5.9	-5.8	3.2	2.9
Rel.Yield (%) 1988	5.2	8.1	17.6	2.8	3.4	3.1	-11.8
Rel.Yield (%) 1989	5.8	-4.8	20.6	2.8	0.7	-0.8	-16.2
Rel.Yield (%) 1990	8.1	-3.7	11.5	9.1	0.4	2.4	-5.1
Rel.Yield (%) AVG	7.1	0.9	9.5	4.7	-1.2	1.5	-5.1
Cesium 1987 (Bq m^{-2})	3852	2899	2314	2048	1838	1667	325
Cesium 1990 (Bq m^{-2})	3649	2897	2162	2009	1950	1679	1407
Available water (cm)	20.1	18.5	18.6	19.0	18.9	19.5	21.1
Air filled porosity (%)	14.8	13.2	12.9	14.6	15.1	17.8	14.6
Soil test P(ppm)	25.9	21.6	15.6	17.4	11.2	12.7	17.0
Soil test K (ppm)	66.8	88.3	75.6	82.3	79	100	98
Soil test Mg (ppm)	122	156	211	191	165	270	223
Bulk density (g m^{-3})	1.4	1.45	1.44	1.4	1.37	1.25	1.24
Dry matter (%)	3.9	2.5	2.5	2.8	2.1	3.4	3.3
%CaC0$_3$	1.24	0.5	1.4	1.4	1.7	0.7	0.3
pH	6.8	5.9	6.8	6.8	6.6	6.8	6.5
%Sand	45.5	46.7	45.5	46.4	45.3	46.1	47.0
%Silt	42.8	42.1	42.4	41.6	43.0	40.9	39.7
%Clay	11.6	10.9	12.1	11.6	11.6	13.1	13.2
Solum depth (cm)	61.5	62.4	49.3	55.1	64.5	50.5	53.0
Ap depth (cm)	29.6	30.2	25.1	23.7	24.9	21.9	19.0
Cross Curvature ($^{o}/_{m}$)	-.31	-2.0	-2.8	-1.08	0.23	-1.41	0.54
Down Curvature ($^{o}/_{m}$)	0.00	-0.05	-.02	-0.02	0.04	0.00	-0.03
Slope (^{o})	1.41	1.9	1.83	1.73	2.01	1.26	1.71
#` Benchmarks	7	9	8	10	7	9	5

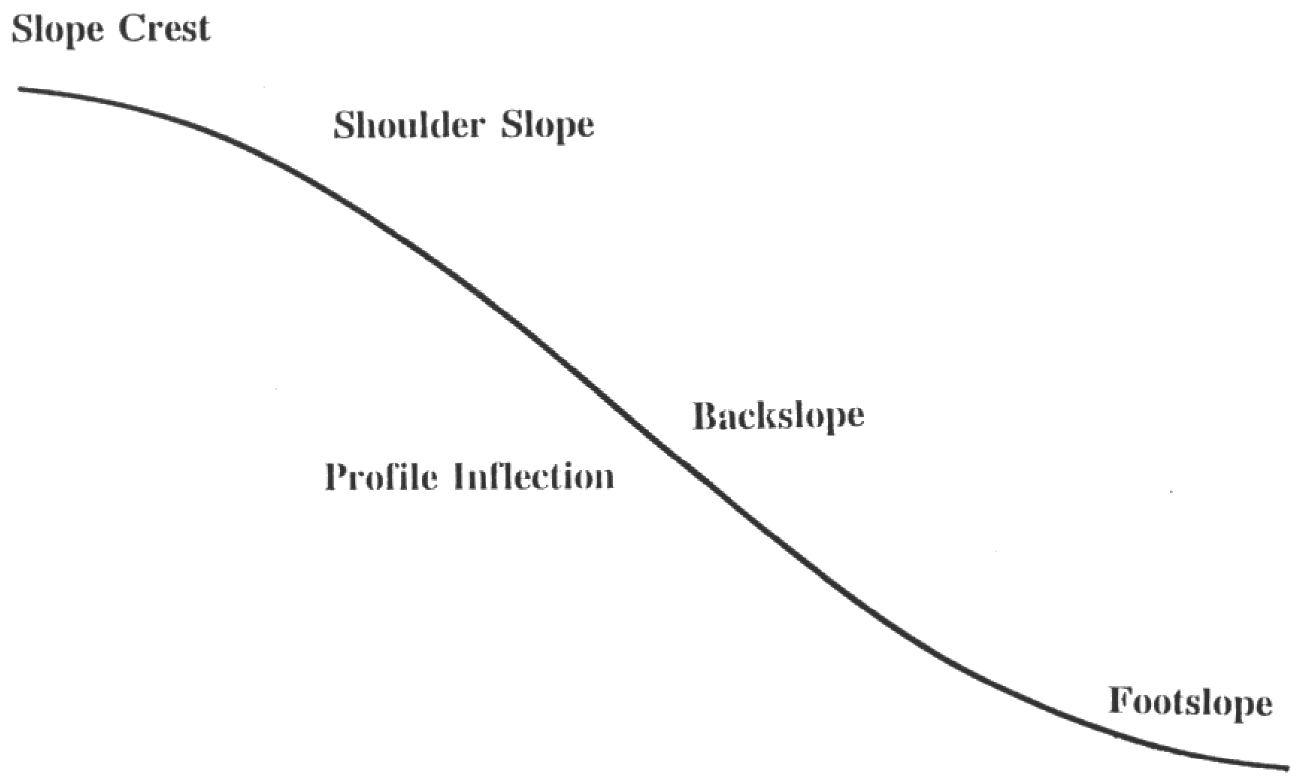

Figure 5.1: Hillslope profile showing landscape positions.

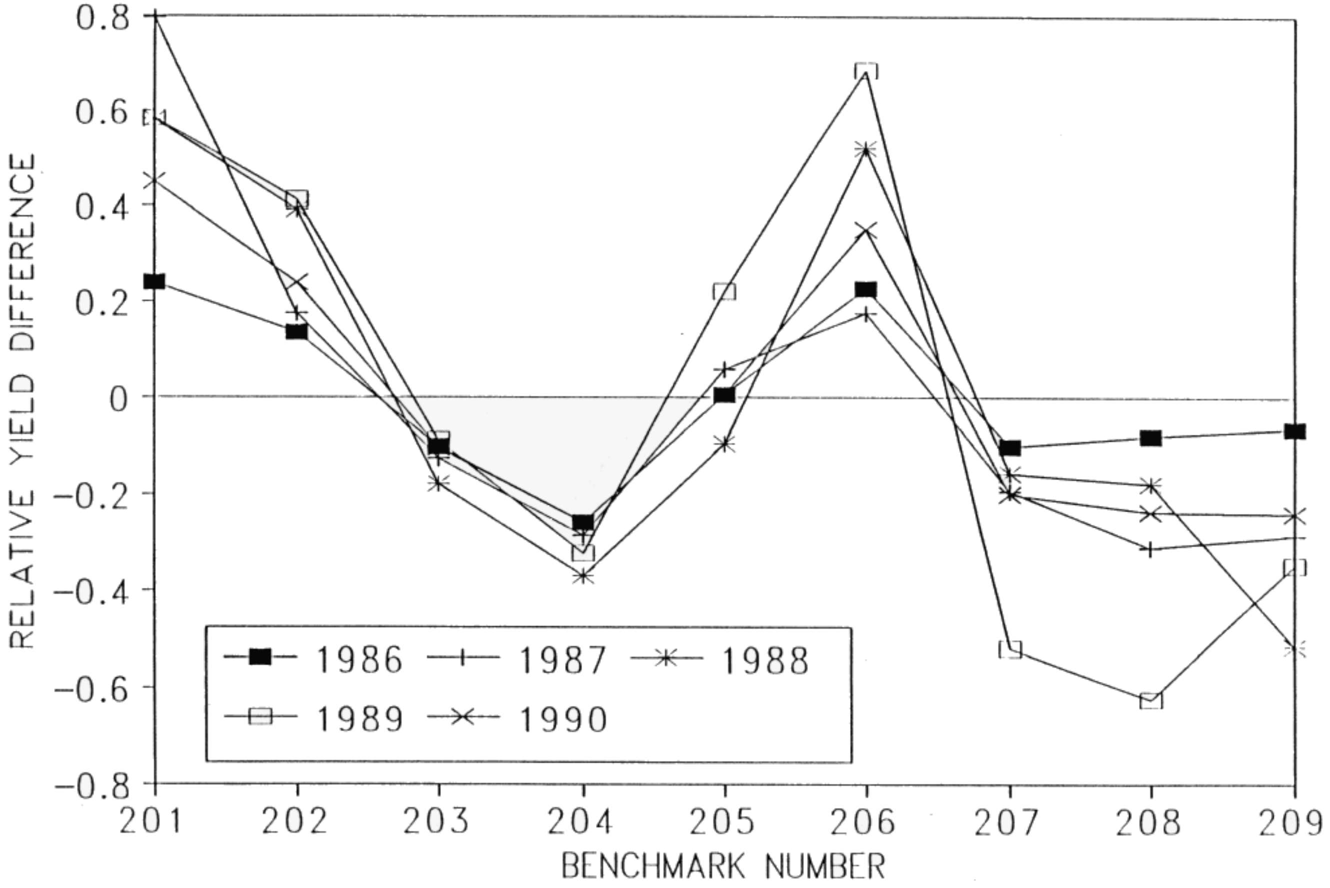

Figure 6.1: Variation in the relative yield difference for Strathmere Field Site.

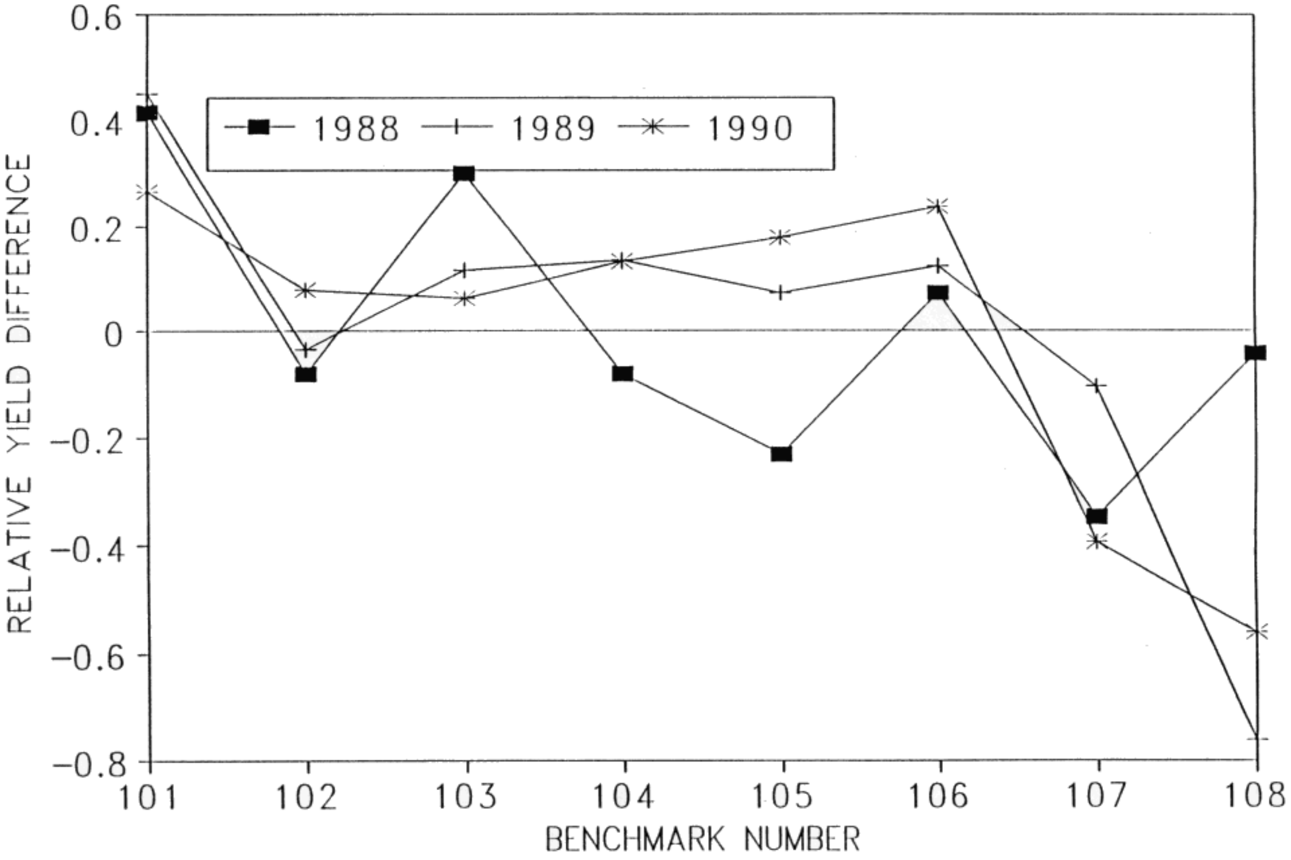

Figure 6.2: Variation in the relative yield difference for Don Lobb Field Site.

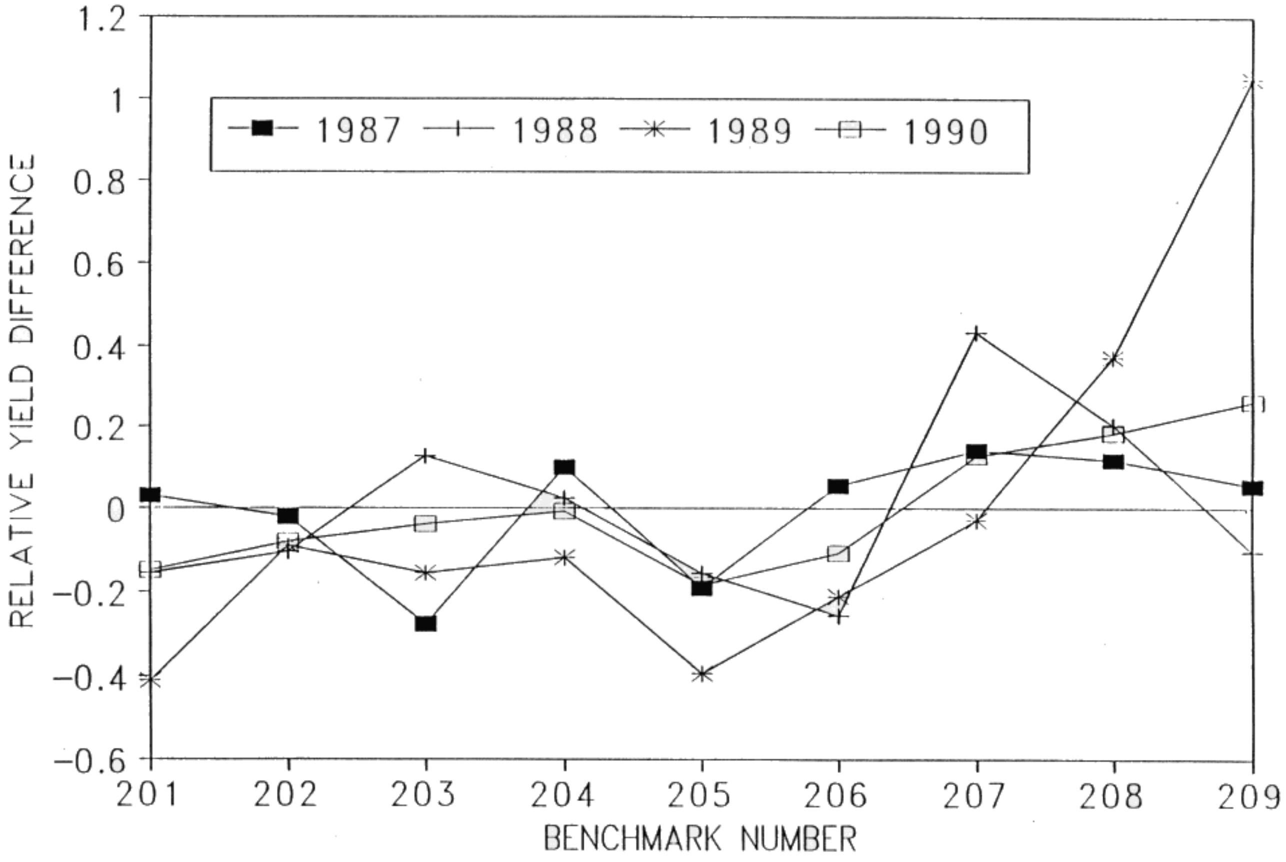

Figure 6.3: Variation in the relative yield difference for Anthony Field Site.

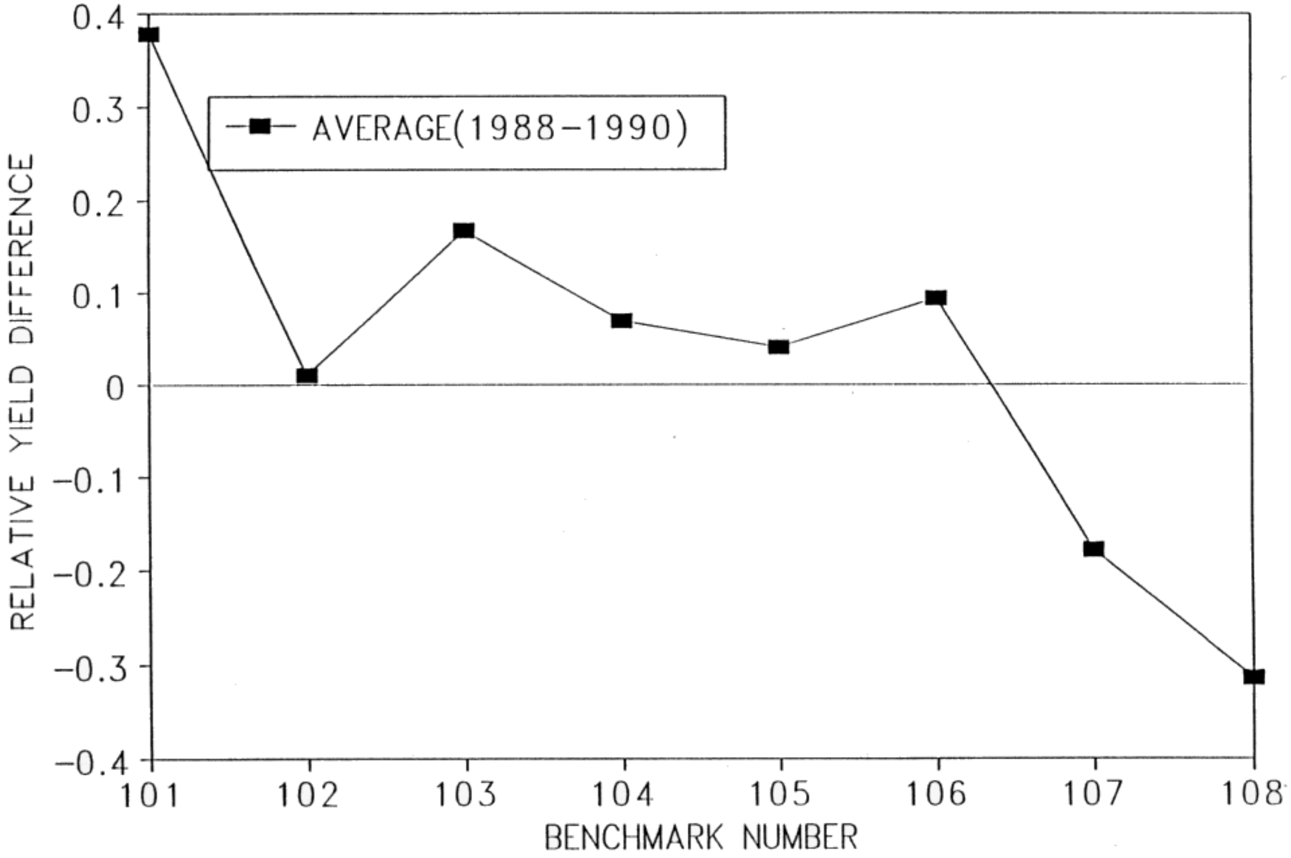

Figure 6.4: Variation in the average relative yield difference at Don Lobb's Field

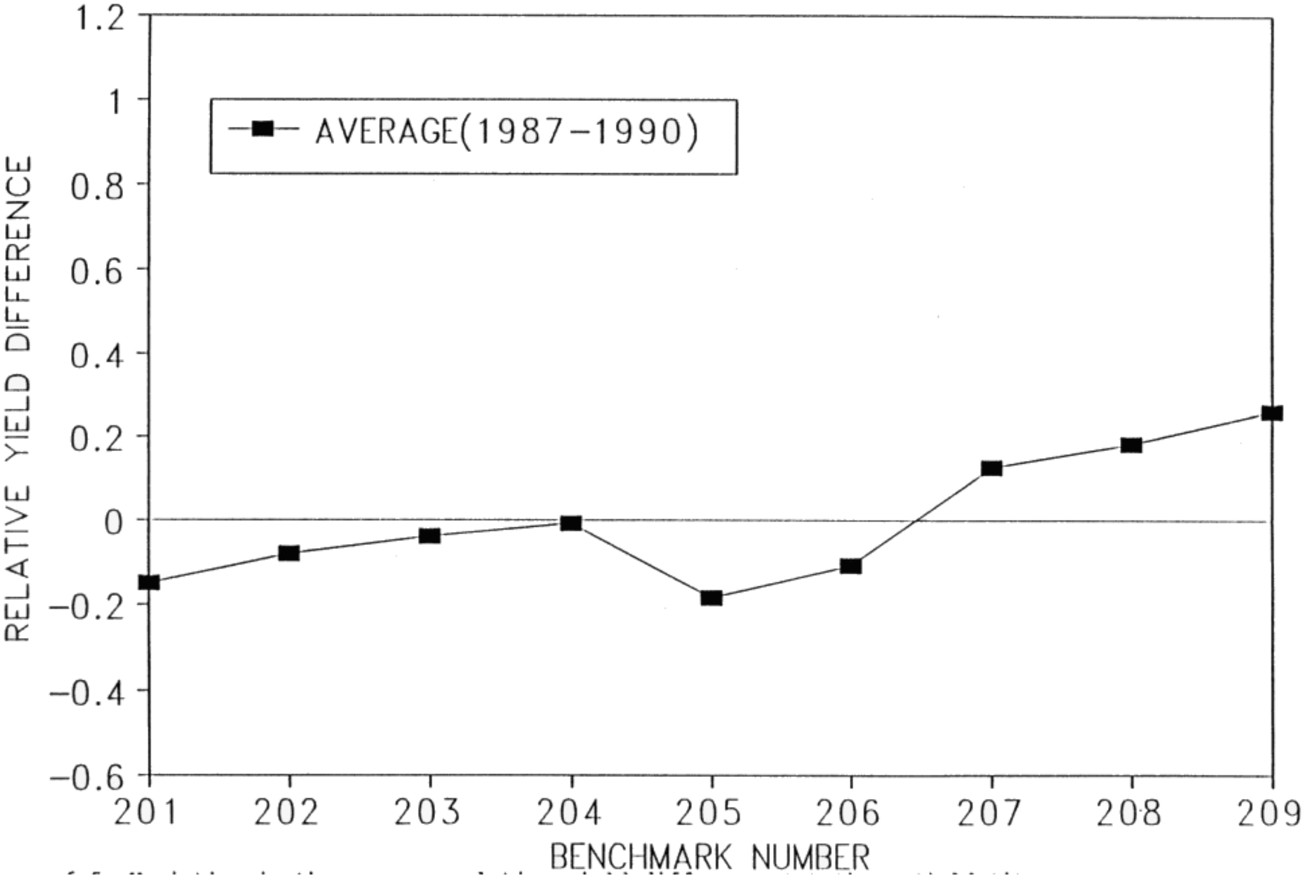

Figure 6.5: Variation in the average relative yield difference at Anthony Field Site.

APPENDIX V.I

Tillage System and Yield Data

Description of Tillage System and Crop Codes

TYPE		CROP	
DSC	Disc	B	Barley
FCP	Fall Chisel Plough	C	Corn
FDC	Fall Disc	O	Oats
FMB	Fall Moldboard	SB	Soybean
FMBN	Fall Moldboard w/o trash cover	SC	Sillage Corn
FSS	Fall Soil Save	WB	White Beans
MB	Moldboard	WW	Winter Wheat
NT	No Till		
RDG	Ridges		
ROT	Rotary Cultivator		
SDC	Spring Disc		
SMB	Spring Moldboard		
SSS	Spring Soil Save		

GROUP	
MB	Moldboard
MIN	Minimum Till
NT	No Till

CLASS	
CONS	Conservation
CONV	Conventional

BM	Soil Management			Yield [kg/ha]				
#	TYPE	GROUP	CLASS	1986	1987	1988	1989	1990
ANTHONY					C	WW	SB	C
101	SSS	MIN	CONS		5847	1933	1307	9255
102	SSS	MIN	CONS		6979	2061	647	7991
103	SSS	MIN	CONS		5596	2600	1051	7482
104	SSS	MIN	CONS		4967	2351	1664	8507
105	SSS	MIN	CONS		6413	1933	1435	6118
106	SSS	MIN	CONS		5407	1711	802	7199
107	SSS	MIN	CONS		6099	3314	1442	8394
108	SSS	MIN	CONS		4150	2762	869	8739
109	SSS	MIN	CONS		6916	2034	1179	8639
201	SMB	MB	CONV		8425	2223	970	7256
202	SMB	MB	CONV		7985	2358	1502	6935
203	SMB	MB	CONV		5910	2964	1394	8802
204	SMB	MB	CONV		8991	2695	1455	7432
205	SMB	MB	CONV		6602	2223	997	7809
206	SMB	MB	CONV		8614	1954	1300	7595
207	SMB	MB	CONV		9305	3772	1603	7457
208	SMB	MB	CONV		9117	3166	2263	8010
209	SMB	MB	CONV		8614	2358	3382	8054
BEE				C	SB	WW	C	SB
101	FDC	MIN	CONS	8802	3705	4715	8764	2816
102	FDC	MIN	CONS	7859	3907	2964	9588	2735
103	FDC	MIN	CONS	8362	3974	3974	9632	2695
104	FDC	MIN	CONS	7293	3368	3233	7626	3065
105	FDC	MIN	CONS	7167	3436	2762		
106	FDC	MIN	CONS	6979	3301			
107	FDC	MIN	CONS	6099				
108	FDC	MIN	CONS	4577				
109	FDC	MIN	CONS	7796				
201	FMB	MB	CONV	7356	3638	3570	9626	3025
202	FMB	MB	CONV	7670	4109	3705	9431	2823
203	FMB	MB	CONV	7293	4446	4042	9972	2203
204	FMB	MB	CONV	5407	3638	2964	6985	1785
205	FMB	MB	CONV	5973	3099	2695		
206	FMB	MB	CONV	7042	3436			
207	FMB	MB	CONV	6162				
208	FMB	MB	CONV	4590				
209	FMB	MB	CONV	6853				

BM	Soil Management			Yield [kg/ha]				
#	TYPE	GROUP	CLASS	1986	1987	1988	1989	1990
CHIPPS				C	C	C		SB
101	SDC	MIN	CONS	8236	8425	8676		2762
102	SDC	MIN	CONS	7733	7796	6256		3368
103	SDC	MIN	CONS	8551	9117	8186		2519
104	SDC	MIN	CONS	5973	3207	4646		2257
105	SDC	MIN	CONS	7356	6162	4879		2378
106	SDC	MIN	CONS	8739	7796	14574		2688
107	SDC	MIN	CONS	9808	7482	7614		3415
108	SDC	MIN	CONS	8676	5784	6199		3516
109	SDC	MIN	CONS	9368	5721	2113		3651
110	SDC	MIN	CONS	8173	6727	6765		3126
201	NT	NT	CONS	8551	8991	7042		3826
202	NT	NT	CONS	8802	8865	5847		3611
203	NT	NT	CONS	9620	9620	817		3085
204	NT	NT	CONS	8173	10123	8048		3294
205	NT	NT	CONS	6665	6413	5910		3543
206	NT	NT	CONS	8425	9494	8048		3550
207	NT	NT	CONS	8425	9557	8236		3523
208	NT	NT	CONS	6539	8802	5910		3402
209	NT	NT	CONS	7042	8991	7356		3584
210	NT	NT	CONS	6790	9494	7608		3469
301	SMB	MB	CONV	9054	8111	4967		3274
302	SMB	MB	CONV	7608	9242	6162		2553
303	SMB	MB	CONV	8236	9557	2012		3631
304	SMB	MB	CONV	7230	3458	5659		3813
305	SMB	MB	CONV	8865	3709	5470		3166
306	SMB	MB	CONV	7796	8048	4024		2257
307	SMB	MB	CONV	8865	7482	2389		3611
308	SMB	MB	CONV	8488	6476	6162		3718
309	SMB	MB	CONV	9682	10123	4212		3382
310	SMB	MB	CONV	9305	7419	6036		3375

BM	Soil Management			Yield [kg/ha]				
#	TYPE	GROUP	CLASS	1986	1987	1988	1989	1990
DYKSTRA				C	C	C	WW	C
101	FMB	MB	CONV	8173	9431	2481	2607	7054
102	FMB	MB	CONV	7545	8425	1794	3786	5923
103	FMB	MB	CONV	6853	10374	1985	372.5	6665
104	FMB	MB	CONV	8111	8425	1565	3004	5313
105	FMB	MB	CONV	6979	10311	2329	3712	5130
106	FMB	MB	CONV	8551	9305	1565	3348	6413
107	FMB	MB	CONV	6790	9682	2061	3436	6036
108	FMB	MB	CONV	9054	9871	2787	3948	7180
201	FSS	MIN	CONS	7105	8928	2405	3496	5960
202	FSS	MIN	CONS	8111	8173	2061	3085	5357
203	FSS	MIN	CONS	7230	8865	1412	3550	4634
204	FSS	MIN	CONS	7545	8362	1641	2849	5237
205	FSS	MIN	CONS	6224	7985	1756	3213	3018
206	FSS	MIN	CONS	6602	6162	1565	3260	3716
207	FSS	MIN	CONS	6665	7545	1107	3092	3477
208	FSS	MIN	CONS	6979	8362	2863	2627	5250
GHENT				SC	B	WW	B	
101	NT	NT	CONS	5017	1617	4715	1196	
102	NT	NT	CONS	3516	2317	4244	1245	
103	NT	NT	CONS	5235	1671	4783	2430	
104	NT	NT	CONS	4379	2425	4918	426	
105	NT	NT	CONS	5090	2102	5322	582	
106	NT	NT	CONS	1869	2210	4648	253	
107	NT	NT	CONS	5291	2263	3840	2236	
108	NT	NT	CONS	5271	2371	3974	2086	
109	NT	NT	CONS	5402	2156	3840	1654	
110	NT	NT	CONS	5067	2102	5254	404	
201	FCP	MIN	CONV	5303	2263	4513	1148	
202	FCP	MIN	CONV	3712	2641	4109	1628	
203	FCP	MIN	CONV	5303	2210	3368	323	
204	FCP	MIN	CONV	4242	2048	3974	577	
205	FCP	MIN	CONV	4772	1940	2762	517	
206	FCP	MIN	CONV	2121	2156	876	2193	
207	FCP	MIN	CONV	5303	2048	2964	781	
208	FCP	MIN	CONV	5303	2802	3436	1854	
209	FCP	MIN	CONV	5303	3287	3368	485	
210	FCP	MIN	CONV	5303	2371	3099	1536	

BM	Soil Management			Yield [kg/ha]				
#	TYPE	GROUP	CLASS	1986	1987	1988	1989	1990
JOHNSON				SB	SB	C	C	SB
101	FSS	MIN	CONV	2290	2492	8488	6822	1371
102	FSS	MIN	CONV	2358	2223	7922	6797	1119
103	FSS	MIN	CONV	2290	2492	8614	6111	679
104	FSS	MIN	CONV	2156	2695	8551	6319	660
105	FSS	MIN	CONV	1954	2560	7105	5872	415
106	FSS	MIN	CONV	2088	2492	6916	6910	409
107	FSS	MIN	CONY	2290	2358	7922	6224	327
108	FSS	MIN	CONV	2358	2964	5659	6740	1358
109	FSS	MIN	CONV	2088	2425	7733	6407	1408
110	FSS	MIN	CONV	1954	2425	6350	6199	616
111	FSS	MIN	CONV	1954	3099	7042	4948	1716
112	FSS	MIN	CONV	2021	2290	7670	6004	264
113	FSS	MIN	CONV	1751	2425	2389	5143	258
114	FSS	MIN	CONV	1886	2560	2955	5589	641
115	FSS	MIN	CONV	2290	2156	3458	4256	1056
201	NT	NT	CONS	2156	2223	8173	7344	2238
202	NT	NT	CONS	3233	2425	9242	5262	2483
203	NT	NT	CONS	2695	2964	7859	4426	2364
204	NT	NT	CONS	2695	2290	8614	6746	2144
205	NT	NT	CONS	2695	2627	6224	6847	1490
206	NT	NT	CONS	3099	1751	8299	6734	1100
207	NT	NT	CONS	3166	2358	4904	6394	1936
208	NT	NT	CONS	3031	3772	5910	6451	2081
209	NT	NT	CONS	2425	3166	7419	7155	1943
210	NT	NT	CONS	2560	2627	7042	6815	2326
211	NT	NT	CONS	2560	2425	6916	5998	2521
212	NT	NT	CONS	2897	2762	7293	5552	2295
213	NT	NT	CONS	2560	3301	4275	3615	937
214	NT	NT	CONS	2492	3099	4275	4980	1025
215	NT	NT	CONS	2425	2964	2955	4024	421

BM	Soil Management			Yield [kg/ha]				
#	TYPE	GROUP	CLASS	1986	1987	1988	1989	1990
LOBB, DON					C	SB	C	SB
101	FMB	MB	CONV		2766	2492	9550	3139
102	FMB	MB	CONV		9494	1617	6350	2674
103	FMB	MB	CONV		10500	2290	7344	2634
104	FMB	MB	CONV		9620	1617	7463	2802
105	FMB	MB	CONV		10060	1347	7067	2917
106	FMB	MB	CONV'		8299	1886	7394	3065
107	FMB	MB	CONV		9934	1145	5904	1502
108	FMB	MB	CONV		9745	1684	1572	1091
201	NT	NT	CONS		12260	3031	9368	2674
202	NT	NT	CONS		8111	2560	10707	2304
203	NT	NT	CONS		10248	1954	5916	1388
204	NT	NT	CONS		7859	2695	4514	1812
205	NT	NT	CONS		9117	1751	7891	2796
206	NT	NT	CONS		9934	2492	8155	2998
207	NT	NT	CONS		9682	1549	5935	1543
208	NT	NT	CONS		9117	1415	1320	2607
LOBB, MURRAY						C		C
101	MB	MB	CONV			7821		10041
102	MB	MB	CONV			8067		7645
103	MB	MB	CONV			6935		7394
104	MB	MB	CONV			8689		8085
105	MB	MB	CONV			6973		8771
201	NT	NT	CONS			8620		8142
202	NT	NT	CONS			9620		8827
203	NT	NT	CONS			8488		9003
204	NT	NT	CONS			9840		8783
205	NT	NT	CONS			8482		7985

BM	Soil Management			Yield [kg/ha]				
#	TYPE	GROUP	CLASS	1986	1987	1988	1989	1990
MARTIN				SC	C	SB	SB	C
101	SSS	MIN	CONS	10075	7356	2762	2964	9330
102	SSS	MIN	CONS	11418	8425	3368	3287	8934
103	SSS	MIN	CONS	10747	7230	2290	1980	9538
104	SSS	MIN	CONS	10747	9808	2964	2695	8846
105	SSS	MIN	CONS	11418	9557	2425	1778	8676
106	SSS	MIN	CONS	9403	9242	3031	2479	8129
107	SSS	MIN	CONS	10075	9117	2560	1765	8758
108	SSS	MIN	CONS	12090	9179	3031	2183	5400
109	SSS	MIN	CONS	11418	9682	3772	2796	8664
110	SSS	MIN	CONS	10075	7419	606	822	8695
111	SSS	MIN	CONS	10075	6287	135	1239	7482
201	SMB	MB	CONV	12090	6287	3301	2216	7872
202	SMB	MB	CONV	13433	8802	3031	2041	8991
203	SMB	MB	CONV	14105	9745	1751	2257	7834
204	SMB	MB	CONV	12090	10311	2829	1812	8551
205	SMB	MB	CONV	13433	10060	1954	1927	8582
206	SMB	MB	CONV	12762	9620	3031	2257	8293
207	SMB	MB	CONV	12762	9179	2627	1522	8148
208	SMB	MB	CONV	12762	9682	4042	1617	8966
209	SMB	MB	CONV	12762	9997	2560	1967	8639
210	SMB	MB	CONV	11418	7733	876	1300	6382
211	SMB	MB	CONV	9403	8488	2560	1745	5627
MURRELL				C	SB	WW	WB	WW
101	FMB	MB	CONV	8676	2762	5995	66	4298
102	FMB	MB	CONV	8048	3638	7612	71	3954
103	FMB	MB	CONV	7733	4109	7410	73	3510
104	FMB	MB	CONV	7356	3907	7882	71	3894
105	FMB	MB	CONV	7608	2964	6467	49	4237
106	FMB	MB	CONV	8488	3031	5052	48	3617
107	FMB	MB	CONV	8173	4109	5928	55	3988
108	FMB	MB	CONV	7293	3907	7275	59	3402
109	FM	MB	CONV	7482	2560	5793	51	3793
201	FSS	MIN	CONS	5533	4648	5456	52	3705
202	FSS	MIN	CONS	7482	4648	4985	47	4911
203	FSS	MIN	CONS	7922	5052	5322	51	4480
204	FSS	MIN	CONS	7796	5322	5456	60	4419
205	FSS	MIN	CONS	7482	4177	6130	28	4271
206	FSS	MIN	CONS	6413	4513	5187	62	4534
207	FSS	MIN	CONS	6790	3907	5120	52	3732
208	FSS	MIN	CONS	7545	3705	4783	45	3914
209	FSS	MIN	CONS	7293	3638	5591	20	2991

BM	Soil Management			Yield [kg/ha]				
#	TYPE	GROUP	CLASS	1986	1987	1988	1989	1990
POTTRUFF				C	C	C	SB	C
101	NT	NT	CONS	7545	9027	8825	2856	7363
102	NT	NT	CONS	7356	9296	8151	2418	7814
103	NT	NT	CONS	7293	8151	7477	1206	6554
104	NT	NT	CONS	6790	6130	6871	2479	7208
105	NT	NT	CONS	7167	7477	7343	1920	7767
106	NT	NT	CONS	7859	10576	7882	2553	7410
107	NT	NT	CONS	7419	7410	8353	2486	7100
108	NT	NT	CONS	7356	8420	6871	2297	7053
109	NT	NT	CONS	6413	8892	4648	1206	7531
110	NT	NT	CONS	6162	6197	5456	1543	6649
111	NT	NT	CONS	6853	8623	6400	2263	8084
112	NT	NT	CONS	5156	5659	4783	849	6467
113	NT	NT	CONS	6224	8286	8959	2183	6528
114	NT	NT	CONS	6287	9027	6669	2627	5793
115	NT	NT	CONS	6790	8555	8555	1280	6346
116	NT	NT	CONS	6099	9027	7275	1879	6359
201	FSS	MIN	CONV	7293	9296	8151	2823	8879
202	FSS	MIN	CONV	7670	8623	7343	3052	8811
203	FSS	MIN	CONV	7419	10239	8420	2856	9377
204	FSS	MIN	CONV	6350	8488	7477	2634	7525
205	FSS	MIN	CONV	7230	8286	7006	1388	6824
206	FSS	MIN	CONV	7796	9498	8690	2122	8468
207	FSS	MIN	CONV	7545	8084	8623	3058	8353
208	FSS	MIN	CONV	7545	10037	6736	3105	8326
209	FSS	MIN	CONV	6350	7545	5659	1118	7154
210	FSS	MIN	CONV	7608	9700	5659	2695	8434
211	FSS	MIN	CONV	6350	8286	8016	2277	8596
212	FSS	MIN	CONV	6727	9566	5928	1738	8104
213	FSS	MIN	CONV	7230	8488	10172	3665	7013
214	FSS	MIN	CONV	6790	8016	7882	1085	7477
215	FSS	MIN	CONV	7419	8892	7679	997	8441
216	FSS	MIN	CONV	6665	8555	8151	3260	7174

BM	Soil Management			Yield [kg/ha]				
#	TYPE	GROUP	CLASS	1986	1987	1988	1989	1990
RIDDELL				WW	C	SB	C	SB
101	FDC	MIN	CONV	3709	12395	2358	9943	1462
102	FDC	MIN	CONV	3207	12530	3638	10859	1233
103	FDC	MIN	CONV	4024	11250	2425	8629	1974
104	FDC	MIN	CONV	4527	11384	2021	9424	1839
105	FDC	MIN	CONV	3458	11048	3099	9283	2277
106	FDC	MIN	CONV	4212	12328	1886	7646	2068
107	FDC	MIN	CONV	4653	9566	1549	7781	3139
108	FDC	MIN	CONV	4967	10037	2021	9444	3894
109	FDC	MIN	CONV	4527	10509	2156	8946	2917
110	FDC	MIN	CONV	2892	7275	1886	6325	3186
111	FDC	MIN	CONV	3835	9700	2762	9559	3079
112	FDC	MIN	CONV	4024	9835	3301	9390	2519
113	FDC	MIN	CONV	4150	12260	2964	9586	2573
114	FDC	MIN	CONV	3709	11789	3031	9640	2479
115	FDC	MIN	CONV	3961	11789	3436	8198	2836
201	NT	NT	CONS	4338	11789	1954	8609	2210
202	NT	NT	CONS	3584	10913	2156	8993	1603
203	NT	NT	CONS	4275	11317	3772	9316	1415
204	NT	NT	CONS	3961	10913	3031	10670	1772
205	NT	NT	CONS	4150	12530	3436	10664	2378
206	NT	NT	CONS	3772	12395	4311	8441	2695
207	NT	NT	CONS	4275	13136	2829	9263	1947
208	NT	NT	CONS	3647	11654	2695	10118	2075
209	NT	NT	CONS	4527	11384	2897	8097	2654
210	NT	NT	CONS	4653	8016	2897	7322	2391
211	NT	NT	CONS	5156	13540	2964	10098	2796
212	NT	NT	CONS	2641	11587	3570	8602	2695
213	NT	NT	CONS	4590	11856	2627	7976	2425
214	NT	NT	CONS	4150	10913	2964	10738	2344
215	NT	NT	CONS	3269	10509	3503	9943	2620

BM	Soil Management					Yield [kg/ha]		
#	TYPE	GROUP	CLASS	1986	1987	1988	1989	1990
STRATHROY				C	SB	WW	C	C
101	NT	NT	CONS	9431	4244	5726	11028	
102	NT	NT	CONS	10374	3368	4648	9814	8375
103	NT	NT	CONS	8991	2492	3301	7557	
104	NT	NT	CONS	8614	2021	2425	5237	
105	NT	NT	CONS	9682	3638	4715	9909	7803
106	NT	NT	CONS	9997	3368	4513	10657	8739
107	NT	NT	CONS	8802	3166	3570	6947	9117
108	NT	NT	CONS	7670	2021	2425	4533	8614
109	NT	NT	CONS	7733	1954	2156	4194	8777
201	SDC	MIN	CONV	10940	5254	5052	10569	8261
202	SDC	MIN	CONV	9997	3436	4446	9412	8683
203	SDC	MIN	CONV	7922	2560	2627	6080	7771
204	SDC	MIN	CONV	6539	2088	2021	4521	7520
205	SDC	MIN	CONV	8865	3099	2897	8142	6665
206	SDC	MIN	CONV	10814	3436	4850	11242	9135
207	SDC	MIN	CONV	7922	2358	2695	3200	7859
208	SDC	MIN	CONV	8111	2021	2627	2502	8060
209	SDC	MIN	CONV	8236	2088	1549	4345	8098
STEWART						W	SB	SB
101	FMB	MB	CONV			2347	3405	2971
102	FMB	MB	CONV			2247	2106	2647
103	FMB	MB	CONV			2437	2445	2755
104	FMB	MB	CONV			3127	1762	2560
105	FMB	MB	CONV			2669	2635	2647
106	FMB	MB	CONV			1520	3204	2661
107	FMB	MB	CONV			1667	2659	2991
108	FMB	MB	CONV			1238	1793	3018
201	NT	NT	CONS			2358	2245	2405
202	NT	NT	CONS			2393	2089	2526
203	NT	NT	CONS			2576	2372	2176
204	NT	NT	CONS			2744	2964	2708
205	NT	NT	CONS			3248	2831	2324
206	NT	NT	CONS			2372	1991	2607
207	NT	NT	CONS			1875	2246	2661
208	NT	NT	CONS			2090	2315	2257

BM	Soil Management			Yield [kg/ha]				
#	TYPE	GROUP	CLASS	1986	1987	1988	1989	1990
TEMPLEMAN						C	SB	WW
101	FMB	MB	CONV			6790	2553	5483
102	FMB	MB	CONV			*9557*	3658	6716
103	FMB	MB	CONV			7230	2647	5955
104	FMB	MB	CONV			8802	2721	6204
105	FMB	MB	CONV			7482	3328	6474
106	FMB	MB	CONV			7042	3409	6925
107	FMB	MB	CONV			7042	3590	6561
108	FMB	MB	CONV			6916	3388	6642
109	FMB	MB	CONV			7859	2587	5874
201	NT	NT	CONS			4841	2028	5813
202	NT	NT	CONS			7922	3577	6561
203	NT	NT	CONS			4841	2654	6359
204	NT	NT	CONS			5973	2735	6676
205	NT	NT	CONS			5218	3382	6588
206	NT	NT	CONS			6413	3274	6346
207	NT	NT	CONS			6162	3570	6858
208	NT	NT	CONS			6162	3388	6622
209	NT	NT	CONS			5218	2277	5975

APPENDIX V.II

Soil Landform Parameters and Moisture Characteristics

DERIVATION OF SLOPE MORPHOLOGICAL VARIABLES

The geometry of the land surface is derived from a matrix of elevation data using the procedure discussed by Young and Evans (1978). The geometric properties of a point are determined by making the point the central point of a 3 by 3 grid. A second order surface in the form of equation 1 is fit to the 3 by 3 grid. The elevation, z, at the central point is given by:

[1] $z = ax^2 + by^2 + cxy + dx + cy + f$

By setting $x = r \cos\theta$ and $y = r \sin\theta$, Equation 1 becomes:

[2] $z = r^2(a \cos^2\theta + b \sin^2\theta + c \cos\theta \sin\theta) + r (d \cos\theta + \sin\theta) + f$

The gradient (dz/dr) at the central point (r-0) can be given as Equation 3:

[3] $$\frac{dz}{dr} = d\ cose\theta + e \sin\theta$$

where Aspect (α) is the value of θ, when the gradient is at a maximum as expressed in Equation 4.

[4] $$\frac{d}{d}\theta \left(\frac{dz}{dr}\right) = -d \sin\theta + e \cos\theta = 0;\ \textit{thus:}$$

[5] $\text{Tan } \alpha = = e/d$

Note that the aspect is indeterminate if the gradient is equal to zero.

Because of Equation 5, then $\text{cas } \alpha = \frac{d}{(e^2+d^2)^{1/2}}$

and $\sin \alpha = \frac{e}{(e^2+d^2)^{1/2}}$ and the expression for gradient becomes:

[6] $$\frac{dz}{dr} = (d^2 + e^2)^{1/2}$$

The general equation for curvature of a plane curve is:

[7] $$\frac{1}{\rho} = \frac{d^2y}{dx^2} \, [1 + ({}^{dx}/{}_{dy})^2]^{3/2}$$

By applying Equation 7 to a vertical plane through the central point, taken at angle a, profile curvature (PROF) can then be expressed as Equation 8. Note that Equation 8 is written to follow the convention that convex curvature is positive.

[8] $$PROF = \frac{-d^2z/dr^2}{[1 = (\frac{dz}{dr})^2]^{3/2}} = \frac{-2(a \cos^2 \alpha + b \sin^2 \alpha + c \; c0s \; \alpha \sin \alpha}{[1+(d \cos \alpha + e \sin \alpha)^2]^{3/2}}$$

Using the equations for Tan α, cos α, and sin α given earlier, Equation 8 can be re-written as:

[9] $PROF = -2(adsup2 = be^2 + cde)/(e^2 + d^2)\ (1 + d^2 + e^2)^{3/2}$

Plan curvature is determined by taking a horizontal plane which is perpendicular to the vertical plane and which is through the central point, giving an expression in the form of Equation 10:

[10] $ax^2 + by^2 + cxy + dx + ey + f = \text{constant}$

The expressions for dy/dx and d^2y/dx^2 are given by Equations 11 and 12 respectively:

[11] $$\frac{dy}{dx} = -(2ax + cy + d)/(zby + cx + e)$$

[12] $$\frac{d^2y}{dx^{-}} = -[(2ax+cy+d)\,(zb\frac{dy}{dx} + c) - (zby+cx+e)\,(2a + \frac{cdy}{dx})]/(2by+cx+e)\,sup2$$

The expression for plan curvature (PLAN) is given by Equation 13:

[13] $$PLAN = \frac{-d^{y}}{dx^2} \; / \; [1 + (\frac{dy}{dx})^2]^{3/2}$$

By taking Equations 11 and 12 at $x = 0$ and $y = 0$ and substituting into Equation 13, Equation 14 is obtained:

[14] $PLAN = -2(bd^2 + ae^2 - cde)/(e^2 + d^2)^{3/2}$

Thus we can determine gradient, aspect, plan curvature and profile curvature once the coefficients a through f are determined. In order to obtain these coefficients, a least squares solution is obtained by fitting equation 1 to 3 by 3 grid of points, using Equation 15:

[15] $F^TFB\beta = F^Tz$

z is a 9x1 matrix containing the elevations for the points (-s,s), (0,s), (s,s),(-s,0),(0,0), (s,0), (-s,-s), (0,s),(-s,-s), where s is the grid spacing and (0,0) is the central point of the 3 by 3 elevation matrix. β is a 6 by 1 matrix consisting of coefficients a through f. F is a 9 by 6 matrix of the form:

$$F = \begin{matrix} s^2 & s^2 & -s^2 & -s & s & 1 \\ 0 & s^2 & 0 & 0 & s & 1 \\ s^2 & s^2 & s^2 & s & s & 1 \\ s^2 & 0 & 0 & -s & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ s^2 & 0 & 0 & s & 0 & 1 \\ s^2 & s^2 & s^2 & -s & -s & 1 \\ 0 & s^2 & 0 & 0 & -s & 1 \\ s^2 & s^2 & -s^2 & s & -s & 1 \end{matrix}$$

and F^T is the transpose matrix of F. Solving Equation 15 for the coefficient matrix β gives Equation 16:

[16] $\beta = (F^TF)^{-1}F^Tz$

For each 3 by 3 grid of elevations, $(F^TF)^{-1}F^T$ is constant and takes the form:

$$\begin{matrix}
\frac{1}{6s^2} & \frac{-1}{3s^2} & \frac{1}{6s^2} & \frac{1}{6s^2} & \frac{-1}{3s^2} & \frac{1}{6s^2} & \frac{1}{6s^2} & \frac{-1}{3s^2} & \frac{1}{6s^2} \\
\frac{1}{6s^2} & \frac{1}{6s^2} & \frac{1}{6s^2} & \frac{-1}{3s^2} & \frac{-1}{3s^2} & \frac{-1}{3s^2} & \frac{1}{6s^2} & \frac{1}{6s^2} & \frac{1}{6s^2} \\
\frac{-1}{4s^2} & 0 & \frac{1}{4s^2} & 0 & 0 & 0 & \frac{1}{4s^2} & 0 & \frac{-1}{4s^2} \\
\frac{-1}{6s^2} & 0 & \frac{1}{6s^2} & \frac{-1}{6s^2} & 0 & \frac{1}{6s^2} & \frac{-1}{6s^2} & 0 & \frac{1}{6s^2} \\
\frac{1}{6s^2} & \frac{1}{6s^2} & \frac{1}{6s^2} & 0 & 0 & 0 & \frac{-1}{6s^2} & \frac{-1}{6s^2} & \frac{-1}{6s^2} \\
\frac{-1}{9} & \frac{2}{9} & \frac{-1}{9} & \frac{2}{9} & \frac{5}{9} & \frac{2}{9} & \frac{-1}{9} & \frac{2}{9} & \frac{-1}{9}
\end{matrix}$$

Thus, the coefficients a through f can be calculated using the following equations:

$a = [z(1)+ z(3) -z(4) -z(6) + z(7) + z(9)]/6x^2 - [z(2) + zZ(5) -z(8)]/3s^2$

$b = [z(1)+ z(2) -z(3) -z(7) + z(8) + z(9)]/6x^2 - [z(4) + zZ(5) -z(6)]/3s^2$

$c = [z(3)+ z(7) - z(1) -z(9)]/4s^2$

$d = [z(3) + z(6) + z(9) -z(1) -z(4) -z(7)]/6s^2$

e $= [z(1)+ z(2) + z(3) -z(7) -z(8) -z(9)]6s^2$

$f = [5(z(1)) + 2(z(2)+ z(4)+ z(6)+ z(8))- (z(1)+z(3)+z(7)+z(9))]/9$

These coefficients can then be used to calculate aspect, gradient, plan curvature and profile curvature.

BM #	LANDFORM					AIR FILLED POROSITY			AVAILABLE WATER [%] 0-100 cm	DRAINAGE CLASS
	Elev m	Slope º/m	PCV º/m	CCV º/m	TOPO Class	0-15 cm %	15-30 cm %	0-20 cm %		
ANTHONY										
101	1.5	0.7	-0.1	3.8	DFS	8	2	6	23	W
102	2.0	1.1	0.1	0.1	DSH	16	12	15	23	W
103	2.5	1.4	-0.1	-1.0	CFS	22	18	21	16	MW
104	3.2	2.0	0.1	-0.8	CSH	16	13	15	21	W
105	4.0	1.0	-0.0	0.0	LEVEL	25	23	25	16	W
106	4.2	0.6	0.0	8.2	LEVEL	11	3	9	24	W
107	3.2	1.7	-0.0	-4.9	LEVEL	19	21	20	17	W
108	2.8	0.8	-0.0	-1.4	LEVEL	16	12	15	22	W
109	2.4	2.2	0.1	-2.3	CSH	23	23	23	18	W
201	1.5	0.6	-0.1	-0.3	CFS	21	19	21	18	W
202	2.0	1.1	0.1	0.1	DSH	13	9	13	20	W
203	2.5	1.4	-0.1	-1.0	CFS	20	17	20	18	W
204	3.2	2.0	0.1	-0.8	CSH	23	19	22	18	W
205	4.0	0.5	0.0	-2.5	LEVEL	10	6	10	23	W
206	3.6	2.3	-0.1	-0.3	CFS	23	22	22	16	W
207	3.0	1.3	-0.1	-2.8	CFS	23	21	23	18	W
208	2.7	1.1	0.1	-1.3	CSH	6	6	5	23	W
209	1.9	2.6	-0.0	-3.4	LEVEL	18	14	18	28	W
BEE										
101	1.2	0.3	0.1	-0.3	CSH	1	0	1	17	P
102	1.0	0.5	-0.0	-5.3	LEVEL	0	1	0	13	P
103	1.0	0.7	-0.1	-4.4	CFS	1	0	1	18	P
104	0.9	0.8	-0.0	2.6	LEVEL	1	0	0	13	P
105	0.8	1.2	0.0	0.0	LEVEL	1	0	1	7	P
201	1.0	0.6	0.0	0.2	LEVEL	3	1	3	18	P
202	0.9	0.7	-0.0	2.5	LEVEL	1	0	1	18	P
203	1.0	0.2	0.0	1.0	LEVEL	2	0	1	19	P
204	0.7	0.6	-0.0	-1.4	LEVEL	1	0	1	10	P
205	0.5	0.9	-0.1	-5.3	CFS	4	1	3	7	P

	LANDFORM					AIR FILLED POROSITY			AVAILABLE WATER [%]	
BM #	Elev m	Slope º/m	PCV º/m	CCV º/m	TOPO Class	0-15 cm %	15-30 cm %	0-20 cm %	0-100 cm	DRAINAGE CLASS
CHIPPS										
101	1.0	0.4	-0.0	-5.3	LEVEL	33	31	33	12	W
102	1.3	1.6	-0.0	-2.7	LEVEL	15	4	13	39	P
103	1.9	1.1	-0.0	4.6	LEVEL	20	18	20	34	I
104	1.6	1.1	-0.0	-0.4	LEVEL	29	27	29	16	MW
105	1.6	0.7	-0.0	-0.3	LEVEL	33	24	31	16	MW
106	1.5	0.2	-0.0	8.0	LEVEL	32	33	32	11	R
107	1.4	0.2	0.0	-4.6	LEVEL	11	3	9	37	I
108	1.0	0.8	-0.1	-7.2	CFS	33	33	32	12	R
109	0.7	0.3	0.0	-16.3	LEVEL	30	28	30	18	MW
110	1.1	1.1	0.2	4.1	DSH	18	10	17	31	MW
201	1.5	0.4	0.2	15.2	DSH	32	21	30	16	MW
202	1.4	1.0	0.0	1.2	LEVEL	29	31	30	19	MW
203	1.4	1.7	-0.1	-2.0	CFS	28	30	29	17	MW
204	2.1	1.4	0.3	0.2	DSH	32	28	32	9	R
205	1.9	1.0	-0.1	2.1	DFS	8	2	7	28	MW
206	1.6	0.0	-0.0	10.0	LEVEL	30	25	28	27	I
207	1.4	0.5	-0.0	0.2	LEVEL	13	4	11	37	P
208	1.0	1.0	0.1	5.1	DSH	28	28	28	26	I
209	0.5	0.5	-0.0	-15.3	LEVEL	24	19	24	28	I
210	0.5	0.5	-0.1	-11.1	CFS	13	4	11	41	P
301	1.2	0.8	0.0	1.8	LEVEL	35	32	34	8	R
302	0.9	0.3	-0.0	2.1	LEVEL	10	3	8	37	P
303	1.8	2.3	0.1	0.6	DSH	12	4	10	35	P
304	1.9	1.5	0.0	-0.7	LEVEL	33	29	33	9	R
305	1.7	1.0	-0.0	-12.8	LEVEL	31	27	30	16	MW
306	1.8	1.4	0.0	1.7	LEVEL	22	27	24	28	I
307	1.0	0.8	0.0	0.8	LEVEL	15	4	13	37	P
308	0.4	0.8	-0.1	-2.5	CFS	5	1	4	35	I
309	0.4	0.2	-0.1	2.3	DFS	11	2	9	35	P
310	1.3	0.9	0.3	4.0	DSH	26	17	25	22	MW

	LANDFORM					AIR FILLED POROSITY			AVAILABLE WATER [%] 0-100 cm	DRAINAGE CLASS
BM #	Elev m	Slope º/m	PCV º/m	CCV º/m	TOPO Class	0-15 cm %	15-30 cm %	0-20 cm %		
DYKSTRA										
101	0.9	1.1	0.0	4.5	LEVEL	15	14	15	13	W
102	1.4	1.7	0.1	3.7	DSH	11	8	11	11	W
103	2.4	2.3	0.0	-0.1	LEVEL	10	9	10	14	MW
104	3.7	3.9	-0.1	0.5	DFS	18	16	18	17	W
105	4.8	3.0	-0.0	0.3	LEVEL	14	12	14	19	W
106	5.3	1.0	-0.2	6.8	DFS	19	16	19	17	W
107	5.2	1.1	0.0	-5.1	LEVEL	20	14	20	17	W
108	5.0	1.1	-0.1	-4.2	CFS	-	-	-	-	-
201	0.6	1.2	0.0	1.5	LEVEL	13	13	13	16	W
202	0.9	1.4	-0.1	2.4	DFS	16	11	15	14	W
203	1.6	2.9	-0.0	1.4	LEVEL	-	-	-	-	-
204	3.6	3.5	-0.1	0.0	DFS	-	-	-	-	-
205	4.9	3.2	0.1	-4.1	CSH	-	-	-	-	-
206	5.2	1.1	0.3	-12.8	CSH	-	-	-	-	-
207	5.3	0.9	-0.2	-6.7	CFS	-	-		-	-
208	5.1	0.5	0.1	-15.3	CSH	19	11	19	24	W
GHENT										
101	2.9	0.9	0.0	11.4	LEVEL	15	8	15	22	I
102	2.5	0.7	-0.0	5.9	LEVEL	13	11	13	24	I
103	2.3	1.0	0.1	2.9	DSH	9	8	9	15	I
104	1.8	1.1	0.0	1.1	LEVEL	11	8	11	18	I
105	0.7	0.9	0.0	1.6	LEVEL	-	-	-	-	-
106	0.4	0.6	-0.0	-0.8	LEVEL	-	-	-	-	-
107	0.3	0.6	0.0	1.6	LEVEL	-	-	-	-	-
108	0.3	0.5	-0.0	2.6	LEVEL	-	-	-	-	-
109	0.5	0.6	0.0	-0.2	LEVEL	-	-	-	-	-
110	0.8	0.4	-0.0	1.4	LEVEL	-	-	-	-	-
201	2.5	0.8	-0.0	-1.4	LEVEL	11	10	11	17	MW
202	2.3	0.8	-0.0	-1.5	LEVEL	9	10	9	17	I
203	2.1	0.8	0.0	0.9	LEVEL	12	13	12	16	W
204	1.6	1.0	0.0	-0.5	LEVEL	7	6	7	25	P
205	1.0	0.8	0.0	-0.6	LEVEL	17	15	17	26	I
206	0.5	0.5	0.0	-4.1	LEVEL	5	5	5	16	P
207	0.5	0.3	0.0	-3.8	LEVEL	8	6	8	20	P
208	0.6	0.6	-0.0	-1.1	LEVEL	10	8	10	20	I
209	0.7	0.8	-0.0	0.2	LEVEL	13	10	13	20	I
210	1.0	0.4	0.0	-0.1	LEVEL	9	8	9	22	I

	LANDFORM					AIR FILLED POROSITY			AVAILABLE WATER [%] 0-100 cm	DRAINAGE CLASS
BM #	Elev m	Slope º/m	PCV º/m	CCV º/m	TOPO Class	0-15 cm %	15-30 cm %	0-20 cm %		
JOHNSON										
101	7.0	2.3	0.1	1.2	DSH	13	9	12	22	MW
102	5.0	3.4	0.0	-0.7	CBS	7	2	6	19	W
103	3.4	3.1	0.0	0.1	DBS	8	4	7	13	W
104	1.7	1.6	-0.0	-0.5	LEVEL	11	12	12	23	MW
105	1.2	0.1	-0.0	-8.1	LEVEL	5	2	4	33	P
106	1.8	2.3	-0.0	0.9	LEVEL	11	7	11	27	I
107	5.6	0.7	-0.0	3.7	LEVEL	16	15	16	19	MW
108	5.3	1.7	0.1	0.7	DSH	25	13	22	17	W
109	4.2	1.6	0.0	1.2	LEVEL	9	6	8	18	MW
110	3.9	0.5	0.0	-2.7	LEVEL	10	6	9	28	P
111	4.3	0.9	0.0	-1.6	LEVEL	9	6	8	2.5	MW
112	2.7	2.6	-0.0	0.1	LEVEL	12	12	11	16	MW
113	0.2	0.2	0.0	2.2	LEVEL	4	2	3	27	P
114	0.1	0.2	0.0	-3.8	LEVEL	4	2	4	28	P
115	0.2	0.2	0.0	-2.1	LEVEL	5	2	4	32	P
201	6.9	2.0	0.0	-0.5	LEVEL	16	12	17	16	MW
202	5.2	3.1	0.0	-0.4	CBS	21	18	20	14	W
203	3.6	3.1	-0.0	-0.2	CBS	17	19	15	13	VR
204	1.8	1.8	-0.1	0.4	DFS	16	15	16	14	W
205	1.2	0.2	0.0	-21.1	LEVEL	6	2	5	38	P
206	2.0	2.7	-0.1	-0.8	CFS	6	2	5	37	P
207	5.7	0.3	0.0	4.5	LEVEL	13	13	13	13	W
208	5.2	1.6	0.0	1.4	LEVEL	19	20	19	18	W
209	4.3	1.5	-0.0	1.1	LEVEL	12	7	11	25	I
210	4.0	0.5	-0.1	0.6	DFS	8	5	7	24	P
211	4.0	2.2	0.1	1.7	DSH	4	5	4	19	R
212	1.8	2.3	-0.0	-0.3	LEVEL	4	1	3	12	W
213	0.3	0.5	-0.0	1.0	LEVEL	8	6	8	25	P
214	0.2	0.4	-0.0	-1.3	LEVEL	2	2	2	33	P
215	0.2	0.1	-0.0	8.9	LEVEL	5	3	5	37	P

	LANDFORM					AIR FILLED POROSITY			AVAILABLE WATER [%] 0-100 cm	DRAINAGE CLASS
BM #	Elev m	Slope º/m	PCV º/m	CCV º/m	TOPO Class	0-15 cm %	15-30 cm %	0-20 cm %		
LOBB, DON										
101	0.6	0.7	0.0	-0.9	LEVEL	30	18	27	17	MW
102	0.9	1.0	-0.0	1.2	LEVEL	25	20	25	18	MW
103	2.9	1.4	0.1	-1.6	CSH	24	25	24	11	R
104	3.7	2.4	0.1	2.6	DSH	22	30	24	14	R
105	5.1	2.9	0.2	-1.5	CSH	2	0	1	23	W
106	4.3	2.0	0.1	2.3	DSH	12	8	11	24	I
107	6.1	2.9	0.0	1.6	LEVEL	15	5	14	8	W
108	6.8	1.9	-0.0	-4.7	LEVEL	17	7	15	10	W
201	0.6	0.7	0.0	-1.4	LEVEL	23	22	23	22	I
202	0.8	0.9	-0.0	-1.0	LEVEL	8	3	7	33	P
203	2.8	1.5	0.0	2.5	LEVEL	8	2	6	35	P
204	5.3	2.8	0.2	3.4	DSH	10	4	9	37	R
205	5.3	1.6	0.1	2.5	DSH	17	17	17	13	R
206	3.7	1.2	-0.2	-12.8	CFS	14	11	13	25	MW
207	6.6	2.5	0.1	1.4	DSH	7	7	7	13	MW
208	7.1	1.9	0.0	2.1	LEVEL	11	8	10	14	MW
MARTIN										
101	0.5	0.8	0.0	1.1	LEVEL	13	6	11	13	P
102	0.2	0.3	-0.0	-23.2	LEVEL	12	9	11	25	P
103	0.4	0.3	0.0	1.6	LEVEL	15	8	14	25	P
104	0.4	0.3	0.0	-1.7	LEVEL	22	13	20	31	P
105	0.5	0.4	-0.1	1.8	DFS	-	-	-	-	-
106	0.6	0.5	-0.1	1.3	DFS	22	22	22	18	W
107	0.9	1.0	-0.1	0.0	DFS	21	18	20	16	I
108	1.4	0.6	0.0	-0.7	LEVEL	23	21	23	13	VR
109	1.9	0.8	0.0	2.5	LEVEL	25	20	25	12	R
110	2.3	1.0	0.1	2.1	DSH	27	27	27	10	R
111	3.0	0.3	0.1	5.6	DSH	35	32	34	11	R
201	0.7	0.9	0.1	2.7	DSH	11	11	11	20	I
202	0.3	0.4	-0.1	-3.2	CFS	12	7	11	23	P
203	0.4	0.3	-0.0	10.5	LEVEL	18	20	18	30	I
204	0.4	0.3	0.0	-3.7	LEVEL	15	19	15	20	I
205	0.5	0.2	0.0	-3.7	LEVEL	-	-	-	-	-
206	0.5	0.4	-0.1	-3.2	CFS	17	15	16	31	I
207	0.6	0.5	-0.1	-3.0	CFS	11	8	11	21	P
208	1.1	0.5	-0.1	-8.1	CFS	16	12	15	30	I
209	2.2	1.1	0.1	3.8	DSH	26	21	25	9	R
210	2.7	0.7	0.0	-1.3	LEVEL	24	23	24	11	R
211	2.7	0.5	0.0	0.8	LEVEL	27	30	28	10	R

BM #	LANDFORM					AIR FILLED POROSITY			AVAILABLE WATER [%] 0-100 cm	DRAINAGE CLASS
	Elev m	Slope º/m	PCV º/m	CCV º/m	TOPO Class	0-15 cm %	15-30 cm %	0-20 cm %		
MURRELL										
101	2.6	0.3	0.0	-1.4	LEVEL	12	13	12	24	I
102	2.7	0.6	0.1	5.7	DSH	18	13	17	23	MW
103	2.5	0.9	0.0	4.2	LEVEL	12	10	12	16	MW
104	1.9	1.0	0.0	2.9	LEVEL	12	6	11	26	I
105	1.7	0.4	-0.1	5.1	DFS	9	8	9	21	1
106	1.7	0.3	0.0	6.5	LEVEL	15	11	15	14	I
107	1.2	1.1	0.0	-2.7	LEVEL	10	9	10	26	I
108	0.9	0.6	-0.1	-9.1	CFS	17	9	15	31	I
109	0.8	0.9	-0.1	-9.1	CFS	19	8	16	15	MW
201	2.8	0.8	-0.1	-L5	CFS	15	10	13	22	MW
202	2.9	0.7	-0.1	7.7	DFS	18	15	17	21	MW
203	2.7	0.8	-0.0	-2.0	LEVEL	15	15	15	19	MW
204	2.2	0.7	0.0	0.3	LEVEL	12	11	12	26	I
205	2.2	0.7	0.0	1.0	LEVEL	13	10	12	28	I
206	2.2	0.5	0.0	0.7	LEVEL	13	12	13	27	I
207	1.6	1.3	0.0	1.0	LEVEL	9	7	9	26	I
208	1.1	1.4	0.0	0.6	LEVEL	12	13	13	29	I
209	1.1	1.4	-0.1	-0.4	CFS	20	19	20	21	MW

BM #	LANDFORM					AIR FILLED POROSITY			AVAILABLE WATER [%] 0-100 cm	DRAINAGE CLASS
	Elev m	Slope °/m	PCV °/m	CCV °/m	TOPO Class	0-15 cm %	15-30 cm %	0-20 cm %		
POTTRUFF										
101	1.4	1.0	0.0	-3.8	LEVEL	12	9	11	23	W
102	1.6	0.5	-0.0	-0.7	LEVEL	12	5	10	22	W
103	1.7	0.3	-0.0	2.1	LEVEL	10	4	9	22	W
104	1.8	0.5	-0.0	-4.3	LEVEL	7	2	6	20	W
105	2.4	1.5	-0.0	1.3	LEVEL	8	7	8	20	W
106	2.7	1.9	-0.0	-0.6	LEVEL	12	8	11	24	W
107	3.2	2.6	-0.1	-0.7	CFS	4	10	3	19	W
108	4.2	3.5	-0.0	0.6	DBS	3	7	2	16	W
109	5.6	4.1	-0.1	-0.9	CFS	8	2	6	18	W
110	9.5	1.5	0.1	0.7	DSH	11	3	9	21	W
111	9.7	0.7	-0.1	-1.9	CFS	13	7	12	21	W
112	10.2	1.8	0.1	-1.6	CSH	14	16	14	12	W
113	9.1	3.5	-0.1	-0.2	CFS	8	4	7	21	W
114	7.4	4.5	0.1	-0.8	CSH	18	16	18	15	W
115	4.9	2.5	-0.0	-1.2	LEVEL	15	13	15	21	W
116	2.1	0.9	-0.0	-1.2	LEVEL	9	4	8	24	W
201	1.1	0.8	0.0	0.3	LEVEL	10	5	9	20	W
202	1.6	0.5	0.1	2.8	DSH	3	11	2	18	W
203	1.5	0.6	0.1	-3.4	CSH	17	11	16	18	W
204	1.6	0.4	0.0	0.2	LEVEL	8	5	8	22	W
205	1.9	1.0	-0.0	1.5	LEVEL	8	2	7	20	W
206	2.1	1.1	-0.1	-1.4	CFS	15	7	13	23	W
207	2.9	2.4	-0.0	0.0	LEVEL	21	17	20	16	W
208	3.6	2.7	-0.0	-0.2	LEVEL	12	8	12	17	W
209	4.7	4.1	0.1	-0.1	CSH	11	6	10	19	W
210	8.7	4.1	0.1	-0.1	CSH	9	3	9	23	W
211	9.2	1.0	-0.1	-4.0	CFS	6	1	5	19	W
212	10.2	3.0	0.1	0.5	DSH	6	1	5	19	W
213	10.4	4.3	0.0	-0.3	CBS	10	6	9	20	W
214	7.5	4.5	-0.1	-1.1	CFS	11	4	10	20	W
215	5.0	3.2	-0.1	-1.1	CFS	6	1	5	19	W
216	2.5	1.5	-0.1	0.2	DFS	13	6	12	23	W

BM #	LANDFORM					AIR FILLED POROSITY			AVAILABLE WATER [%] 0-100 cm	DRAINAGE CLASS
	Elev m	Slope º/m	PCV º/m	CCV º/m	TOPO Class	0-15 cm %	15-30 cm %	0-20 cm %		
RIDDELL										
101	0.6	0.8	-0.0	-2.7	LEVEL	4	2	3	28	P
102	0.3	0.2	-0.0	-8.8	LEVEL	4	2	3	28	P
103	0.7	0.6	0.1	8.4	DSH	4	2	4	21	P
104	0.4	1.1	-0.1	-0.5	CFS	4	2	3	20	P
105	0.2	0.1	0.0	-16.1	LEVEL	5	2	5	21	P
106	0.6	0.6	0.0	-2.1	LEVEL	5	2	4	28	P
107	0.8	1.1	0.0	1.2	LEVEL	12	8	11	24	I
108	0.6	0.6	0.0	0.2	LEVEL	5	2	5	27	P
109	2.1	0.9	0.0	-1.0	LEVEL	10	9	10	21	I
110	2.3	1.1	-0.1	2.0	DFS	9	6	9	9	I
111	2.1	0.0	-0.1	-31.2	CFS	6	2	5	29	P
112	2.5	1.9	-0.1	-0.6	CFS	12	8	11	18	I
113	3.2	0.6	0.0	-0.7	LEVEL	12	9	11	25	I
114	3.2	0.4	-0.1	6.2	DFS	4	2	4	28	P
115	3.2	0.9	-0.1	-1.7	CFS	5	2	4	27	P
201	0.6	0.6	0.0	-2.8	LEVEL	4	2	4	24	P
202	0.3	0.2	0.0	-3.8	LEVEL	5	2	4	29	P
203	0.6	0.6	0.0	6.8	LEVEL	4	2	3	25	P
204	0.5	0.7	0.0	0.7	LEVEL	3	2	3	24	P
205	0.2	0.5	0.1	-3.1	CSH	4	2	4	24	P
206	0.7	0.7	0.0	-0.3	LEVEL	4	2	3	26	P
207	0.7	1.2	0.1	-0.9	CSH	4	1	4	27	P
208	0.3	0.6	-0.1	-3.4	CFS	5	2	4	28	P
209	2.3	0.7	0.0	-1.5	LEVEL	17	12	16	16	MW
210	2.3	0.4	-0.0	-9.1	LEVEL	19	14	19	29	I
211	2.1	0.5	-0.1	-11.0	CFS	5	2	5	26	P
212	2.6	2.0	-0.1	-0.9	CFS	13	9	12	23	I
213	3.1	0.5	0.0	5.4	LEVEL	16	10	15	18	MW
214	2.9	0.3	0.0	-18.0	LEVEL	6	2	5	24	P
215	3.4	0.3	-0.0	8.8	LEVEL	8	2	7	31	P

BM #	LANDFORM					AIR FILLED POROSITY			AVAILABLE WATER [%] 0-100 cm	DRAINAGE CLASS
	Elev °/m	Slope °/m	PCV °/m	CCV °/m	TOPO Class	0-15 cm %	15-30 cm %	0-20 cm %		
SMITH-TELEDALE										
101	4.5	0.1	-0.0	-5.5	LEVEL	7	3	6	19	W
102	4.6	0.4	0.1	8.9	DSH	20	22	20	18	W
103	3.5	1.6	-0.0	-1.1	LEVEL	18	8	16	25	W
104	3.1	1.2	-0.0	-0.7	LEVEL	17	16	17	16	W
105	2.6	1.4	0.0	6.6	LEVEL	19	16	19	18	W
106	2.1	1.5	0.0	0.7	LEVEL	19	20	19	19	W
107	1.5	1.3	0.0	-0.5	LEVEL	14	11	13	27	W
108	1.1	1.0	0.0	-1.7	LEVEL	15	13	15	26	W
201	4.2	1.0	-0.1	-1.8	CFS	17	15	17	18	MW
202	4.1	1.0	-0.0	1.0	LEVEL	16	25	18	19	W
203	4.2	1.2	0.0	0.5	LEVEL	18	17	18	22	MW
204	3.2	1.1	-0.0	-0.1	LEVEL	22	22	22	17	W
205	2.8	1.3	0.1	-0.4	CSH	14	17	15	18	W
206	2.4	1.9	0.1	1.0	DSH	20	17	20	17	W
207	1.6	1.2	0.1	3.4	DSH	19	21	19	20	W
208	1.1	0.8	-0.0	4.9	LEVEL	11	7	10	22	W
302	4.0	0.6	-0.0	-0.9	LEVEL	20	15	19	18	W
303	3.7	1.1	-0.0	-0.6	LEVEL	27	26	27	19	W
304	3.5	0.8	-0.0	-0.5	LEVEL	9	2	7	29	W
305	3.3	0.9	0.0	0.9	LEVEL	24	22	24	17	W
306	2.6	1.7	0.1	0.3	DSH	22	20	23	14	W
307	1.7	1.4	-0.0	-0.7	LEVEL	22	27	22	20	W
308	1.1	0.7	-0.0	5.3	LEVEL	22	23	22	21	W
STRATHROY										
101	2.8	0.3	-0.0	-1.4	LEVEL	21	14	19	29	I
102	3.0	0.5	0.1	3.1	DSH	23	15	21	28	I
103	2.9	0.3	0.0	1.7	LEVEL	30	28	30	12	W
104	2.8	0.2	0.0	6.9	LEVEL	27	30	27	11	R
105	2.6	0.9	-0.0	-0.9	LEVEL	21	22	21	21	W
106	1.7	1.6	0.0	-1.4	LEVEL	24	23	23	22	MW
107	0.8	1.6	0.1	-1.4	CSH	31	25	30	18	MW
108	0.6	0.4	0.1	0.2	DSH	22	18	22	29	I
109	0.7	0.8	0.1	-0.6	CSH	27	27	27	3	R
201	2.7	0.3	-0.1	-5.0	CFS	23	21	23	29	I
202	2.8	0.5	0.0	2.6	LEVEL	21	27	23	17	W
203	2.9	0.1	-0.0	44.6	LEVEL	22	20	22	27	I
204	2.8	0.1	-0.0	1.4	LEVEL	25	24	25	17	MW
205	3.0	0.9	0.2	8.6	DSH	16	17	16	28	I
206	1.9	1.4	-0.0	0.2	LEVEL	20	17	19	29	I
207	1.0	1.3	0.0	0.6	LEVEL	19	20	19	25	I
208	0.7	0.0	-0.0	16.6	LEVEL	30	28	30	11	W
209	0.8	0.2	0.0	9.5	LEVEL	27	28	27	13	W

BM #	LANDFORM					AIR FILLED POROSITY			AVAILABLE WATER [%] 0-100 cm	DRAINAGE CLASS
	Elev m	Slope º/m	PCV º/m	CCV º/m	TOPO Class	0-15 cm %	15-30 cm %	0-20 cm %		
STEWART (Brighton)										
101	2.6	0.5	-0.1	-2.1	CFS	18	17	17	16	W
102	2.3	2.0	0.0	0.1	LEVEL	21	19	21	17	W
103	2.1	2.7	0.1	-1.2	CSH	17	16	17	16	W
104	1.0	2.2	-0.0	-3.0	LEVEL	20	20	20	20	w
105	0.6	0.8	-0.1	-4.6	CFS	17	18	17	19	W
106	1.6	2.3	-0.0	1.8	LEVEL	21	17	21	18	W
107	2.8	0.8	-0.0	0.6	LEVEL	16	17	16	15	W
108	2.7	1.0	-0.1	-1.0	CFS	20	20	20	17	W
201	2.6	0.2	0.0	-0.2	LEVEL	19	19	19	18	W
202	2.1	2.0	0.0	-1.4	LEVEL	20	20	20	17	W
203	1.9	3.2	0.2	-0.8	CSH	20	19	20	17	W
204	0.7	1.5	-0.2	-2.2	CFS	20	18	20	20	W
205	0.7	0.7	0.1	-6.9	CSH	11	17	12	18	W
206	1.5	2.1	-0.1	-0.5	CFS	26	16	24	22	MW
207	2.8	1.2	0.0	-0.0	LEVEL	21	20	21	19	W
208	3.1	0.4	0.0	2.7	LEVEL	19	19	19	18	W
TEMPLEMAN										
101	1.3	1.0	0.0	6.0	LEVEL	13	10	12	20	MW
102	1.0	0.7	0.0	-3.9	LEVEL	13	10	12	28	I
103	1.0	0.3	-0.0	11.6	LEVEL	13	18	14	18	W
104	0.8	0.3	-0.1	-1.1	CFS	4	2	4	33	P
105	1.1	0.4	-0.0	10.6	LEVEL	12	10	12	26	I
106	0.9	0.7	0.0	1.5	LEVEL	12	11	11	32	I
107	0.6	0.3	-0.0	-19.3	LEVEL	13	12	12	26	I
108	0.7	1.1	-0.1	-0.4	CFS	16	16	16	20	W
109	1.9	1.0	0.0	3.4	LEVEL	8	8	8	29	I
201	0.9	1.0	-0.0	0.1	LEVEL	10	10	10	26	I
202	0.8	0.8	-0.0	-1.2	LEVEL	10	12	9	27	I
203	0.8	0.4	0.0	5.5	LEVEL	10	8	10	24	1
204	0.8	0.7	-0.1	-1.1	CFS	5	2	4	27	P
205	0.9	0.3	0.0	5.3	LEVEL	11	9	11	30	I
206	0.7	0.9	-0.0	1.4	LEVEL	8	7	8	24	I
207	0.5	0.6	0.0	-2.3	LEVEL	4	2	3	25	P
208	0.9	1.2	0.0	0.5	LEVEL	13	9	12	26	I
209	1.6	0.9	-0.0	1.4	LEVEL	11	10	10	32	I

APPENDIX V.III

Soil Properties Data

	Ap	SOLUM				PARTICLE SIZE										CaCO3	OM	P	K	Mg
BM #	Thick cm	Depth cm	GRA %	VCS %	CS %	MS %	FS %	VFS %	SAND %	SILT %	CLAY %	TEXTURE Class	BD g/cm3	pH CaCl2	pH Water	%	%	ppm	ppm	ppm
ANTHONY																				
101	23	69	5	4	5	12	14	12	48	38	14	L	1.2	6.5	6.9	0.0	3.9	11	53	170
102	26	56	7	3	5	11	15	14	48	38	13	L	1.3	6.5	6.9	0.0	3.3	29	90	191
103	22	66	8	4	5	11	18	15	53	36	11	FSL	1.3	6.6	6.9	0.0	2.8	22	61	161
104	17	64	6	4	6	14	9	19	53	37	10	FSL	1.3	6.4	6.8	0.0	2.7	19	83	160
105	20	89	6	2	4	11	17	16	50	39	11	L	1.4	7.0	7.3	0.7	2.2	16	59	154
106	23	60	3	3	5	14	20	14	57	32	11	FSL	1.3	7.2	7.2	1.3	2.2	20	57	176
107	37	70	3	1	4	14	23	15	58	33	9	FSL	1.4	6.3	6.7	0.0	2.1	15	98	229
108	27	42	5	3	5	11	13	10	42	43	15	L	1.2	6.3	7.0	0.0	3.7	15	86	211
109	23	76	9	1	4	11	17	13	47	40	13	L	1.1	6.1	6.8	0.0	3.0	10	67	157
201	28	42	6	6	6	0	0	0	54	33	13	FSL	1.3	6.3	6.7	0.0	3.3	17	65	158
202	28	83	3	3	5	0	0	0	49	39	13	L	1.4	6.3	6.8	0.0	2.4	13	91	154
203	2.5	47	4	3	5	13	19	12	52	40	8	FSL	1.4	6.7	6.8	0.0	2.3	22	71	152
204	22	61	5	5	4	11	17	13	50	40	9	L	1.3	6.7	6.9	0.0	2.4	18	52	153
205	20	96	4	11	5	12	16	11	55	37	8	FSL	1.5	6.5	7.2	0.0	2.3	10	48	146
206	23	71	5	8	6	14	19	11	58	34	8	FSL	1.7	6.7	7.0	0.0	2.4	10	51	166
207	27	55	4	6	6	12	15	10	49	42	9	L	1.5	6.5	6.8	0.0	3.3	20	111	221
208	19	60	12	3	5	12	15	12	47	42	11	L	1.5	7.0	7.2	0.8	2.8	17	93	157
209	21	84	3	4	4	9	22	19	59	31	10	FSL	1.4	6.5	7.0	0.0	1.7	14	86	169
BEE																				
101	8	66	0	0	2	7	19	8	36	41	22	L	1.3	5.7	5.5	0.0	2.5	33	103	249
102	20	64	0	0	2	5	12	5	24	35	41	C	1.4	6.1	5.9	0.0	2.7	29	115	200
103	25	65	2	1	2	6	15	6	31	45	23	L	1.4	6.0	6.3	0.0	2.8	21	101	200
104	23	58	0	0	2	4	10	6	22	51	27	SIL	1.5	6.1	5.9	0.0	2.3	10	120	200
105	29	40	0	0	1	3	13	7	26	36	38	C	1.6	7.0	6.4	0.6	1.8	11	128	200
201	24	72	0	0	2	6	19	8	35	43	21	L	1.3	6.5	6.4	0.0	2.0	17	107	249
202	30	59	0	0	2	6	8	7	23	50	27	CL	1.4	6.7	6.6	0.0	2.4	21	112	200
203	23	52	1	1	2	5	14	5	27	47	26	L	1.4	6.3	6.6	0.0	2.4	22	124	200
204	18	49	0	1	1	3	11	6	22	44	34	CL	1.4	5.9	6.3	0.0	1.8	9	145	200
205	22	49	0	0	2	4	14	8	28	40	33	CL	1.6	5.8	5.7	0.0	1.7	15	140	200

BM #	Ap Thick cm	SOLUM Depth cm	PARTICLE SIZE										BD g/cm3	pH CaCl2	pH Water	CaCO3 %	OM %	P ppm	K ppm	Mg ppm
			GRA %	VCS %	CS %	MS %	FS %	VFS %	SAND %	SILT %	CLAY %	TEXTURE Class								
CHIPPS																				
101	26	69	0	0	1	37	39	8	85	10	5	LS	1.3	5.2	6.2	0.0	3.3	19	117	881
102	40	73	0	0	1	41	35	7	84	11	5	LS	1.2	5.7	6.4	0.0	3.6	17	141	109
103	38	93	0	0	1	41	40	6	88	8	4	S	1.3	5.3	5.6	0.0	2.3	37	192	79
104	22	81	0	0	1	42	40	6	89	7	5	S	1.3	6.4	6.0	0.0	2.8	45	502	871
105	32	47	0	0	1	39	40	7	87	8	5	LS	1.4	6.0	6.8	0.0	2.3	28	1173	96
106	24	99	0	0	1	38	35	8	83	12	5	LS	1.4	5.1	5.8	0.0	2.8	19	1217	109
107	26	86	0	0	1	30	39	9	79	15	6	LS	1.1	5.5	5.5	0.0	3.0	21	443	72
108	2.3	51	0	0	1	37	38	9	85	11	4	LS	1.4	5.5	5.4	0.0	2.1	20	103	55
109	27	84	0	0	1	37	29	10	77	17	6	SL	1.2	6.0	6.1	0.0	4.1	26	158	85
110	37	85	0	0	1	35	31	14	81	14	5	LS	1.2	5.8	6.0	0.0	3.7	17	114	85
201	24	88	0	0	1	30	41	8	80	15	5	LS	1.3	5.9	5.1	0.0	4.2	14	158	421
202	27	84	0	0	1	28	37	17	83	17	5	LS	1.3	5.4	6.0	0.0	3.4	18	103	68
203	44	138	0	0	0	36	44	8	89	7	4	S	1.4	6.9	5.7	0.0	1.8	18	72	60
204	22	92	0	0	1	43	40	6	91	5	5	S	1.4	7.0	5.7	1.5	2.0	17	166	90
205	23	66	0	0	1	29	41	16	86	9	5	LS	1.3	4.8	7.4	0.0	2.3	54	139	59
206	23	89	0	0	1	15	33	28	76	18	5	LFS	1.2	4.9	5.7	0.0	2.8	45	138	59
207	24	81	0	0	1	14	34	29	78	17	5	LFS	1.3	4.7	5.2	0.0	2.8	17	141	35
208	19	68	0	0	1	29	44	11	86	10	4	LS	1.2	5.6	6.1	0.0	3.7	32	200	114
209	26	104	0	0	1	26	43	12	82	13	5	LS	1.3	5.1	6.8	0.0	3.9	9	146	122
210	35		0	0	1	35	39	8	84	12	4	LS	1.3	5.3	6.6	0.0	3.4	14	144	125
301	28	87	0	0	1	36	38	8	84	12	5	LS	1.3	5.7	6.7	0.0	4.6	11	74	110
302	34	91	0	0	1	26	34	12	74	18	8	FSL	1.3	5.5	5.8	0.0	4.4	29	129	93
303	43	62	0	0	1	38	42	10	90	6	4	S	1.4	6.2	6.1	0.0	2.4	33	202	92
304	21	48	0	0	1	44	37	8	91	5	4	S	1.4	7.1	7.0	2.5	2.2	41	69	77
305	30	50	0	0	1	31	41	12	85	10	5	LS	1.3	6.0	7.2	0.0	2.8	51	108	54
306	27	98	0	0	1	28	44	12	85	10	5	LS	1.4	5.8	7.4	0.0	3.1	60	70	51
307	34	96	0	1	1	18	49	11	80	14	6	LFS	1.3	5.8	6.3	0.0	3.6	18	82	61
308	19	64	0	0	1	30	46	9	86	11	3	LS	1.3	5.8	6.4	0.0	2.9	18	136	113
309	35	58	0	0	0	8	30	32	71	19	11	VFSL	1.2	6.1	6.9	0.0	3.7	17	107	134
310	21	104	0	0	1	21	42	11	76	17	6	FSL	1.0	5.8	5.9	0.0	3.7	23	211	100

BM #	Ap Thick cm	Solum Depth cm	PARTICLE SIZE										BD g/cm3	pH CaCl2	pH Water	CaCO3 %	OM %	P ppm	K ppm	Mg ppm
			GRA %	VCS %	CS %	MS %	FS %	VFS %	SAND %	SILT %	CLAY %	TEXTURE Class								
DYKSTRA																				
101	28	49	1	1	1	2	5	7	16	47	38	SICL	1.2	6.4	7.3	0.0	4.9	46	154	-
102	24	65	1	1	2	2	4	8	16	46	37	SICL	1.4	7.0	7.5	1.7	4.4	44	154	-
103	23	66	2	1	2	2	5	8	18	50	32	SICL	1.4	7.0	7.7	2.0	4.4	49	159	-
104	24	0	24	6	4	4	6	9	29	46	25	L	1.1	7.2	7.8	12.1	4.8	62	222	-
105	16	0	9	4	4	4	7	8	28	51	21	SIL	1.3	7.2	7.9	29.5	3.5	52	173	-
106	22	0	13	7	5	5	9	9	35	44	21	L	1.2	7.2	7.8	30.9	3.4	50	183	-
107	22	44	12	3	3	4	7	10	28	47	26	L	1.1	7.1	7.8	12.5	4.2	44	182	-
108	2.3	72	0	1	1	2	4	10	19	55	26	SIL	-	7.0	7.7	2.4	4.9	56	170	-
201	21	34	5	2	2	2	4	8	19	48	34	SICL	1.3	7.1	7.5	3.9	4.8	56	176	-
202	30	54	7	1	1	2	5	9	18	50	33	SICL	1.2	6.9	7.5	0.0	4.7	54	169	-
203	31	0	13	3	2	3	5	8	21	46	33	CL	1.2	7.1	7.6	5.2	4.7	49	173	-
204	2.5	0	17	5	3	4	6	9	28	44	28	CL	1.3	7.2	7.8	12.1	4.8	51	291	-
205	2.5	0	27	6	5	5	8	8	32	42	26	L	1.3	7.3	7.8	20.7	4.7	55	267	-
206	23	0	15	5	4	5	9	7	30	45	25	L	1.1	7.4	7.8	20.9	4.5	62	282	-
207	23	0	17	5	5	5	7	9	31	43	26	L	1.0	7.2	7.8	18.0	4.8	65	260	-
208	36	53	6	1	2	3	5	9	19	53	27	SIL	1.4	7.1	7.9	5.0	5.0	55	249	-
GHENT																				
101	20	23	1	0	1	3	6	10	20	57	23	SIL	1.1	7.0	7.4	3.3	5.2	31	147	598
102	23	39	3	1	2	5	12	15	35	45	20	SIL	1.3	7.1	7.4	4.2	5.3	31	156	548
103	42	33	1	1	1	2	6	6	15	62	22	SIL.	1.3	7.1	7.5	3.1	5.9	25	147	559
104	23	47	1	1	1	3	6	10	22	56	23	L	-	7.1	7.4	2.8	4.5	32	146	538
105	30	21	0	1	1	3	7	7	19	59	22	SIL	-	7.2	7.4	1.4	4.2	21	132	464
106	26	52	0	1	1	3	9	8	21	55	25	SIL	-	7.1	7.4	0.8	4.8	20	147	551
107	17	39	0	2	2	5	7	8	24	58	18	SIL	-	7.3	7.4	2.7	4.0	17	132	554
108	21	53	0	1	2	4	8	10	24	58	18	SIL.	-	7.3	7.3	5.6	3.8	20	141	457
109	30	59	0	1	1	3	7	9	21	60	19	SIL.	-	7.3	7.4	2.5	4.6	19	156	497
110	21	21	0	1	1	3	6	7	18	62	20	SIL	-	7.3	7.6	1.8	5.1	16	136	423
201	23	27	2	1	1	5	8	11	26	51	23	SIL	1.4	7.1	7.5	3.9	4.1	26	146	539
202	25	44	1	1	2	4	8	11	25	52	23	SIL	1.3	7.1	7.4	3.9	4.2	27	156	617
203	33	42	1	2	1	3	7	10	23	54	23	SIL	1.3	7.2	7.4	4.5	4.4	29	150	577
204	27	38	0	1	2	4	6	11	24	56	21	SIL.	1.4	7.2	7.4	1.1	2.1	20	144	565
205	21	43	1	0	1	3	7	9	21	60	19	SIL.	1.1	7.6	7.4	3.8	3.5	18	116	501
206	19	62	0	0	1	3	6	11	22	54	24	SIL	1.6	7.5	7.4	0.7	5.4	24	130	601
207	22	38	1	1	2	5	7	11	26	56	18	SIL	1.4	7.4	7.4	2.0	4.9	20	122	548
208	22	0	1	1	2	5	8	9	2.5	57	18	SIL	1.4	7.3	7.5	1.3	4.2	20	100	498
209	22	30	1	1	2	4	7	10	25	56	19	SIL	1.3	7.4	7.5	1.7	4.3	24	110	454
210	21	28	1	1	2	4	7	10	23	61	16	SIL	1.5	7.5	7.5	2.7	4.4	22	87	466

\- denotes missing or not available data

BM #	Ap Thick cm	SOLUM	PARTICLE SIZE										BD g/cm3	pH CaCl2	pH Water	CaCO3 %	OM %	P ppm	K ppm	Mg ppm
		Depth cm	GRA %	VCS %	CS %	MS %	FS %	VFS %	SAND %	SILT %	CLAY %	TEXTURE Class								
JOHNSON																				
101	40	57	1	1	1	4	12	22	41	45	15	L	1.3	6.9	7.7	0.5	2.3	13	66	247
102	36	0	2	1	2	5	14	21	42	43	14	L	1.5	7.2	7.6	3.1	2.3	9	65	221
103	28	0	1	0	1	5	14	24	44	41	14	L	1.4	7.4	7.7	3.0	2.5	10	60	220
104	27	48	0	0	1	4	12	22	39	48	14	L	1.4	7.2	7.7	1.5	2.6	17	56	215
105	72	92	0	0	1	2	8	17	29	53	18	L	1.4	6.9	7.6	0.4	4.3	19	73	237
106	29	50	0	1	1	3	11	16	32	51	16	SIL	1.2	6.8	7.5	0.0	3.2	4	73	392
107	48	59	3	1	2	5	12	17	37	49	13	SIL	1.4	7.0	7.5	7.1	2.6	15	80	259
108	29	57	1	1	1	4	13	17	38	48	15	L	1.3	6.5	7.6	0.0	3.0	9	66	292
109	24	59	0	1	1	2	7	17	29	54	17	SIL	1.4	6.8	7.4	0.0	3.9	7	55	372
110	46	94	0	1	1	3	10	16	30	49	20	L	1.3	6.2	7.2	0.0	5.5	7	85	437
111	26	26	0	0	1	4	10	19	34	48	18	L	1.4	6.9	7.6	0.0	2.6	11	65	261
112	2.5	38	1	1	1	5	12	17	36	48	16	L	1.5	6.9	7.7	0.0	3.0	3	63	350
113	20	30	0	0	1	3	9	8	21	56	22	SIL	1.1	6.5	7.6	0.0	12.4	8	43	373
114	19	19	0	0	1	5	22	10	38	40	21	L	1.0	6.7	7.4	0.0	14.6	8	36	274
115	24	36	0	0	0	7	44	7	59	26	15	FSL	1.3	7.1	7.3	1.7	8.9	7	41	250
201	30	30	0	1	1	5	16	23	46	40	14	L	1.5	7.2	7.4	2.0	2.4	12	68	264
202	25	25	1	2	4	5	15	21	45	43	12	L	1.3	7.2	7.6	4.3	2.3	9	59	265
203	20	0	18	2	2	6	16	22	47	41	13	L	1.5	7.4	7.6	7.6	1.7	6	59	254
204	23	0	1	1	2	4	14	21	42	45	14	L	1.4	7.3	7.6	3.0	2.2	5	51	263
205	90	90	2	0	1	3	8	20	31	50	18	L	1.2	7.1	7.4	1.6	3.9	12	58	299
206	27	41	0	0	1	3	7	19	30	50	20	L	1.2	7.2	7.5	1.4	3.5	5	57	301
207	22	0	0	1	2	5	11	18	37	49	14	L	1.5	7.2	7.7	3.3	3.4	27	100	157
208	24	24	1	2	3	6	14	20	45	41	14	L	1.3	7.3	7.5	5.8	2.6	13	58	340
209	33	59	0	0	0	2	6	18	27	56	17	SIL	1.4	6.6	7.4	0.0	3.7	6	54	347
210	21	51	1	1	1	3	7	16	28	51	21	SIL	1.4	6.5	6.9	0.0	4.8	7	74	403
211	27	0	2	1	2	6	12	16	36	47	17	L	1.3	6.9	7.7	5.5	3.0	11	67	267
212	22	27	1	1	1	3	8	19	32	49	19	L	1.5	6.8	7.6	0.0	2.8	6	72	330
213	23	23	1	0	2	8	17	8	36	41	23	L	1.2	6.9	7.5	0.0	9.9	7	62	414
214	19	19	1	0	1	3	8	18	30	51	18	SIL	1.2	6.9	7.3	0.0	2.8	8	48	384
215	20	28	0	0	1	14	41	5	60	24	16	FSL	1.2	6.7	7.5	0.0	9.8	7	35	223

BM #	Ap Thick cm	SOLUM Depth cm	PARTICLE SIZE										BD g/cm3	pH CaCl2	pH Water	CaCO3 %	OM %	P ppm	K ppm	Mg ppm
			GRA %	VCS %	CS %	MS %	FS %	VFS %	SAND %	SILT %	CLAY %	TEXTURE Class								
LOBB, DON																				
101	17	0	0	0	1	13	33	11	59	30	12	FSL	1.0	7.1	-	4.6	6.7	-	-	-
102	19	0	1	1	1	12	38	16	67	24	9	FSL	1.2	7.2	-	3.6	5.9	-	-	-
103	19	19	0	1	1	16	37	8	62	25	13	FSL	1.3	7.3	-	0.2	5.2	-	-	-
104	30	67	0	0	1	21	34	12	67	23	10	FSL	1.3	7.1	-	1.7	2.6	-	-	-
105	34	76	0	0	1	4	9	4	18	59	23	SIL	1.3	7.1	-	1.0	2.0	-	-	-
106	35	0	0	1	2	8	20	8	39	34	27	CL	1.3	7.2	-	2.3	3.2	-	-	-
107	17	0	0	0	1	4	11	5	21	45	34	CL	1.2	7.4	-	6.7	2.6	-	-	-
108	18	41	0	0	1	4	9	3	17	46	37	SICL	1.1	7.3	-	1.7	4.2	-	-	-
201	25	30	2	1	1	9	25	11	48	39	13	L	1.2	7.2	-	5.9	8.9	-	-	-
202	23	31	1	0	1	13	45	13	72	21	8	FSL	1.3	7.1	-	2.0	4.8	-	-	-
203	26	0	1	1	1	14	35	9	59	27	14	FSL	1.3	7.2	-	4.8	4.9	-	-	-
204	25	0	0	0	0	24	52	6	82	11	6	LFS	1.5	7.2	-	8.5	1.5	-	-	-
205	23	0	0	0	1	10	30	15	56	30	14	FSL	1.5	7.2	-	5.5	2.7	-	-	-
206	24	38	1	1	1	14	27	6	49	31	20	L	1.3	6.8	-	0.0	4.0	-	-	-
207	16	0	0	0	1	4	9	4	18	45	38	SICL	1.5	7.4	-	3.3	2.6	-	-	-
208	19	27	1	0	1	3	7	3	13	50	37	SICL	1.3	7.2	-	1.2	3.4	-	-	-
MARTIN																				
101	28	42	1	0	3	9	8	10	32	47	21	L	1.3	7.2	7.4	3.4	3.5	11	163	436
102	22	65	1	0	4	14	15	11	44	37	19	L	1.3	7.0	7.3	1.2	4.7	20	154	433
103	18	50	3	3	8	19	17	12	59	31	9	SL	1.4	7.3	7.5	6.8	2.4	18	149	446
104	42	74	4	5	8	17	18	11	59	32	9	SL	1.2	7.2	7.3	4.3	3.6	15	156	441
105	0	0	4	6	8	16	16	11	57	35	8	SL	0.0	7.3	7.4	8.6	4.6	14	138	431
106	23	43	4	5	6	14	15	8	47	42	11	L	1.2	6.9	7.3	0.0	5.2	13	149	491
107	17	35	5	2	6	14	17	8	47	38	15	L	1.2	6.9	7.4	0.0	3.5	15	181	366
108	21	57	4	2	5	16	15	9	47	39	14	L	1.3	6.5	7.4	0.0	3.0	13	137	318
109	22	39	1	1	4	23	20	8	56	33	10	FSL	1.3	6.8	7.1	0.0	3.1	18	190	273
110	26	26	5	4	14	31	18	4	72	18	10	SL	1.3	6.9	7.2	0.0	2.7	30	222	234
111	27	54	1	2	16	40	22	3	82	11	7	LS	1.2	6.8	7.2	0.0	3.4	34	251	235
201	24	52	3	1	2	7	10	13	32	45	22	L	1.4	7.2	7.4	1.2	4.5	18	103	387
202	32	63	1	2	4	10	11	10	37	41	22	L	1.3	6.6	7.4	0.0	4.7	19	79	414
203	20	20	5	5	8	18	17	10	59	29	12	SL	1.3	6.6	7.4	0.0	3.4	22	84	340
204	18	52	7	4	8	0	34	10	58	34	8	FSL	1.5	6.6	7.5	0.0	3.2	21	72	354
205	22	22	2	5	9	18	16	10	59	33	8	SL	1.2	6.8	7.4	0.0	3.6	23	132	373
206	38	74	2	3	6	14	18	12	53	34	13	FSL	1.3	7.3	7.5	2.6	3.9	14	141	433
207	26	26	4	3	5	13	17	13	51	33	16	L	1.4	7.4	7.4	10.2	3.9	14	141	370
208	27	42	1	1	3	15	18	9	46	41	13	L	1.4	7.5	7.4	1.9	3.5	15	142	410
209	30	30	1	1	7	34	32	5	79	13	7	LS	1.5	7.2	7.3	4.2	2.1	19	150	418
210	24	70	2	2	12	33	27	4	78	14	8	LS	1.5	7.1	7.3	3.7	2.2	33	244	345
211	27	74	1	1	8	37	33	5	83	10	7	LS	1.4	6.9	7.0	1.2	3.0	29	172	355

BM #	Ap Thick cm	SOLUM	PARTICLE SIZE										BD g/cm3	pH CaCI2	pH Water	CaCO3 %	OM %	P ppm	K ppm	Mg ppm
		Depth cm	GRA %	VCS %	CS %	MS %	FS %	VFS %	SAND %	SILT %	CLAY %	TEXTURE Class								
MURRELL																				
101	37	85	2	1	4	6	11	11	33	56	11	SIL	1.2	6.8	7.8	0.0	3.9	14	103	200
102	29	54	0	0	1	3	8	16	29	56	14	SIL	1.3	6.9	7.3	0.3	4.1	10	106	200
103	22	37	0	0	1	3	5	9	18	62	20	SIL	1.3	7.2	7.6	0.5	3.9	10	118	200
104	25	75	1	0	1	3	4	8	16	62	23	SIL	1.3	6.8	7.7	0.3	5.1	12	137	200
105	26	34	1	1	1	3	6	10	21	58	20	SIL	1.5	7.2	6.8	1.6	3.2	15	106	200
106	26	37	11	1	3	6	10	10	30	49	20	L	1.2	6.9	7.7	0.0	3.2	21	96	200
107	28	103	0	1	2	3	5	8	20	60	21	SIL	1.4	6.7	7.1	0.0	4.4	12	111	200
108	38	87	0	1	1	2	6	11	21	61	18	SIL	1.3	6.5	6.5	0.0	4.4	19	114	199
109	26	45	1	1	2	4	8	15	30	55	15	SIL.	1.4	7.0	7.2	0.1	2.5	11	106	198
201	29	63	2	1	1	4	8	11	26	55	18	SIL	1.4	7.0	7.6	0.5	3.5	23	96	182
202	27	72	3	1	2	5	9	13	29	54	17	SIL	1.2	6.9	8.0	0.0	3.0	10	93	198
203	25	50	1	1	2	4	12	16	35	48	16	L	1.4	6.3	7.6	0.0	3.4	9	82	200
204	27	85	1	0	1	3	8	12	25	54	21	SIL	1.3	6.2	7.4	0.0	4.8	12	117	200
205	28	56	1	1	1	2	5	12	20	61	19	SIL	1.3	6.9	6.9	0.2	3.6	12	91	200
206	29	90	1	1	2	4	9	12	28	53	19	SIL	1.3	6.1	7.7	0.0	4.4	15	102	200
207	29	90	2	1	2	5	9	8	25	55	21	SIL	1.5	6.9	7.8	0.2	3.4	11	66	200
208	33	80	1	0	1	3	8	19	32	55	14	SIL	1.3	6.3	6.8	0.0	3.2	11	100	200
209	26	90	1	0	1	2	10	28	41	50	9	L	1.3	5.5	5.9	0.0	2.2	13	116	126

BM #	Ap Thick cm	SOLUM Depth cm	PARTICLE SIZE										BD g/cm3	pH CaCl2	pH Water	CaCO3 %	OM %	P ppm	K ppm	Mg ppm
			GRA %	VCS %	CS %	MS %	FS %	VFS %	SAND %	SILT %	CLAY %	TEXTURE Class								
POTTRUFF																				
101	30	125	0	1	2	7	10	13	33	57	10	SIL	1.5	5.2	5.8	0.0	1.7	24	81	109
102	30	111	1	0	2	8	12	11	33	57	10	SIL	1.4	5.1	5.4	0.0	1.9	30	55	79
103	23	122	0	0	1	7	12	12	32	58	10	SIL	1.4	4.8	5.2	0.0	1.8	22	72	64
104	21	115	0	1	2	7	12	16	39	53	8	SIL	1.4	5.0	4.9	0.0	1.9	18	47	88
105	16	62	1	0	2	10	16	15	43	48	9	L	1.7	5.9	5.2	0.0	1.5	16	54	116
106	38	110	0	0	2	8	15	15	41	50	8	SIL	1.5	5.3	5.4	0.0	1.7	25	66	77
107	23	76	1	0	1	11	19	16	48	44	8	L	1.4	6.3	6.5	0.0	1.7	28	71	141
108	21	79	1	0	2	11	17	14	45	47	8	L	1.5	5.0	5.5	0.0	1.5	23	61	87
109	35	43	2	1	3	11	19	13	48	41	11	L	1.6	7.2	6.4	0.5	1.5	17	69	216
110	19	51	2	1	2	9	19	17	49	40	11	L	1.2	7.3	7.5	1.2	1.0	10	69	171
111	29	89	0	1	1	7	11	11	30	58	12	SIL	1.4	6.0	6.7	0.0	2.0	20	72	140
112	20	0	3	2	4	16	24	14	60	28	12	FSL	1.6	7.4	6.8	10.0	1.0	9	70	101
113	19	79	1	2	2	8	13	14	38	52	9	SIL	1.5	4.5	4.9	0.0	1.7	25	64	82
114	20	63	1	1	3	12	22	13	51	41	8	L	1.5	5.7	5.6	0.0	1.3	26	65	140
115	44	100	1	1	3	11	17	15	46	46	7	SIL	1.5	4.5	5.4	0.0	1.2	22	77	78
116	28	41	0	1	3	8	11	14	37	54	9	SIL	1.4	4.6	5.4	0.0	1.9	27	85	83
201	21	85	2	1	3	9	12	13	36	53	10	SIL	1.5	5.2	5.1	0.0	2.0	29	58	50
202	22	80	0	0	2	9	13	13	37	54	9	SIL	1.4	4.6	5.1	0.0	1.9	26	82	60
203	25	80	1	1	2	7	11	13	33	56	11	SIL	1.4	4.5	4.9	0.0	2.0	28	71	56
204	27	84	2	0	1	5	9	11	28	61	11	SIL	1.5	4.4	5.0	0.0	2.0	30	87	63
205	24	80	25	0	2	8	14	14	38	53	9	SIL	1.4	4.9	5.2	0.0	1.8	21	78	67
206	32	94	7	1	2	9	14	12	39	52	9	SM	1.4	4.5	5.1	0.0	1.8	34	88	75
207	28	82	5	1	3	13	21	14	51	41	8	FSL	1.4	5.2	6.1	0.0	1.4	20	60	112
208	21	64	1	1	3	10	17	14	45	46	8	L	1.5	5.2	5.9	0.0	2.0	15	73	112
209	14	52	8	1	3	10	16	14	45	45	10	L	1.4	5.5	6.4	0.0	1.7	14	68	166
210	24	80	9	1	4	8	18	13	44	46	10	L	1.3	6.6	6.9	0.0	2.2	12	61	178
211	32	94	20	1	2	12	18	12	43	48	8	L	1.5	4.2	5.1	0.0	1.6	30	88	65
212	16	76	0	1	3	10	18	12	44	46	10	L	1.4	6.3	7.2	0.0	1.9	17	75	156
213	25	96	12	1	3	10	15	14	43	48	9	L	1.5	4.7	5.7	0.0	1.7	14	60	122
214	20	78	8	1	3	14	22	11	51	42	7	L	1.3	4.8	5.5	0.0	1.7	20	70	87
215	31	87	0	1	3	12	18	13	48	43	8	L	1.5	4.3	5.2	0.0	1.4	19	72	79
216	28	84	2	1	2	6	11	13	33	57	10	SIL	1.2	4.9	5.7	0.0	1.8	19	92	102

BM #	Ap Thick cm	SOLUM Depth cm	PARTICLE SIZE										BD g/cm3	pH CaCl2	pH Water	CaCO3 %	OM %	P ppm	K ppm	Mg ppm
			GRA %	VCS %	CS %	MS %	FS %	VFS %	SAND %	SILT %	CLAY %	TEXTURE Class								
RIDDELL																				
101	24	54	0	0	0	0	0	0	9	69	22	SIL	1.2	6.5	6.9	1.2	6.1	60	115	332
102	60	79	0	0	0	0	0	0	8	67	25	SIL	1.3	6.8	6.8	1.4	6.8	69	184	379
103	22	50	0	0	0	0	0	0	8	73	19	SIL	1.2	6.7	7.2	0.7	5.9	42	126	317
104	25	58	0	0	0	0	0	0	7	68	25	SIL	1.3	6.8	7.0	1.1	6.8	51	139	339
105	28	44	0	0	0	0	0	0	8	61	31	SICL	1.1	6.9	7.4	1.1	8.1	60	144	423
106	25	64	0	0	0	0	0	0	6	68	26	SIL	1.2	6.2	6.5	0.6	5.9	42	153	345
107	25	25	0	1	1	2	3	7	14	68	18	SIL	1.3	7.2	7.5	2.2	3.7	44	139	221
108	40	0	5	1	1	1	4	5	12	55	33	SICL	1.2	7.3	7.7	5.9	4.3	59	207	296
109	23	0	2	0	1	2	2	6	11	68	20	SIL	1.3	7.3	7.6	3.0	3.9	46	169	195
110	20	0	2	2	2	2	4	5	15	54	31	SICL	1.4	7.3	7.7	7.6	3.5	43	184	214
111	37	72	1	0	0	0	1	1	10	55	34	SICL	1.2	7.1	7.4	1.1	5.0	63	274	337
112	32	32	0	0	1	2	3	6	12	64	25	SIL	1.3	7.2	7.5	1.3	3.8	29	152	303
113	21	28	0	1	2	2	4	7	16	63	21	SIL	1.3	7.2	7.6	2.0	4.0	22	110	242
114	33	72	0	1	1	2	3	5	13	59	29	SICL	1.3	7.0	7.4	0.7	5.0	42	174	334
115	36	84	0	0	0	0	0	0	8	63	28	SICL	1.2	7.3	7.7	1.1	4.6	34	125	363
201	18	60	0	0	0	0	0	0	7	69	24	SIL	1.1	6.3	6.6	0.5	5.6	36	128	324
202	33	50	0	0	0	0	0	0	8	62	30	SICL	1.2	6.9	7.3	0.6	7.0	51	152	312
203	23	58	0	0	0	0	0	0	8	68	24	SIL	1.3	6.7	6.8	0.6	5.5	39	147	362
204	41	67	0	0	0	0	0	0	8	68	24	SIL	1.4	6.2	5.9	0.5	6.3	56	159	287
205	30	57	0	0	0	0	0	0	6	66	28	SICL	1.3	6.9	7.5	0.7	4.4	32	178	301
206	25	33	0	0	0	0	0	0	7	70	23	SIL	1.3	6.8	7.7	0.8	4.3	26	125	168
207	26	69	0	1	1	1	2	7	13	66	22	SIL	1.4	6.6	7.8	0.8	3.7	52	148	288
208	44	44	1	0	0	0	0	0	6	61	33	SICL	1.2	7.1	7.8	2.0	7.0	71	189	263
209	36	0	2	1	2	2	5	7	17	59	25	SIL	1.2	7.2	7.7	3.5	5.3	85	209	293
210	20	0	3	2	2	2	4	6	15	57	27	SICL	0.9	7.3	6.8	6.8	3.7	52	188	155
211	31	86	0	0	0	0	0	0	8	64	27	SIL	1.3	6.5	7.4	0.6	5.3	50	169	369
212	27	78	0	0	0	0	1	3	10	71	19	SIL	1.2	6.3	7.0	1.0	3.5	28	80	486
213	31	50	0	2	1	1	2	6	13	69	19	SIL	1.3	7.1	7.5	1.0	3.4	72	182	618
214	40	80	1	1	1	3	4	6	15	55	30	SICL	1.3	7.0	7.3	0.7	4.5	30	172	314
215	33	93	0	0	0	0	1	3	10	65	24	SIL	1.4	7.0	7.6	0.9	4.4	24	113	172

BM #	Ap Thick cm	SOLUM Depth cm	PARTICLE SIZE										BD g/cm3	pH CaCl2	pH Water	CaCO3 %	OM %	P ppm	K ppm	Mg ppm
			GRA %	VCS %	CS %	MS %	FS %	VFS %	SAND %	SILT %	CLAY %	TEXTURE Class								
SMITH-TELEDALE																				
101	18	37	1	0	3	11	19	12	47	38	16	L	1.4	7.3	-	1.5	3.4	-	-	-
102	25	69	1	1	4	12	20	13	51	38	11	L	1.4	7.4	-	1.5	3.0	-	-	-
103	18	53	1	1	3	11	20	12	47	39	14	L	1.0	7.2	-	1.7	4.0	-	-	-
104	21	63	1	2	3	9	15	10	39	43	18	L	1.3	7.3	-	1.4	3.3	-	-	-
105	23	70	3	1	3	8	15	11	39	42	19	L	1.3	7.3	-	1.1	3.3	-	-	-
106	24	55	2	2	3	10	16	11	43	42	14	L	1.3	7.4	-	1.8	3.1	-	-	-
107	20	55	2	1	3	8	14	13	39	47	14	L	1.2	7.3	-	0.8	3.7	-	-	-
108	21	64	1	1	3	10	17	13	45	42	13	L	1.3	7.3	-	2.0	3.5	-	-	-
201	22	57	1	1	3	11	18	13	47	38	15	L	1.4	7.3	-	1.3	3.0	-	-	-
202	32	77	3	1	4	11	18	14	46	41	13	-	1.3	7.4	-	1.5	2.7	-	-	-
203	20	31	2	2	4	14	21	13	54	32	14	FSL	1.4	7.4	-	2.9	3.0	-	-	-
204	16	62	1	0	3	10	19	18	49	39	12	L	1.3	7.1	-	0.8	3.8	-	-	-
205	18	84	6	1	3	11	20	14	49	36	15	L	1.5	7.4	-	1.4	2.7	-	-	-
206	24	39	2	2	4	11	19	15	50	36	14	L	1.3	7.3	-	1.3	3.0	-	-	-
207	23	80	1	2	4	11	18	14	49	38	12	L	1.4	7.2	-	1.1	3.2	-	-	-
208	22	47	3	1	5	11	16	14	47	40	13	L	1.3	7.1	-	1.0	5.3	-	-	-
302	19	70	5	2	5	14	19	13	53	35	12	FSL	1.4	7.4	-	4.2	2.6	-	-	-
303	20	0	1	2	4	11	17	15	49	40	11	L	1.1	7.2	-	1.2	3.5	-	-	-
304	17	52	2	2	4	12	20	15	52	38	11	L	1.2	7.4	-	1.3	2.6	-	-	-
305	21	43	1	2	4	12	20	15	53	36	11	FSL	1.3	7.3	-	0.5	3.5	-	-	-
306	19	25	2	1	3	12	22	16	54	34	11	FSL	1.3	7.4	-	1.4	2.6	-	-	-
307	23	84	1	1	4	10	18	16	49	41	10	L	1.3	7.2	-	0.8	3.0	-	-	-
308	25	52	1	0	3	8	14	13	39	47	14	L	1.1	7.1	-	0.4	5.4	-	-	-
STRATHROY																				
101	31	96	1	0	1	6	25	27	60	32	8	-	1.4	5.2	5.2	0.0	2.6	26	198	48
102	30	97	1	1	3	21	38	14	76	17	7	-	1.4	7.2	7.5	1.1	2.0	25	298	50
103	27	56	1	0	2	22	43	13	81	17	3	LFS	1.4	7.1	7.4	0.5	2.0	24	139	73
104	22	36	1	1	4	28	41	8	82	11	7	LS	1.4	7.1	7.4	0.8	2.6	28	227	59
105	28	89	0	1	2	18	32	15	67	25	8	FSL	1.5	6.7	7.0	0.0	1.7	24	111	85
106	29	77	0	0	1	8	30	18	56	38	6	FSL	1.3	6.1	5.9	0.0	2.1	24	169	68
107	27	76	0	0	2	16	4^6	16	80	15	5	-	1.4	5.9	5.8	0.0	1.9	29	209	62
108	21	64	2	0	2	20	45	13	80	13	7	LFS	1.4	6.6	6.8	0.0	2.5	34	147	76
109	23	0	2	0	2	18	46	14	80	15	5	LFS	1.5	7.1	7.5	3.4	2.2	54	196	53
201	28	92	0	0	1	8	27	30	66	29	5	VFSL	1.3	5.3	5.1	0.0	2.6	18	189	57
202	15	76	0	0	1	12	33	22	69	25	6	FSL	1.5	5.7	5.5	0.0	2.3	18	183	49
203	23	60	0	0	2	19	42	15	79	15	6	LFS	1.4	7.2	7.2	1.4	2.0	21	157	42
204	19	47	1	0	2	20	47	12	81	13	5	LFS	1.4	5.4	6.1	0.0	2.2	24	162	53
205	19	70	1	0	2	19	30	22	72	23	6	FSL	1.6	7.0	6.1	0.4	1.7	20	138	47
206	27	67	0	0	1	11	38	22	71	24	5	FSL	1.5	4.9	4.7	0.0	1.7	26	186	34
207	23	41	2	0	2	18	45	15	81	15	5	LFS	1.5	6.6	6.2	0.0	1.8	23	141	39
208	19	31	1	0	2	17	50	14	83	12	5	LFS	1.4	5.6	5.8	0.0	2.2	27	176	53
209	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.9	-	-	32	152	38

BM #	Ap Thick cm	SOLUM Depth cm	PARTICLE SIZE										BD g/cm3	pH CaCl2	pH Water	CaCO3 %	OM %	P ppm	K ppm	Mg ppm
			GRA %	VCS %	CS %	MS %	FS %	VFS %	SAND %	SILT %	CLAY %	TEXTURE Class								
STEWART (Brighton)																				
101	27	41	1	2	3	8	15	20	49	40	11	L	1.4	6.9	-	0.0	3.1	-	-	-
102	24	51	5	1	3	8	16	22	50	38	11	L	1.3	6.8	-	1.1	2.8	-	-	-
103	23	63	8	2	4	8	16	20	50	39	10	L	1.5	6.6	-	0.0	2.9	-	-	-
104	42	67	3	2	3	8	15	23	50	39	10	L	1.4	6.3	-	0.0	2.7	-	-	-
105	26	41	0	1	2	5	12	19	39	47	14	L	1.4	6.5	-	0.0	3.1	-	-	-
106	44	77	2	2	2	11	14	20	50	41	9	L	1.4	6.8	-	0.0	2.4	-	-	-
107	44	44	1	2	3	7	14	21	48	43	10	L	1.5	6.9	-	0.0	3.0	-	-	-
108	31	60	3	1	3	7	14	20	46	42	12	L	1.3	6.5	-	0.0	3.5	-	-	-
201	30	47	1	0	2	7	17	23	50	40	10	L	1.4	7.1	-	1.2	3.1	-	-	-
202	29	0	1	0	2	7	17	24	51	38	11	L	1.4	7.2	-	1.2	2.7	-	-	-
203	26	74	7	1	2	7	16	2.5	50	40	10	L	1.4	7.0	-	0.6	3.1	-	-	-
204	37	73	1	1	2	8	16	24	52	39	9	L	1.4	6.6	-	0.0	2.9	-	-	-
205	31	112	2	1	2	5	12	20	40	45	15	L	1.5	6.8	-	0.0	3.5	-	-	-
206	32	75	1	2	3	8	17	22	51	38	11	L	1.3	7.1	-	0.8	2.6	-	-	-
207	31	44	1	1	2	7	15	23	48	41	11	L	1.3	7.1	-	0.9	3.0	-	-	-
208	27	46	2	1	1	7	15	23	46	43	11	L	1.4	7.0	-	0.4	3.5	-	-	-
TEMPLEMAN																				
101	16	0	2	2	2	3	5	8	20	56	24	SIL	1.3	7.3	-	14.0	4.3	-	-	-
102	26	68	0	0	0	0	0	0	9	64	26	SIL	1.1	6.7	-	0.0	5.4	-	-	-
103	17	0	4	4	4	5	9	10	32	47	20	L	1.4	7.3	-	10.5	3.1	-	-	-
104	65	65	1	1	1	2	3	6	14	61	26	SIL	1.3	6.7	-	0.5	4.3	-	-	-
105	22	65	0	1	2	3	5	7	17	62	21	SIL	1.2	7.1	-	4.6	4.2	-	-	-
106	2.5	2.5	1	2	3	4	5	8	22	58	20	SIL	1.3	7.2	-	2.8	3.1	-	-	-
107	46	68	1	2	3	4	6	6	19	63	18	SIL	1.2	6.6	-	0.0	5.8	-	-	-
108	14	0	9	5	4	5	8	10	32	48	20	L	1.3	7.4	-	19.6	2.9	-	-	-
109	20	61	0	0	0	0	0	0	8	71	21	SIL	1.4	6.2	-	0.0	3.9	-	-	-
201	22	34	3	2	2	3	6	9	22	53	24	SIL	1.3	7.0		8.9	4.1	-	-	-
202	2.5	59	7	1	1	2	3	6	12	59	28	SICL	1.3	6.5	-	0.0	6.2	-	-	-
203	32	0	5	2	2	3	8	9	26	49	26	CL	1.4	7.3	-	11.7	2.4	-	-	-
204	17	17	11	3	3	5	8	10	29	49	22	L	1.3	7.3	-	21.1	2.7	-	-	-
205	18	18	5	2	3	4	6	9	24	55	20	SIL	1.3	6.8	-	0.0	3.1	-	-	-
206	21	0	3	1	1	2	3	7	13	70	17	SIL	1.4	7.0	-	1.0	3.1	-	-	-
207	26	72	1	1	1	1	2	5	11	63	26	SIL	1.3	6.3	-	0.0	5.3	-	-	-
208	23	69	4	1	1	2	5	7	16	63	20	SIL	1.2	7.0	-	1.1	4.6	-	-	-
209	24	57	27	1	2	3	6	8	20	59	21	SIL	1.3	6.9	-	0.0	3.3	-	-	-