# Detecting Landuse Change in the Swan Lake Basin

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Thisreport provides RuralMunicipalityofSwanRiverandtheSwanLake Basin Technical AdvisoryGroup withvaluable tools andknowledgethatwillassist theminmakinginformed decisions regarding sustainableagricultural and ruraldevelopment,protectingthewater and soil resource.

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# Abstract

The Swan Lake Basin extends from the Porcupine Hills, south to Duck Mountain and from Swan Lake, west into Saskatchewan draining an area of about 1.01 million hectares, 565,658 ha of which is in Manitoba. The Swan Lake Basin Technical Advisory Group (SLBTAG) has been assembled to develop a comprehensive resource management plan for the Basin and help identify future needs for the Basin in the areas of agricultural and other natural resource uses. Understanding changing land use trends in the Basin is needed for the development of the management plan.

Using specialized geographical information system (GIS) software, classified satellite imagery for the Manitoba portion of the Basin from 1994 and 1999 was compared to identify changes in land use cover. Notable increases (>10%) were detected in forages, grasslands, treed rock, and bare rock/sand/gravel, and forest cutblocks categories and a notable decrease was found in annual cropland.

The largest increases in land use occurred in grasslands (2,519 ha) and forages (12,343 ha), and the largest decreases occurred in annual cropland (15,942 ha). Of the lost annual cropland, 97% is now under grass or forages. The shift in production can be attributed to the loss of the grain transportation subsidy, low grain prices with increasing input costs, strong cattle prices and an increase in forages into crop rotations. The increase in forest cutblocks was also sizeable with an overall increase of 5,657 ha from 1994 to 1999. The majority of the increase can be attributed to increasing logging activity in the basin.

Changes in land use will change the potential impacts of land use activities on the Basin's water quality. Changing agricultural production may result in less siltation and soil erosion from agricultural lands now under grass and forage cover but also may result in a potential increase of impacts from expanding livestock herds and operations in riparian areas. Increasing logging activity may increase soil erosion and siltation of water courses and water bodies in the Basin. While the extent of the potential water quality impacts can not be determined in this project, GIS proved useful in identifying land use trends that are necessary for use in decision making by both the SLBTAG and local governments.

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## 1.0 Introduction and Background

The Swan Lake Basin extends from the Porcupine Hills, south into Duck Mountain and west into Saskatchewan (Map1). The basin drains approximately 1.01 million ha (2.5 million acres) of land, 565,658 ha (1.4 million ac) of which is located in Manitoba including parts of the Rural Municipalities of Mountain North, Mountain South, Minitonas and Swan River (Map 2). Changes in how agricultural and other industries use natural resources have the potential to impact land and water resources within the Basin. The Swan Lake Basin Technical Advisory Group (SLBTAG), a multi-disciplinary team, has been established to help collect and analyse data to make recommendations to the stakeholders (RM's, rural residents, and special interest groups) to help protect and improve water quality, address water quantity, and promote sustainable land management practices within the Swan Lake Basin.

The RM of Swan River and the SLBTAG recognize the need to understand changes in land use over time to identify current trends of resource management, including agricultural and forestry practices, within the Swan Lake Basin. This information will help to focus the stakeholders on the areas of greatest need for future sustainable agricultural projects, including bank stabilization, riparian management, and soil conservation. Identifying the current trends in land use practices is one of the beginning step needed to develop an effective and comprehensive sustainable land and water strategy for the Swan Lake Basin.

To accomplish this task skills in remote sensing and geographical information systems (GIS) are required. Using GIS in combination with remote sensing can detect and show changes in land cover over time, as well as identify and map out areas where the changes have taken place.

## 2.0 Project Description and Objectives

The main objective of this project is to develop a methodology to identify the changes in land use practices over the period of time from 1994-1999 within the Manitoba side of the Swan Lake Basin including the RM of Swan River. This project will also serve to help educate and introduce how GIS and resource information can be utilized as a decision making and planning to SLBTAG and basin stakeholders . The deliverables at the conclusion of the project will include:

i) a methodology that supports resource based decision making by local governments and the Swan Lake Basin Technical Advisory Group on focusing efforts in sustainable resource management, including agriculture.

ii) a demonstrated capacity among participating local governments and the Swan Lake Technical Advisory Board to utilize advanced decision making tools on their decision making

iii) reports for the RM of Swan River and the Swan Lake Basin Technical Advisory Board that includes hard copy (tabular and map form) results of analysis.

## 3.0 Methodology

### 3.1 Land Use Data

1994 and 1999 Landsat satellite images for the Manitoba portion of the Swan Lake Basin, with a 30 m resolution, were obtained from RadarSat International. These images were classified by the Manitoba Remote Sensing Centre into 16 land cover classes: annual cropland; forages; grasslands; open deciduous; deciduous forest; mixed wood forest; coniferous forest; burns; forest cut-overs; bogs; marsh/fens; open water; treed rock; bare rock/sand/gravel; cultural features and roads/trails. While1986 land use data was available, it was not used due to a variety of technical and resource constraints.

### 3.2 Detecting Changes in Land Use

Using specialized GIS software, a comparison between the 1994 and 1999 satellite images was performed to identify specific areas of land use change within the Basin. A total of 256 different land use change types could be identified using this method. Each specific area of land use change was classified into one of these 256 types. These land use change types were then grouped to form the following categories: No Change, Change to Annual Cropland, Change to Forage, Change to Grasslands, Change to Mixed, Deciduous, and Coniferous Trees, Change to Forest Cutblocks, Change to Water, Change to Marsh/Fens and Bogs, Change to Cultural Features and Roads, Change to Bare Rock/Sand/Gravel for summary purposes. These ten new categories were used in the final analysis of land use change.

## 4.0 Analysis and Discussion

Agricultural lands occupy most of the land base within the valley of the Swan Lake basin, while forested land is mostly concentrated in the uplands of the Duck Mountain and the Porcupine Hills as seen on Maps 3 and 4. Total area of each land cover category for 1994 and 1999 land cover imagery is summarized in Table 1. Annual crop land dominates the landscape with 30.73 % of the total area in 1994 and 27.91% in 1999, this is followed by Mixedwood (16.60 % and 16.19 %) and Deciduous forests (15.75% and 15.41%) in 1994 and 1999 respectively.

Assuming a 10% change in land cover as a notably significant level of change, there have been increases in forage crops, grasslands, forest cutblocks, bare rock/sand/gravel, and treed rock, while simultaneously, there has been a significant decrease in annual croplands from 1994 to 1999 (Table1). A change of 10% being a notably significant change was arbitrarily selected for the purposes of this preliminary report and is not a statistically supported level of change.

**Table 1: A summary of land cover change for the Swan Lake basin (MB side), 1994 and 1999.**

| Land Cover Class | 1994 Total Area | | 1999 Total Area | | 1994-1999 Overall Trend | |
|---|---|---|---|---|---|---|
| | (Hectares) | (%) | (Hectares) | (%) | (Hectares) | (%) |
| Annual Cropland | 173,827 | 30.73 | 157,885 | 27.91 | -15,942 | -10.10 |
| Bare Rock/sand/gravel | 108 | 0.02 | 169 | 0.03 | 61 | 35.84 |
| Bogs | 27,024 | 4.78 | 26,977 | 4.77 | -47 | -0.17 |
| Burns | 1 | <0.01 | 1 | <0.01 | 0 | 0.00 |
| Coniferous Forest | 18,705 | 3.31 | 18,604 | 3.29 | -102 | -0.55 |
| Cultural | 688 | 0.12 | 702 | 0.12 | 14 | 1.99 |
| Deciduous Forest | 89,090 | 15.75 | 87,182 | 15.41 | -1,907 | -2.19 |
| Forage Crops | 12,529 | 2.21 | 15,047 | 2.66 | 2,519 | 16.74 |
| Forest Cutblocks | 1,132 | 0.20 | 6,789 | 1.20 | 5,657 | 83.33 |
| Grassland | 43,231 | 7.64 | 55,574 | 9.82 | 12,343 | 22.21 |
| Marsh/Fens | 13,938 | 2.46 | 13,744 | 2.43 | -194 | -1.41 |
| Mixedwood Forest | 93,898 | 16.60 | 91,595 | 16.19 | -2,303 | -2.51 |
| Open Decidous | 22,418 | 3.96 | 22,254 | 3.93 | -164 | -0.74 |
| Roads/trails | 8,286 | 1.46 | 8,308 | 1.47 | 22 | 0.26 |
| Treed Rock | 22 | <0.01 | 44 | 0.01 | 22 | 49.94 |
| Water Bodies | 37,252 | 6.59 | 37,277 | 6.59 | 24 | 0.07 |

Note: 1994 and 1999 Total Area (%) are calculated as: Total Area (ha)/MB side basin (ha) x 100
1994-1999 Overall Trend (%) is calculated as: Overall Trend (ha)/1994 Total Area (ha) x 100
Significant Land Cover Trends highlighted in red.
A significant level of 10% was used.

Total forage crop cover within the Basin increased by 16.7% or 2,519 hectares between 1994 an 1999 to a total area of approximately 15,000 hectares (Table 1). During this period, 12,266.7 hectares or 2.12 % of the Basin changed from one type of land cover to forage crops (Table 2 and Map 5). As the total new area of forage crops is greater than the increase in total area of forage crops, not all forage cover in 1994 remained forage cover in 1999. Even with the loss of forage crops in some areas, forage crop cover increased in respect to the entire basin. As shown in Map 5, this increase in forage occured throughout the basin, with the largest increases occurring in the Rural Municipalities of Mountain North and Minitonas with each RM showing an increase of approximately 1,000 ha of forage from 1994 to 1999 (Table 1a).

Grassland cover within the Basin increased 22.2 % or 12,343 hectares between 1994 and 1999 to a total area of 55,600 hectares (Table 1). Of this area, 19,891.6 hectares is new grassland (Table 2). As was the case for forage land, while there was an increase in total grasslands hectares, some land was also removed from grassland cover. As shown on Map 5 and Table 1a, most of the increase in grassland cover occurred in the Rural Municipality of Swan River, an increase of almost 10,000 ha from 1994 to 1999.

The increase in treed rock of 22 hectares is very small in size and occurs sporadically throughout the Porcupine and Duck Mountain Provincial Forest areas. This change could be areas of increased forest growth in small pockets where only bare rock, or bare gravelly soils were found in 1994. The increase in area of bare rock/sand/gravel is also fairly small, but appears to be localized to areas just north west of the city of Swan River and are gravel pits. Since these changes are small in comparison to the size of the basin in Manitoba, they are difficult to distinguish on Map 4.

Total annual cropland has decreased by 10.1% or 15,942 hectares within the Basin between 1994 and 1999 (Table 1). The largest of this change occurred in the RM of Swan River (Table 1a). While a significant portion of annual cropland was converted into other land cover classes there was 8,437.4 hectares or 1.49% of the Basin converted into annual cropland (Table 2).

Of the total decrease in annual cropland, 97% can be attributed to the increase in grassland and forages. In just five years the agricultural production in the Swan Lake Basin has changed dramatically, as increased forages and grasslands are being seeded on lands previously under annual crop production. Of the areas that have converted from cropland to grassland or forages, the largest percentages of this change has occurred on soils with an agricultural capability rating of Class 3 to Class 5 according to the Canada Land Inventory rating (Map 6 and Table 3). This trend makes intuitive sense, as profit margins in grain farming continue to shrink, Class 3 to Class 5 lands, which have more limitations for crop production, become less profitable to support grain farming, and producers will seek alternatives.

**Table 1a: A summary of land cover change for the Swan Lake basin (MB side), 1994 and 1999 categorized by RM.**

| Land Cover Class | Swan River Total Area (ha) | | Minitonas Total Area (ha) | | Mountain N. Total Area (ha) | | Mountain S. Total Area (ha) | | Other Total Area (ha) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1994 | 1999 | 1994 | 1999 | 1994 | 1999 | 1994 | 1999 | 1994 | 1999 |
| Annual Cropland | 91,740 | 81,145 | 59,891 | 55,987 | 22,104 | 20,568 | <1 | 117 | 92 | 68 |
| Bare Rock/sand/gravel | <1 | 70 | 9 | <1 | 4 | 4 | <1 | <1 | 96 | 96 |
| Bogs | 544 | 554 | 2,589 | 2,589 | 2,676 | 2,651 | 2,515 | 2,515 | 18,700 | 18,669 |
| Burns | 1 | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Coniferous Forest | 1,244 | 1,294 | 1,481 | 1,478 | 2,317 | 2,360 | 2,521 | 2,565 | 11,143 | 10,907 |
| Cultural | 549 | 556 | 89 | 78 | 50 | 68 | <1 | <1 | 11 | <1 |
| Deciduous Forest | 28,356 | 28,389 | 19,868 | 19,667 | 9,144 | 9,091 | 1,189 | 1,260 | 30,533 | 28,776 |
| Forage Crops | 6,390 | 6,859 | 3,936 | 4,742 | 2,110 | 3,427 | 92 | 12 | 1 | 8 |
| Forest Cutblocks | 96 | 1,468 | <1 | 555 | <1 | <1 | <1 | <1 | 1,036 | 4,766 |
| Grassland | 16,637 | 26,065 | 12,384 | 15,221 | 10,281 | 10,437 | 686 | 598 | 3,244 | 3,253 |
| Marsh/Fens | 1,624 | 1,429 | 580 | 536 | 4,811 | 4,937 | 199 | 199 | 6,724 | 6,644 |
| Mixedwood Forest | 15,723 | 15,083 | 2,338 | 2,346 | 2,070 | 2,032 | 683 | 667 | 73,085 | 71,467 |
| Open Decidous | 859 | 813 | 5,010 | 4,953 | 4,216 | 4,198 | 5,392 | 5,344 | 6,942 | 6,946 |
| Roads/trails | 3,910 | 3,919 | 2,579 | 2,585 | 1,215 | 1,222 | 65 | 65 | 517 | 517 |
| Treed Rock | 19 | 22 | <1 | 14 | 3 | 8 | <1 | <1 | <1 | <1 |
| Water Bodies | 1,821 | 1,845 | 469 | 471 | 774 | 773 | 117 | 117 | 34,072 | 34,071 |

Note: 'Other' refers to the Porcupine Hills, Duck Mountain and Unorganized lands not belonging to a Rural Municipality.

**Table 2: Summary of change detection in land cover from 1994 to 1999**

| Category of Change Detected | Total Area (Hectares) | Percent (%) |
|---|---|---|
| Change to Annual Cropland | 8,437.4 | 1.49 |
| Change to Bare Rock/Sand/Gravel | 69.2 | 0.01 |
| Change to Cultural Features and Roads | 64.5 | 0.01 |
| Change to Forage | 12,266.7 | 2.17 |
| Change to Forest Cutblocks | 5,780.3 | 1.02 |
| Change to Grassland | 19,891.6 | 3.52 |
| Change to Mixed, Deciduous & Coniferous Trees | 3,497.7 | 0.62 |
| Change to Water | 40.7 | 0.01 |
| Change to Marsh/Fens & Bogs | 323.5 | 0.06 |
| No Change | 515,257.9 | 91.09 |

Note: Percent (%) is calculated as: Total Area (ha)/MB side basin (ha) x 100

**Table 3: Summary of agricultural capability classes comparing the soil of the MB side of the Swan Lake basin and areas of change from cropland to grassland/forage.**

| Agricultural Capability | Total Soil | Area Changed | % of Total Changed |
|---|---|---|---|
| | Hectares | | |
| Class 1 | 7,462.3 | 473.3 | 6.34 |
| Class 2 | 117,609.2 | 6,673.6 | 5.67 |
| Class 3 | 127,059.7 | 10,192.1 | 8.02 |
| Class 4 | 24,281.1 | 1,945.4 | 8.01 |
| Class 5 | 36,103.5 | 3,008.6 | 8.33 |
| Class 6 | 15,367.9 | 376.2 | 2.45 |
| Class 7 | 80.1 | 3.1 | 3.87 |
| Organic | 27,898.2 | 454.0 | 1.63 |

Note: Class 1- no significant limitations to crop production
Class 2- moderate limitations
Class 3- moderately severe limitations; range of crops restricted
Class 4- severe limitations
Class 5- suited for forage crops; improvement practices feasible
Class 6- suited for forage crops; improvement practices not feasible
Class 7- no capability for crop production, or permanent pasture

The total area of forest cutblocks in the Basin increased by 5,657 hectares or 83.33% from 1994 to 1999 (Table 1). This change is attributed to an increase in commercial forestry activity in the Duck Mountain and Porcupine Provincial Forests, with the opening of the new Louisiana Pacific Canada OSB mill. Although not all of the increase in cutblocks can be attributed to LP, they are the largest influencing factor. The increasing total area of forest cutblocks could be a continuing trend, until cutblocks are given enough time to regenerate back into treed areas, and re-growth rates approximate the rate of logging.

## 5.0 Summary and Conclusions

Over the period of time from 1994 to 1999 the Swan Lake Basin on the Manitoba side has seen some significant changes in land use in both agricultural production and forestry activities, reflecting the changing social and economic forces that have taken place over that time.

The largest change in agricultural production was the approximately 16,000 hectares or 10 % decrease in annual cropland. This decrease reflects the changing agricultural industry. Producers are faced with higher grain transportation costs, with the loss of grain transportation subsidy, and ever rising input costs, such as fertilizer and fuel. These increased costs have shrunk producers' profit margins and in some cases have depressed their margins into net losses for traditional grain farming on some lands. Shrinking profit margins have forced producers in the area to look for alternatives to annual cropping, especially on the marginal lands. Over the same time frame beef prices have remained stronger than grain prices and many producers have simply expanded their cattle herds, or converted into a mixed farming method of cattle and grains from strictly grain farming. This change in production has shown on the landscape as the bulk of the decrease in annual cropland (97 %) has been re-seeded into tame forages and grassland pastures, most of which has been on marginal lands with a Class 3 to Class 5 agricultural capability rating for soils (Table 3). There has also been a greater uptake of using forages in normal cropping rotations, even on the more productive Class 1 and Class 2 lands, and selling this forage as export (eg. high quality timothy hay).

This change in agricultural production means there could be a shift in pressures on water quality from the agriculture sector in the Basin. An increase in permanent cover results in less pressure from soil erosion and fertilizer run-off and an increasing potential impact from cattle pasturing on riparian areas and overwinter sites in the Basin. This data is not able to reflect the extent to which these forces are acting, but only point out its potential.

There have also been some significant changes in the forestry resource management within the Swan Lake Basin. This is noted as there have been a significant increase of forest cutblocks from 1994 to 1999 of 5,657 ha (14,000 ac), an increase of 83.3%. This has been mostly facilitated by the operation of the new LP mill, located just outside of the town of Minitonas. This change in forestry management of the area also has the potential to create new pressures on resources of the Basin such as increased soil erosion and siltation in the rivers/streams. Again, this data cannot show the extent of this pressure, or even if it is occurring, but only point out its possibility.

With proper management techniques in agriculture and logging, the potential impact of these changing land use practices on the landscape and water quality in the Basin, can be minimized and reduced to acceptable levels. How this is accomplished will be up to the SLBTAG and the stakeholders, including local governments in preparing an overall management plan to implement. Data derived from this project, through the use of a GIS, system will assist the SLBTAG and local governments in their management of the Swan Lake Basin.

### 5.1 Future Steps

As a follow up to this report, a more detailed statistical analysis of the data should be conducted, as this is only a preliminary analysis. This could lead to an overall methodology of performing future land use change detections using GIS. There is also the need to document the changes identified, to ground truth and verify that these changes detected are actually occurring on the landscape to the extent the study has indicated.

In the overall Swan Lake Basin Management project, this report and analysis will be utilized in assisting the stakeholders group and local area governments decide on priority issues in the Basin to address. At present, the stakeholders group has only begun to form, and will not come up with an overall management plan for implementation for the Swan Lake Basin until later into 2002 and 2003.

## 6.0 Data Sources

Land Use: Satellite imagery obtained from RSI. Landsat TM (30 m pixel resolution) 1994 and 1999. Classification from the Manitoba Remote Sensing Centre. Winnipeg, Manitoba.

Soils: Ehrlich W.A., Pratt L.E. and Leclaire F.P. 1962. Reconnaissance Soil Survey of Swan River. Report No. 13 1:126,720. Canada-Manitoba Soil Survey. Winnipeg, Manitoba.

Topographic Data: Geomatics Canada, National Topographic Survey sheets (62N11 - 62N15, 62M16, 63C02 - 63C07, 63C12 - 63C14, 63D01, 63D08 and 63D09) 1:50,000. Sherbrooke, Quebec.

Watershed Boundry: PFRA Gross Watershed Boundries (Version 1.0) 1:50,000. PFRA, Regina, Saskatchewan. July 1997.