SUMMARY TECHNICAL REPORT

REGIONAL AGRICULTURAL PRACTICES AND THEIR POTENTIAL FOR LAND AND WATER CONTAMINATION

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1. RATIONALE AND OBJECTIVES

Agriculture and the agri-food sector are central to Ontario's economic development. At the same time, the agri-food sector exerts a direct and diffuse influence on environmental quality. Based on 1989 AVHRR remotely sensed land cover data the total area of agricultural land in Ontario is about 6.1 million hectares of which approximately 82%, or 5.0 million hectares is located in the Great Lakes basin. The Great Lakes Action Plan (GLAP) was established to manage the land and land use practices in the Great Lakes Basin in order to achieve sustainable development, a healthy environment and a strong economy.

Under GLAP, field research was conducted at sites representative of important soil, ecological and land use and management conditions in the province. These studies determined some of the conditions of soil and crop management for which contamination from pesticides, nitrates and bacteria (farm toxic chemicals) were most likely to occur. It is not, however, a straight-forward task to extrapolate site research results and apply them across a region. Both biophysical and land management conditions vary widely from farm to farm and even within individual farms. Also, it is only relatively recently that computer hardware, software and a consistent digital databases have been developed to permit any form of extrapolation.

The objectives of this research were threefold. The first objective was to characterize agricultural land use and management practices and land resource conditions in the Canadian portion of the Great Lakes Basin. The second objective is to incorporate data from a wide range of sources into one consistent spatial framework for analysis, classification and reporting of more detailed results. The third objective was to explore procedures to extrapolate field research to surrounding areas where conditions are similar.

2. METHODOLOGY

The methods are divided into three parts, they are:

1. The assembly of all relevant and available data which characterize the biophysical conditions as well as land use and management practices in the agricultural portion of the Great Lakes Basin and organize them within a Geographic Information System (GIS).
2. Demonstrate the application of broad pesticide loss potential ratings at both Soil Landscape scale (1:1,000,000) and detailed soils map scale (1:50,000) to indicate areas of the basin potentially at risk to contamination.
3. Explore the problems associated with regional extrapolation of field research results to areas around the study sites to show where conditions may be similar, and where research findings may be applicable.

2.1 GIS Assembly

The system was developed using ARC/INFO GIS software operating on a DEC 3100 Vaxstation and a DEC 3000 Alpha Station with an Open VMS operating environment. The database was assembled with primarily pre-existing data inventories and some detailed drainage mapping digitized from hard copy. The database consists of:

i) The Soil Landscapes of Canada (SLC) at 1:1,000,000 scale. The SLC is a small scale land resource database containing several soil and landscape related attributes such as texture, slope, surface form and drainage class. The SLC database was used for basin- wide biophysical characterizations and regional extrapolation of site specific research results. The SLC database is part of the National Soils Data Base (NSDB) of Agriculture and Agri-Food Canada.

ii) Detailed artificial drainage maps were digitized from Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) 1:25,000 scale Artificial Drainage maps. The areas converted to digital coverage were Oxford, Elgin, Middlesex and Essex Counties. The entire agricultural portion of the basin is available in hardcopy format. The digital drainage mapping depicts areas of random and systematic artificial drainage. This mapping was used for regional extrapolation of site specific research conditions.

iii) Watershed data representing stream flow volume and sediment loadings, received from the Monitoring and Systems Branch of Environment Canada, in digital format. This data provided gross runoff and sediment loss estimates for the basin.

vii) The 1991 Census of Agriculture based on Consolidated Census Sub-divisions (CCSD) and re-compiled based on SLC boundaries and ecologically based Land Resource Areas. These census compilations were used to characterize land management and land use.

viii) Advanced Very High Resolution Radiometer imagery(AVHRR), 1989 composite, classified according to land cover class and vectorized from 1 kilometre pixels. This layer offers generalized land cover which can be used to delineate the location of agricultural areas, as well it can be further analyzed to give a measure of the diversity of land cover.

ix) Detailed soil pedon data from the Ontario Soil Names(SNF) and Soil Layer(SLF) files. The Ontario detailed soil database is part of the National Soils Data Base (NSDB) of Agriculture and Agri-Food Canada. Detailed soil records are maintained and linked to the SLC database and used as representative soils found within the SLC map units. The detailed data in conjunction with the SLC data was used to develop soil related potentials for adsorbed and solution losses of pesticides.

The data base was used to develop biophysical, land use and management characterizations of the Great lakes Basin. As well the data base provides the information required to estimate pesticide loss potentials and to develop regional extrapolations of field site results.

2.2 Pesticide Loss Potentials

Pesticide loss potentials were calculated based on the chemical and physical characteristics of the pesticide and soil to estimate losses in solution or adsorbed form. These procedures were developed from the Soil/Pesticide Interaction Screening Procedure, or SPISP(Goss 1988; Goss 1991; Goss and Wauchope, 1990). Rating classes were developed by running a variety of soil conditions and pesticide characteristics under a GLEAMS computer model (Goss 1988; Goss 1991). Stover and Hamill (1993) described how these procedures could be adopted to Ontario conditions. These procedures were further developed and used as a basis for broad level, SLC based, comparisons of pesticide loss potentials. For more detailed assessments, it is recommended that the evaluation be repeated, using site specific soils, land use and management data.

Pesticide properties are based on solubility, half life and soil adsorption coefficient. These values have been calculated and published for all pesticides used in the Canadian Great Lakes Basin (Goss 1991). Using the regression equations developed by Goss (1991) runoff potential is categorized as large, small or medium for both adsorbed and solution phase loss. The loss potential for atrazine was determined. Atrazine was chosen since it is the most widely used pesticide in the Great Lakes Basin and was one of the pesticides used in all the field research activities presented in this report which collected pesticide data.

The soil loss potential in solution phase was calculated based on the soil hydrologic groupings (Goss, 1991). The hydrologic groupings were derived from the Drainage Guide For Ontario (Irwin 1986). The guide contains soil series based hydrologic groupings for all soils found on published soils maps in Ontario. Small scale, SLC based ratings were developed using the dominant soil code in the Soil Landscape database linked to the Drainage Guide classification. For the detailed soil maps the dominant soil in the map unit name was used as a link to the drainage guide.

The soil loss potential in adsorbed phase was based on a combination of the hydrologic group from the drainage guide for Ontario and the erodibility (K) factor. K factor calculations are based on surface and subsurface particle size distributions and organic matter concentrations derived from the detailed soil layer and names files (Ontario Land Resource Unit 1994). The K factor was calculated for the first dominant soil for each SLC soil polygon. For the detailed soil maps the K factor was derived from the County soil report. The combinations of K factor and hydrologic group were run through the soil adsorbed runoff loss potential algorithm to determine if the potential was high, low or intermediate.

Final ratings were developed by integrating the soil and pesticide specific loss potentials using a screening matrix for adsorbed and solution loss. The final rating is a three class system with class 1 having the highest loss potential (Goss 1991).

2.3 Regional Extrapolation of Field Research Results

The basic principle to extrapolate field research results was to establish the conditions at field research sites and to identify the degree to which surrounding areas were similar. Once similar areas are identified research results can be extrapolated to these areas, maximizing the return from field research. The level of confidence associated with the extrapolation is indirectly related to the degree of similarity. In the future a similar approach can be used prior to locating field sites, in order to choose sites which are representative of large areas of land.

Regional assessments were applied to three sites; Kintore, Belmont and Harrow. The site conditions addressed by the research included site biophysical, land use and management conditions. These conditions, along with the pollutant studied, pathways of movement and the major research findings were summarized for each study area. The summary resulted in the development of a series of site scale criteria defining field scale conditions.

Site scale criteria were converted to landscape scale criteria which could be applied against the GLAP database at a scale of about 1:1,000,000. This technique allowed the field conditions to be regionally extrapolated to determine the potential of other areas of Ontario having conditions similar to field conditions.

The potential area of extrapolation was first determined by applying the biophysical or permanent criteria to the data base. The artificial drainage mapping was included with the biophysical conditions because of its semi-permanent nature. Climate was implied by focusing the extrapolation to areas within the same Ecoregion. The potential area of extrapolation was then used to focus the land use and management criteria.

Farm and Field Scale Management Options can be regionally extrapolated to determine the likelihood of finding land use and management conditions similar to field conditions. Farm scale conditions include crop selection, input kind and application levels. Field scale options include timing of application, tillage and input application practices. Land Use and management data are derived from Census of Agriculture data spatially linked to the SLC.

3. FINDINGS

3.1 Basin Wide Biophysical, Land Use and Management Conditions.

Various data themes contained in the data base were analyzed to produce simple characterizations of biophysical, land use and management conditions in the Great Lakes Basin. These characterizations are presented in figure 3.1.1 to 3.1.6.

Land cover is presented for the Canadian portion of the Great Lakes basin is presented in figure 3.1.1. This map indicates that virtually all agricultural land use occurs in the South-Central and South-Western Ontario in the Lake Erie, Lake Huron and Lake Ontario Watersheds, known as the Mixed Wood Plain Ecozone. In this zone agriculture is by far the dominant land cover with limited areas of urbanization, mixed and deciduous forests.

Biophysical characterizations are presented in figures 3.1.2 to 3.1.4. These maps are based on the Soil Landscapes (SLC) mapping. The attributes mapped include surface texture, slope and surface shape. Together these landscape attributes have significant influence on the risk of non-point contamination from agricultural inputs. Generally three types of landscapes are easily observed. These include clay dominated soils which are found on level landscapes; sand dominated loams located on low to moderately sloped hummocky, ridged and rolling landscapes and loam to silt loam textured soils also on moderately sloped hummocky, ridged and rolling landscapes.

Characterizations of land management were developed from census data compiled on the basis of slc SLC map units are presented in figures 3.1.5 to 3.1.6. The level of agricultural inorganic input application is proportional to cropping intensity (figure 3.1.5). Input application rates have direct implications to the risk of surface and subsurface contamination from nitrates and pesticides. Generally crop intensity increases from east to west, with the most intensive cropping located in Kent and Essex Counties. The production and use of organic nitrogen is proportional to intensity of livestock production (figure 3.1.6). The production of manure has direct implications to the risk of surface and sub-surface contamination from nitrates and bacteria. Intensive livestock production is concentrated in central Southwestern Ontario in Oxford, Perth, Wellington and Huron Counties.

3.2 Pesticide Loss Potentials

The adsorbed and solution runoff potentials for atrazine have been estimated for the entire Mixed Wood Plain Ecozone of Southern Ontario based on SLC level data. In addition the ratings were also run with detailed, 1:50,000 scale data for the Belmont research site using data from the Middlesex County soil survey. The loss potentials are based on the soils erodibility, drainage class and the ability for specific pesticides to become bound to soil particles or to be dissolved. The estimates are presented Figure 3.2.1 to 3.2.4. The province wide SLC based ratings are very generalized estimates based on the predominant soil conditions, and as such do not present the level of detail required for farm of field scale management decision making. This scale does however provide the level of detail required for regional planning and policy making.

Goss and Wauchope (1990) have developed guidelines for interpreting the loss potentials. Generally class 1 indicates a high Loss Potential which suggests the use of an alternate pesticide of lower loss potential or a site specific evaluation to more definitely establish the pesticide's potential for loss at the site of application should be made. Class 2 indicates an intermediate Loss Potential. This suggests that an alternate compound of lower loss potential should be used or

if the pesticide is foliar applied, incorporated or banded under the soil's surface, the pesticide specific loss potential is reduced by 1 rank and the overall potential should be recalculated. Otherwise, a site specific evaluation to more definitely establish the pesticide's potential for loss at the site of application. Class 3 indicates a low loss potential and the use of the pesticide in accordance with the label can be considered as having a low potential for loss.

The development of loss potentials at small and large scale gives and indication of soil variability. The adsorbed and solution loss rating at the SLC scale is high for the area around the Belmont field site. However, running the same algorithm at a more detailed level produces a map which has a variety of ratings, although the area still has a predominantly high rating. Greater levels of detail, down to the field level would introduce even greater levels of variability. This illustrates the variability inherent in soils and suggests that these ratings are most appropriate for general levels of assessment only.

Care must be taken to ensure that interpretations are appropriate to the scale of representation. For instance, the detailed level ratings are an indicator that some caution should be exercised when applying Atrazine to most fields in the Belmont area, however, detailed knowledge of the site specific soil conditions and management practices are required for actual field scale assessment. This scale of decision making is usually made by the farmer who has the highest level of familiarity with field conditions and management requirements on his farm.

3.3 Regional Extrapolations of Field Site Conditions

The conditions for each of the three field scale sites was determined and then converted to corresponding Landscape scale criteria. These conditions and criteria are presented in section 3.3.1 to 3.3.3, for each of the study sites.

The Landscape scale criteria were applied against the SLC, Census and drainage databases in order to extrapolate field conditions to the surrounding region. For Belmont, criteria were developed for application at the more detailed scale based on County level soil mapping, agricultural drainage mapping and a detailed digital elevation model of the site.

The regional extrapolations are presented on maps 3.3.1 to 3.3.3 for the three field sites. The maps display areas which have similar biophysical conditions to the field sites. The polygons which have the highest level of similarity are circled in dark blue. For the highlighted areas characterizations of probability based land use and management data have to be developed. These characterizations consist of land use and management activities in terms of proportions of land area or total acreages. Together these biophysical and management characteristics can be used to develop the probability of finding field conditions elsewhere in the surrounding area. This system of analysis can be reversed to indicate proactively, areas which contain important agricultural landscapes for future field activities.

3.3.1 Kintore Site

The site conditions and corresponding landscape scale criteria for the Kintore site are presented in Tables 3.3.1 to 3.3.3. The objective of the Kintore research was to determine conditions of soil, crop and management for which vertical transport of nutrients and bacteria from manure may lead to contamination of tile drained water.

The major finding was that liquid manure applied at a rate of 90,000 l/Ha (8000 gal/Ha) led to some contamination of tile drainage water. The level of contamination was greater where (i) application was not accompanied by disruption of macro pore structure, and (ii) where the application was immediately followed by heavy rain.

Table 3.3.1 Kintore Site - Biophysical Site Conditions and landscape Scale Criteria

Variable	**Site Scale Conditions**	**Landscape Scale Criteria**	**Findings**
SOIL TEXTURE	SILT LOAM TEXTURE	SOIL TEXTURE WITH HIGH CLAY CONTENT	FIGURE 3.3.1
ARTIFICIAL DRAINAGE	TILE DRAINED	ARTIFICIAL DRAINAGE MAPPING	FIGURE 3.3.1

Table 3.3.2 Kintore Site - Farm Scale Management Options

Variables	**Site Scale Conditions**	**Landscape Scale Criteria**	**Findings**
CROP	CORN	AREA OF CORN CROP	38 PERCENT CROPLAND IN CORN (16,000 Ha)
INPUT KIND	LIQUID MANURE	LIQUID MANURE PRODUCTION (Assume all swine manure managed in liquid form, and 13,000 l of manure/pig/year)	69,000 PIGS 151 MILLION LITRES OF MANURE.
INPUT LEVEL	90,000 l/Ha	TOTAL AREA RECEIVING LIQUID MANURE	1,700 Ha RECEIVING LIQUID MANURE

Table 3.3.3 Kintore Site - Field Scale Management Options

Variables	**Site Scale Conditions**	**Landscape Scale Criteria**	**Findings**
TILLAGE	DISRUPTION OF MACROPORE STRUCTURE	AREA OF CONSERVATION TILL	17 PERCENT CROPLAND UNDER CONSERVATION TILLAGE, ONE PERCENT IN NO TILL.
TIMING	APPLICATION SHORTLY BEFORE HEAVY RAIN	SEASONAL WEATHER PATTERNS	NO DATA

The Kintore site is presented in Figure 3.3.1. In order to identify potential areas for extrapolation the biophysical conditions and corresponding landscape criteria outlined in table 3.3.1 were used to identify areas with natural conditions similar to the study site. Table 3.3.1 indicates that these conditions consist of high surface and subsurface clay contents, and a large proportion of the area tile drained. One area with these conditions was identified and it is shown bounded by blue on figure 3.3.1. Further extrapolation of land use and management characterizations were performed for this polygon only.

Land use and management characterizations of the resultant area gives an indication of the proportion of the entire polygon which can be expected to reflect site conditions. Farm and field scale management conditions are identified in tables 3.3.2 and 3.3.3. Applying these criteria indicated that the proportion of the area in corn is 38.3%, or 15,771 Ha.

The Kintore field research found that disturbing the macro pore structure during manure injection decreases the loss of nutrients and bacteria to tile drains. Since only one percent of cropped land was in no-till in 1991, adoption of incorporation measures by farmers using liquid manure could be a viable strategy to reduce nutrient and bacteria loss in the Kintore region. The extrapolation gives some indicator of the potential area at risk, and the type of management decisions required to mitigate or prevent potential environmental degradation.

By analyzing the management data further it is possible to focus in on the risk posed by current (1991) practices. As calculated, the proportion of the area potentially at risk is relatively high at 38%, however, the probability of finding corn receiving liquid manure is much less than this. The area receiving liquid manure was estimated based on swine production. Using this estimate it was possible to calculate the probability of any site having all the risk factors identified by the field research. While this method is crude it does give some indicator of the land area at risk. The potential area receiving liquid manure was estimated to be 1,680 Ha. There is a total of 15,880 Ha of corn in the area and the total area is 41,200 Ha, therefore the probability of any particular site having all the land use and management risk factors identified by the field research is 4% and the risk of any corn field meeting these conditions is only 10%. Consequently, by targeting technology transfer and education programs to a relatively small number of farms, it may be possible to reduce the risk of nutrient and bacteria runoff. However, a greater level of detail would be required to identify these specific farms.

3.1.2 Woodslee Site

The Woodslee site conditions and Landscape scale criteria are presented in Tables 3.3.4 to 3.3.6. The objective of this field research was to determine the conditions of soil, crop and management on level agricultural landscapes characterized by high clay content for which surface, subsurface and tile transport of herbicides and nitrogen may lead to contamination of surface water.

The major finding was that on cracking soils, the large cracks and pores contributed significantly to herbicide transport to the tile drains. The use of conservation tillage and intercropping practices reduced herbicide losses by up to 57 percent as compared to conventional tillage practices, and was most effective at limiting surface loss. Subsurface drainage during the winter months was the dominant nitrogen transport pathway.

The Woodslee site is presented in Figure 3.3.2. In contrast to the Kintore and Belmont sites the Woodslee site has relatively homogeneous soil conditions. This low level of variability is reflected in the size of the SLC polygon. The data base was used to identify areas which have similar conditions as the research site based on landscape scale criteria, as outlined in table 3.3.4. These criteria included areas with silty clay surface texture on a level landscape with a high proportion of systematic drainage. One polygon was selected based on these criteria, it is bounded by blue on the map. The areas selected encompasses over

80 percent of the land area in Essex County. Land use and management characterizations were focused on this polygon.

Table 3.3.4 Woodslee Site - Biophysical Site Conditions and Landscape Scale Criteria

Variables	**Site Scale Conditions**	**Landscape Scale Criteria**	**Findings**
SOIL TEXTURE	SILTY CLAY SURFACE TEXTURE	SURFACE AND SUBSURFACE SOIL TEXTURE WITH HIGH CLAY CONTENT	FIGURE 3.3.2
SLOPE	LESS THAN 1% SLOPE	AREAS OF LOW SLOPE	FIGURE 3.3.2
SURFACE SHAPE	LEVEL	LEVEL	FIGURE 3.3.2
ARTIFICIAL DRAINAGE	TILE DRAINED	TILE DRAINED	FIGURE 3.3.2

Table 3.3.5 Woodslee Site - Farm Scale Management Options

Variables	**Site Scale Conditions**	**Landscape Scale Criteria**	**Findings**
CROP	CORN	AREA OF CORN CROP	18 PERCENT LAND AREA IN CORN (24,000 Ha)
INPUTS	APPLICATION OF ATRAZINE SENCOR/LEXONE DUAL	AREA OF HERBICIDE APPLICATION	17 PERCENT CROPLAND RECEIVING HERBICIDE

Table 3.3.6 Woodslee Site - Field Scale Management Options

Variables	**Site Scale Conditions**	**Landscape Scale Criteria**	**Findings**
TILLAGE	CONVENTIONAL TILLAGE	AREA OF CONVENTIONAL AND CONSERVATION TILLAGE	19 PERCENT OF CROPLAND UNDER CONSERVATION TILLAGE, 81 PERCENT CONVENTIONAL TILL
NON-TILLAGE CONSERVATION PRACTICES	NO INTERCROP USED	AREA OF INTERCROP	NO DATA
TIMING	APPLICATION SHORTLY BEFORE HEAVY RAIN	SEASONAL WEATHER PATTERNS	NO DATA

Land use and management characterizations of the resultant area gives an indication of the proportion of the entire polygon which can be expected to reflect site conditions. Using the farm and field scale criteria (Table 3.3.5 and 3.3.6), the proportion of the polygon area in corn was calculated to be 17.8%.With a total land area of 134,200 Ha, 17.8 percent translates to 23,887 Ha. This value represents the proportion of land which meets the biophysical and farm scale management conditions of the field site and is the area at risk of having pesticide and manure loses similar to the research findings.

The Woodslee field research found that conservation tillage practices reduced the off site movement of pesticide by 57 percent over conventional tillage. According to the 1991 census 19 percent of the cropland was already under conservation tillage practices. Also, only 74 percent of the cropland had pesticide applied. Based on these numbers only 10.6 percent of the area was actually at risk of having conditions and loss rates comparable to the field site worse case scenario. This percentage translates to 14,318 Ha.

This extrapolation gives some indicator of the area at risk and the field research suggests that adoption of conservation tillage practices could greatly reduce the loss of pesticides by up to 57 percent on almost 11 percent of the land area.

3.3.3 Belmont Site

The site conditions and corresponding landscape scale criteria for the Belmont site are presented in Tables 3.3.7 to 3.3.9. The objective of the Belmont research was to determine conditions of soil, crop and management for which surface runoff of herbicides may lead to contamination of surface water.

The major finding was that surface runoff of atrazine and metolachlor in solution and adsorbed by soil, on rolling agricultural landscapes appears to be the dominant pathway of herbicide transport to tributaries. The level of contamination was greatest immediately followed by heavy rain. These events produced loses of up to 10% of the applied chemical. Water transported off site exceeded water quality guidelines for up to one month after application.

The Belmont site extrapolation is presented in Figure 3.3.3. Landscape scale biophysical criteria identified in table 3.3.7 were used to locate areas in the surrounding region which could be used for extrapolation. The criteria identified areas of high clay content in the surface soils, high slope, rolling landscape and the absence of artificial drainage. There was one polygon which had all of these conditions and was used for extrapolation. This polygon is bounded by blue on the map (Figure 3.3.3). Land use and management characterizations were produced for this polygon.

Land use and management characterizations of the area gives an indication of the proportion of the entire polygon which can be expected to reflect site conditions. The proportion of the polygon area in corn was calculated to be 25%. In terms of spatial extent, 25 percent corresponds to 10,675 Ha. This value represents the proportion of land which meets the biophysical and farm scale management conditions of the field site and is the area at risk of having pesticide loss rates similar to the research findings.

According to the 1991 census only 67 percent of the cropland received herbicide. Based on this only 16.7 percent of the area was actually at risk of having losses comparable to the field site worse case scenario. This percentage translates to 7,150 Ha. The site research found that surface loses of dissolved pesticide could be greatly reduced by banding the application between rows.

Figure 3.3.4 displays the detailed adsorbed atrazine loss potentials for the Belmont area (Section 3.2) draped on top of a three dimensional digital elevation model (DEM). The elevation model was created with a vertical exaggeration factor of 60. The model clearly depicts the Belmont area as having a rolling landscape with areas of considerable slope, confirming the findings using SLC scale data. The DEM demonstrates the close relationship of soils and landscape.

Table 3.3.7 Belmont Site - Biophysical Conditions and Landscape Scale Criteria

Variables	**Site Scale Conditions**	**Landscape Scale Criteria**	**Finding**
SOIL TEXTURE	SILT LOAM OVER CLAY LOAM TEXTURE (MODERATE TO LOW PERMEABILITY)	SURFACE SOIL TEXTURE WITH HIGH CLAY CONTENT	FIGURE 3.3.3
SLOPE	HIGH SLOPE	AREAS OF HIGH SLOPE (>9%)	FIGURE 3.3.3
SURFACE SHAPE	ROLLING	AREAS OF ROLLING OR RIDGED LANDSCAPE	FIGURE 3.3.3
ARTIFICIAL DRAINAGE	NON TILE DRAINED	NON TILE DRAINED	FIGURE 3.3.3

Table 3.3.8 Belmont Site - Farm Scale Management Options

Variables	**Site Scale Conditions**	**Landscape Scale Criteria**	**Findings**
CROP	CORN	AREA OF CORN CROP	25 PERCENT OF LAND AREA IN CORN
INPUTS	APPLICATION OF ATRAZINE AND METOLACHLOR	AREA OF HERBICIDE APPLICATION	67 PERCENT OF THE CROPLAND RECEIVES HERBICIDE

Table 3.3.9 Belmont Site - Field Scale Management Options

Variables	**Site Scale Conditions**	**Landscape Scale Criteria**	**Data Base Attributes**
TILLAGE	CONVENTIONAL TILLAGE	AREA OF CONVENTIONAL TILLAGE	14 PERCENT OF CROPLAND UNDER CONSERVATION TILL, 86 PERCENT CONVENTIONAL TILLAGE.
TIMING	APPLICATION SHORTLY BEFORE HEAVY RAIN	SEASONAL WEATHER PATTERNS	NO DATA

All soil polygons within the study area that had the required data to run the model have a high or medium potential for adsorbed atrazine loss. The ratings indicated by the model are substantiated by field observations which indicate that surface loss is the most important pathway of pesticide transport. The main reason for these high ratings is high slope gradients and the relatively poor drainage characteristics of the soils which together act to increase the susceptibility to erosion, permitting the movement adsorbed pesticides off site. The general relationship to slope can be observed in figure 3.3.4. Generally, areas of greater slope have a high loss rating. In contrast, soils on the more gently rolling landscapes demonstrate predominantly medium loss potentials. Analysis at this level indicates that from a management perspective, practices which reduce erosion and adsorbed pesticide runoff should be used in conjunction with pesticide application. This observation is supported by research which showed that conservation tillage and pesticide banding was an effective method of reducing pesticide loss, reducing loses by as much as 50 percent.

4. STUDY CONCLUSIONS

The biophysical, land use and management characterizations of the agricultural portion of the Great Lakes Basin give an indication of the range of conditions found in the basin. Overall they indicate an area of intensive agricultural production on a variety of soil conditions. Two dominant agricultural landscapes can be identified, each having specific land resource and management implications towards environmental quality. One of these landscapes includes the intensive cash crop region of Essex and parts of Kent Counties. The management practices and soil conditions specific to this area have implications to off site movement of pesticides and nitrates to sub-surface tile drains and ground water. The Woodslee field site is representative of this landscape

The second distinctive agricultural landscape is the intensive livestock based system found in portions of Oxford, Perth, Huron and Wellington Counties. The biophysical land use and management conditions specific to these areas result in a high susceptibility to surface and subsurface pesticide, bacteria and nitrate loss. The dominant pathway of transport is highly dependent on the slope at the site of application. The Kintore and Belmont field sites are representative of these types of landscapes.

The remainder of the agricultural portion of the Mixed Wood plain has a more diverse mix of agricultural practices. Generally these areas are less intensive in terms of cropping and livestock production. Consequently, the susceptibility to pesticide, bacteria and nitrate contamination is decreased in proportion to the reduction in input levels.

The potential for surface losses of pesticide were calculated based on a generalized soil-pesticide model. The model was used to estimate loss potentials for atrazine at the SLC scale for the Mixed Wood Plain Ecozone. Almost all the intensively farmed areas identified in section 3.1 were rated as having a high or medium loss potential in adsorbed and solute form, although adsorbed losses were generally lower. A high or medium potential indicates the need to make a site specific evaluation to definitely establish the pesticides potential for loss at the site of application, highlighting the need for more detailed assessments. A more detailed assessment was produced for the Belmont area based on the detailed soil map. At the SLC level the entire area is rated high, but the detailed assessment demonstrates the high level of soil variability within the SLC polygon.

Research has demonstrated that detailed soils and slope data can be used to produce even better estimates of loss potential. This would permit research and cropping recommendations to be directed at areas which can benefit the most. While it is not possible from these analyses to make precise predictions of the area represented by the field studies it was shown that these conditions occur over extensive areas and are representative of conditions over significant portions of the Great Lakes Basin. The GIS provided a powerful tool to manage, integrate and analyze data at various scales. Using the existing database it was possible to develop broad scale characterizations of the biophysical, land use and management conditions in the basin and to apply models to predict the potential for contaminant loss. The data layers and the GIS processing capability facilitate analysis which addresses the likely consequences of policy decisions which provide specific recommendations for combinations of land management practices (e.g. liquid manure can only be applied if there is some soil treatment to disrupt macropores). The use of detailed soils maps and digital elevation data may provide better resolution to identify potential sources of agricultural non-point contamination.

5. NEW TECHNOLOGIES AND BENEFITS

This research represents an application of geographic information system technology. Techniques have been developed to integrate socio-economic and census data with biophysical land resource data. The study's digital database represents the best collection of agriculturally oriented, SLC scale land resource, land use and management data available. Techniques have been tested to identify the degrees of similarity between detailed field site conditions and the surrounding region. The research demonstrates the capability to make broad scale generalizations regarding the implications of agriculture to environmental quality and it also highlights the importance of detailed field and farm scale assessments to pinpoint areas where changes in practices can have the greatest impact. Also, the extrapolation techniques can be applied proactively to locate field site locations which are most representative of the surrounding agricultural landscape, maximizing the benefit from research investment.

6. IMPLICATIONS FOR GREAT LAKES ECOSYSTEM

This research provides an indication of the relative magnitude and location of potentially detrimental agricultural practices. It also demonstrates the relative importance of individual field research studies in determining overall implications to the health of the Great Lakes Ecosystem. Research places the implications of specific field and farm scale agricultural practices within the context of the entire basin, thus permitting time trend assessments of changes in risk to ecosystem health by tracking changes in management practices.

7. TECHNOLOGY TRANSFER POTENTIAL

The research indicates areas which are spatially similar to the field research conditions and where research findings of mitigation techniques may be applicable. Extrapolation of field results makes a strong case for directing technology transfer programs to the areas which need them the most. For instance, these extrapolation techniques can be used to identify where recommendations for safe use of pesticides based on field scale research are applicable and can be used most effectively.

8. GAPS/NEEDS FOR FUTURE RESEARCH

The most immediate need is for the completion of the database, particularly at detailed scale. T hese include artificial drainage mapping which was only prepared for Essex, Elgin, Middlesex and Oxford. Census data compiled on the basis of SLC mapunits for previous years would give some indication of time trend. The detailed soils maps require correlation between counties to permit spatially extensive extrapolation at the detailed level. The detailed pedon data linked to the SLC and detailed soil maps is incomplete and often based on estimates.

Aside from data base needs, there is a need to refine the techniques developed for making interpretations over a range of scales and establishing the level of credibility to be associated with the various scales. The area of extrapolation should be expanded to include more areas of the basin, at more scales. In future efforts these spatial assessments should be based on natural units, rather than the county boundaries used for this research.

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