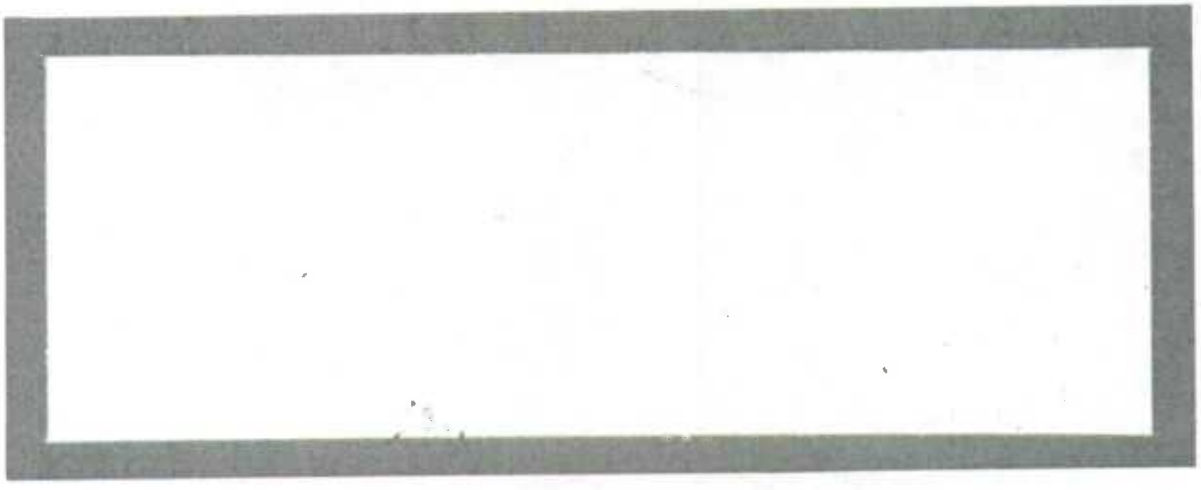

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RURAL LAND USE SURVEY
REPORT ON METHODOLOGY & ESTIMATES
FROM THE 1984 MANITOBA PILOT SURVEY

by

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May, 1985

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Rural Land Use Survey
Report on Methodology and Estimates from the 1984 Manitoba Pilot Survey

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May 1985

1. INTRODUCTION

The Lands Directorate of Environment Canada approached Statistics Canada in May 1984 for assistance in a survey of rural land use in Canada. The main purpose of this survey is to monitor changes in rural land use across Canada by measuring the changes between 10 categories of land activities and between 8 categories of land cover that have occurred over a period of time. The list of activity classes and cover classes is given in Appendix A.

As a first stage in the development of a full scale survey, a feasibility study was conducted in the spring of 1984 in Sub-Provincial Area (SPA)[1] 4A of Alberta and in SPA 2 of New Brunswick using 94 segments of land that were sampled for the 1983 National Farm Survey (NFS)[2] for which remotely sensed (satellite) data had been collected. This study helped in improving methods of measuring change in land use from photographs at two time points.

The second stage of this project was a pilot survey conducted in Manitoba in the summer of 1984. The objective of this survey was to identify potential problems in different stages of the survey: in data collection, data processing and estimation procedures, and the adequacy of the sample design for measuring relative and absolute changes[3].

This document gives a description of the sample design and estimation procedures for the pilot survey and also presents the estimates of change and level[4] from that survey along with their coefficients of variation (C.V.). Tables of sample sizes needed for different desired levels of C.V. are given based on the results of the pilot survey.

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[1] A SPA was defined as a crop district or a group of neighbouring similar crop districts, for the purposes of the NFS.

[2] The NFS is an annual probability survey of farms conducted by Statistics Canada. Part of the sample for this survey consists of a sample of area segments.

[3] Relative change = ratio of areas under a given category, at two time points.
Absolute change = area changed (in hectares) between categories and time points

[4] Level estimate = estimate of the area under a given category for one time point only (in this survey, 1984 only).

2. SAMPLING DESIGN

A stratified two-stage sample of segments of land was selected; the first-stage units were 1981 Census EAs[5] and the second-stage units were segments of land within EAs.

2.1 Sampling Frame

For the purpose of the NFS, Manitoba was divided into 6 sub-provincial areas. The target population for this pilot survey was restricted, due to cost constraints, to all 1981 EAs of Manitoba in the sub-provincial areas covered by the NFS sampling frame excluding SPA 3, SPA 4 and crop district 1 of SPA 1 (NFS sampling frame covered all agricultural areas of Manitoba). The metropolitan areas of Winnipeg and Brandon were also excluded. On the other hand, some EAs in the Northern regions of the province that are not in the NFS sampling frame were included in the target population of the pilot survey because this survey intended to measure change in rural land use of non-agricultural areas also.

2.2 Stratification

The sampling frame was stratified according to two characteristics: firstly by census division to ensure a good geographical spread of the units; and secondly, by two broad activity types: agricultural and non-agricultural land. No further details on activity classes or cover classes at the EA level were available from the Census to allow a more detailed breakdown. Hence, a stratum was defined as the intersection of a census division and type of EA (agricultural or non-agricultural)[6].

2.3 Sample Size and Allocation

An initial sample size of 300 EAs was fixed because of cost constraints. The 300 EAs were allocated to the strata proportional to the number of EAs in the population in each stratum. A little more than one-fourth of the sample units were in non-agricultural EAs.

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[5] EA = Enumeration Area is an area of land with clearly identifiable boundaries that was assigned to one Census representative for enumeration during the Census. The size of an EA is based on the population (number of persons) living within its boundaries.

[6] An agricultural EA is one that had the Headquarters of at least one farm located within its boundaries at the time of the 1981 Census of Agriculture.

2.4 Sample Selection

Within each stratum, the allocated number of EAs (first-stage units) were selected by systematic sampling with the frame previously arranged by order of contiguous EAs. As an EA covers a very large area of land, it was decided to subsample within selected EAs. Therefore, each sampled EA was partitioned into segments of land of 3 sections each, using maps, and one or more segments (second-stage units) per EA were drawn by simple random sampling. The criterion used for subsampling was 1 segment selected for each 30 or less segments in the EA. The number of segments into which an EA is divided depends on the area of the EA.

In the agricultural strata, the sample was selected according to the Kish and Scott method[7] so as to retain as many sampled EAs from the 1984 NFS as possible, without changing the desired probabilities of selection within strata. By the use of EAs already selected for NFS, we were able to avoid segmenting too many EAs, a procedure which is costly and time-consuming.

As a result of stratification and sample allocation, a total of 297 EAs were selected from 26 strata and a total subsample of 349 segments were drawn from those 297 EAs. Table 1 of Appendix B gives the population and sample sizes per strata in terms of EAs as well as the number of segments selected.

2.5 Modifications to the Target Population and Sample Sizes

Additional modifications to the target population after sample selection were made by Environment Canada and Canadian Centre for Remote Sensing (CCRS), prior to flying the segments. Cost and practical constraints made it necessary to further reduce the sample size to approximately 220 segments, chosen in regions where changes had most likely occurred between 1970 and 1984. As a result, census divisions 6, 16 and 21 were excluded from the target population as no segments in these census divisions were flown. Note that this subsample of 220 segments selected by Environment Canada and CCRS is not a random subsample of the initial sample.

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[7] Kish, L., Scott, A. (1971), "Retaining Units after Changing Strata and Probabilities", Journal of the American Statistical Association, 66, pp. 461-470.

For approximately 150 segments out of 220, there were 1970 aerial photographs available for estimating change. Therefore, the sample sizes, prior to flying in terms of the number of segments (second-stage units), were 220 segments for estimates of level and 150 segments for estimates of change.

3. NON-RESPONSE AND STRATA COLLAPSING

After flying there were a few segments with no data available because of cloud cover or because the wrong location had been photographed. No imputation was performed on those missing segments as it was felt that no information closely related to land use was available from other or previous surveys. Therefore, the weights of the remaining segments in strata where there was non-response were adjusted at both stages of the design to account for missing segments.

The resulting total sample size to be used in the estimation of level was reduced to 176 EAs and 206 segments. For the estimation of change between 1970 and 1984, the total number of EAs and segments available were 123 and 141 respectively. A breakdown by strata of the number of EAs and segments used in the estimation of level and of change is given in table 2 of Appendix B.

No estimation was possible in some strata because of lack of sampled units flown. They are:

a) for estimates of change between 1970 and 1984: strata 5, 6, 8, 17, 18, 24, 25 and 26;

and

b) for 1984 estimates of level: strata 5, 6, 17, 18, 25 and 26.

For a few other strata, although it was possible to calculate totals for both change and level estimates, we could not calculate estimates of variance. For these strata, an asterisk is indicated beside the number of EAs in table 2. To calculate estimates of variance, a minimum number of two units per stratum is necessary. Therefore, for variance calculation purposes, we needed to collapse neighbouring strata in order to get this minimum number of units. As in this survey a stratum is a combination of a census division and a type of land (agricultural/non agricultural), the collapsing was done by grouping strata of the same type and of neighbouring census divisions. The

grouping is indicated by arrows in table 2. For estimation of change, strata 2 and 10 were grouped and stratum 14 was grouped with stratum 12. For estimation of level, only one grouping was done, stratum 8 with stratum 16.

4. DESCRIPTION OF THE DATA COLLECTED

For each segment for which a 1970 photograph was available, the area (in hectares) under each activity class (or cover class) was measured on the 1984 photograph. Then, the 1970 photograph was examined and if a change of activity (or cover) had occurred in a section of the segment, that changed area was then measured and the 1970 type of activity (or cover) was noted. Therefore, a set of three items of data were reported for each section of a segment. They were the 1970 activity (cover) code, the 1984 activity (cover) code and area measured, and were accompanied by identification information.

For those segments used in the estimation of level only and for which no 1970 photograph was available, only the 1984 activity (cover) class and total area under that class were collected. Hence, the first data item was given the 1970 code for total (code 11).

The data collected for each segment can be viewed in a pair of two-way tables, one table for activity classes and the other one for cover classes. The rows correspond to 1970 activity/cover classes and the columns to 1984 activity/cover classes. Each set of data for a section can be related to a cell in the table, the first data item being the line number and the second data item, the column number. Finally, the cell contains the area measured in the section (see example on next page).

For those segments used in the estimation of change, the cells on the diagonal of the table, contain areas for which no change has occurred between 1970 and 1984 whereas the off-diagonal cells give areas for which change occurred between 1970 and 1984. For instance, x hectares went from class a in 1970 to class b in 1984 (a different from b). For the segments used for estimation of level, only the last row of the table (the 1970 total) is used.

EXAMPLE

Table of Activity Classes

for Segment with LUSID=62J14 and NFSID=605-207-103

1984 Activity Classes

1970 ACTIVITY CLASSES \ 1984	1	2	3	4	5	6	7	8	9	10	Total
1	81.6										81.6
2		51.3									51.3
3											
4		71.8									71.8
5	20.5					5.5					26.0
6						39.2					39.2
7											
8								11.3			11.3
9											
10										8.9	8.9
Total	102.1	123.1				44.7		11.3		8.9	290.1

5. EDIT PROCEDURES

Once the data had been transferred to Statistics Canada, a few simple edits were performed on them. The first edits checked for invalid identification information (wrong map number or segment number). Then, a manual verification was done on segments located in small rural towns and villages. The total area and the shape of the segment interpreted were checked against those given by topographic maps or town plans. This allowed detection of errors of incomplete coverage, of wrong location or of problems with boundaries.

For each table of a segment, the final automated edit checked that, the sum over the rows was equal to the area recorded in the total line. This was done for each column in the table.

6. ESTIMATION PROCEDURES

Several estimates were calculated from the data collected. Two different estimates were produced to measure change in land use from the 141 segments for which 1970 and 1984 photographs were available. These were an estimate of absolute change and an estimate of relative change.

Estimates of level were derived from the larger sample of 206 segments, i.e., estimates of total area of land under each activity/cover class in 1984 in the target population.

In the following pages, estimation formulas used for calculating these estimates and their estimated coefficients of variation (cv) are given along with a brief description of the calculation steps.

6.1 Estimates of Absolute Change

These estimates are totals calculated for each cell of the activity (or cover) table. For a given cell (a, b), the estimate is obtained in two steps. Firstly, we take the sum over all segments in the same EA of the weighted area (weighted by the raising factor for the EA) reported for that cell. Therefore, the same table that was 'built' at the segment level is built at the EA level. Secondly, we sum

6.1.2 Estimated Coefficient of Variation of $\hat{Y}(a,b)$

Estimated variance of $\hat{Y}(a,b)$ = $v(\hat{Y}(a,b))$

$$= \sum_{h=1}^{H} \frac{N_h^2}{n_h} \sum_{i=1}^{n_h} \frac{(\hat{y}_{hi} - \bar{y}_h)^2}{n_h - 1}$$

(p. 38, Des Raj; assuming the first-stage units were selected with replacement (see section 7))

where $\hat{y}_{hi} = \sum_{j=1}^{m_{hi}} \frac{M_{hi}}{m_{hi}} y_{hij}^{(a,b)}$

and $\bar{y}_h = \sum_{i=1}^{n_h} \frac{\hat{y}_{hi}}{n_h}$

and coefficient of variation of $\hat{Y}(a,b)$ = $cv(\hat{Y}(a,b)) = \frac{\sqrt{v(\hat{Y}(a,b))}}{\hat{Y}(a,b)}$

6.2 Estimates of Relative Change

These estimates are ratios of the total area under class a in 1984 by total area under the same class in 1970. They give an idea of the percentage of increase or decrease of the area for a given class between two time points. The numerator and the denominator are respectively the estimates of the total line and of the total column from the tables of estimates of absolute change.

Des Raj, (1968), Sampling Theory, McGraw-Hill, New-York, 302 pages.

the weighted area (this time weighted by the raising factor for the stratum) reported under the given cell over all EAs in a stratum and then over all strata. Then, we obtain an estimate of the area of land changing from use a in 1970 to use b in 1984. The notation used in the following formulas is explained as it is used.

6.1.1 Estimate of Total $\hat{Y}^{(a,b)}$

$\hat{Y}^{(a,b)}$ = total area under class a in 1970 and class b in 1984.

a and b = 1 to 10 for activity tables
a and b = 1 to 15 for cover classes (not grouped)
or = 1 to 8 for grouped cover classes

$$\hat{Y}^{(a,b)} = \sum_{h=1}^{H} \sum_{i=1}^{n_h} \frac{N_h}{n_h} \sum_{j=1}^{m_{hi}} \frac{M_{hi}}{m_{hi}} y_{hij}^{(a,b)}$$

segment level
EA level
stratum level
target population estimate

where h represents a stratum h=1, ... H
i represents an EA i=1, ... n_h
j represents a segment j=1, ... m_{hi}

$y_{hij}^{(a,b)}$ = area in cell (a,b) for segment j in i^{th} EA in stratum h.

M_{hi} = total number of segments in i^{th} EA in stratum h

m_{hi} = number of selected segments in i^{th} EA in stratum h

N_h = total number of EAs in stratum h

n_h = number of selected EAs in stratum h

6.2.1 Ratio Estimate $\hat{R}^a$

$\hat{Y}$(Total, a) = total area under class a in 1984

$$= \sum_{h=1}^{H} \sum_{i=1}^{n_h} \frac{N_h}{n_h} \sum_{j=1}^{m_{hi}} \frac{M_{hi}}{m_{hi}} y_{hij}^{(Total,a)}$$

$\hat{Y}$(a, Total)= total area under class a in 1970

$$= \sum_{h=1}^{H} \sum_{i=1}^{n_h} \frac{N_h}{n_h} \sum_{j=1}^{m_{hi}} \frac{M_{hi}}{m_{hi}} y_{hij}^{(a,Total)}$$

and $\hat{R}^a = \dfrac{\hat{Y}(Total, a)}{\hat{Y}(a, Total)}$

6.2.2 Estimated Coefficient of Variation of $\hat{R}^a$

Estimated variance of $\hat{R}^a$ = $v(\hat{R}^a)$

$$= \frac{1}{(\hat{Y}^{(a,\ Total)})^2} \left[v(\hat{Y}^{(Total,\ a)}) + (\hat{R}^a)^2\ v(\hat{Y}^{(a,\ Total)}) \right.$$

$$\left. - 2\ (\hat{R}^a)\ cov\ (\hat{Y}^{(Total,\ a)},\ \hat{Y}^{(a,\ Total)}) \right]$$

with $v(\hat{Y}(\text{Total, a}))$ and $v(\hat{Y}(\text{a, Total}))$ calculated as in 6.1.2

and $\text{cov}(\hat{Y}\text{Total, a}))\ \hat{Y}(\text{a, Total}))$

$$= \sum_{h=1}^{H} \frac{N_h^2}{n_h} \frac{1}{(n_h - 1)} \left[\sum_{i=1}^{n_h} \hat{y}_{hi}^{(\text{Total,a})} \times \hat{y}_{hi}^{(\text{a,Total})} - \frac{\left(\sum_{i=1}^{n_h} \hat{y}_{hi}^{(\text{a,Total})} \right) \left(\sum_{i=1}^{n_h} \hat{y}_{hi}^{(\text{Total,a})} \right)}{n_h} \right]$$

Hence, $\text{cv}(\hat{R}^a) = \dfrac{\sqrt{v(\hat{R}^a)}}{\hat{R}^a}$

6.3 Estimates of Level for 1984

These estimates are derived from the total number of segments flown in 1984 (206 segments). They are calculated for the cells (Total, a), i.e. for the cells of the total line only. The formulas are identical to the ones used for estimates of absolute change except for the numbers m_{hi} and n_h which have been adjusted to account for the additional segments and EAs in the sample.

6.3.1 Estimates of Total

$$\hat{Y}_{84}^{(\text{Total, a})} = \sum_{h=1}^{H} \sum_{i=1}^{n'_h} \frac{N_h}{n'_{hi}} \sum_{j=1}^{m'_{hi}} \frac{M_{hi}}{m'_{hi}} \hat{y}_{hij}^{(\text{Total, a})}$$

where m'_{hi} = total number of selected segments flown in 1984 in i^{th} EA in stratum h.

and n'_h = number of selected EAs in stratum h flown in 1984.

6.3.2 Estimated Coefficient of Variation of $Y_{84}^{(Total, a)}$

Same formula as 6.1.2 but replacing m_{hi} by m'_{hi} and n_h by n'_h.

7. NOTES ON VARIANCE CALCULATION

The estimates of variance used for the calculation of the estimated coefficients of variation and provided in the preceding pages were based on the assumption that the first stage design was simple random sampling with replacement. As a matter of fact, it would be almost impossible to calculate the variance according to a two-stage design because only one segment was selected in most EAs. That does not allow us to estimate the second-stage variance, that is the variance due to the variation between selected segments within an EA. Using the formulae for simple random sampling with replacement, we take into account implicitly the second-stage variance. On the other hand, as the sample was selected systematically, using simple random sampling formula tends to overestimate the variance, if the systematic sample did give a better spread of the population studied.

8. COMMENTS ON THE RESULTS AND LIMITATIONS TO THEIR USE

The estimates of change and of level are presented in Appendix C. Tables 1 (page C-1 to C-3), 3 (pages C-5 to C-8) and 5(pages C-10 to C-12) give the estimates of absolute change and their coefficients of variation for activity classes, cover classes and grouped cover classes, respectively. Tables 2, 4 and 6 give the number of segments with an area different from zero in a given cell. The difference between the total number of segments and the number in the table gives the number of segments with no area in the given cell.

Tables 7, 9 and 11 present the estimates of level and their coefficients of variation for activity classes, cover classes and grouped cover classes, respectively whereas tables 8, 10 and 12 give the number of segments reporting an area different from zero in a given activity (cover) class. Finally, tables 13 and 14 show the estimates of relative change and their coefficients of variation.

As no data were available from previous surveys or even other sources on land use, it was not possible to evaluate the accuracy of the estimates from this survey. The only estimate that could be evaluated was the total area broken down by census

division, for which areas by census divisions were available from the 1981 Census. The results of the comparison are given in table 1 on the next page. The figures in brackets are percentages of difference between the Land Use Survey estimate and the Census value. The modifications made to the target population and the collapsing of strata and, consequently, of census divisions) limited the comparisons possible. A few of the largest differences are explained by the latter. Nonetheless, some differences remain important, even for total area. This leads us to question the accuracy of total estimates for the breakdown by activity or cover classes. Moreover, by looking at the tables for absolute change or level estimates, we notice that the estimates in the margins (total line or column) as well as the estimates on the diagonal bear rather large coefficients of variation (in the range of 10 to 30% with a few around 60% and over). For the off diagonal estimates, the coefficients of variation are even larger, usually 50% and over. Therefore, there are serious limitations to the use of some estimates, while others should be used with caution.

On the other hand, the estimates of relative change (tables 13 and 14) seem more stable than the estimates of absolute change, with coefficients of variation less than 10% (except in one case) and most of them less than 2%. This measure of change appears to be a better indicator of change than the estimate of absolute change.

9. SAMPLE SIZE NEEDED IN FUTURE SURVEYS

One of the objectives of this pilot survey was to predict the sample size required to conduct a large-scale survey covering eventually all Canada, using the survey results and more specifically, the coefficients of variation.

For a start, we can give an estimate of the sample size needed to obtain a desired level of precision, i.e. a target coefficient of variation, using the simple rule:

$$\text{cv(estimate)} \propto \frac{1}{\sqrt{n}}$$

where $\propto$ means "is proportional to"
and $\propto n$ is the sample size.

Table 1

Comparison of total area by census division between census estimates and survey estimates

Census Division	1981 Census Total Area (in hectares)	Survey Total Area in 1984 (in hectares)	
		Estimate 1[1]	Estimate 2[2]
1	1,472,408	723,742 (-50.8%)[3]	726,950 (-50.1%)
2	426,570	400,346 (- 6.1%)	386,545 (- 9.4%)
7	558,229	606,036 (+ 8.6%)[4]	736,470 (+31.9%)[7]
12	179,064	163,757 (- 8.5%)[3]	163,313 (- 8.8%)
13	164,816	165,655 (+ 0.5%)[5]	162,297 (- 1.5%)
14	274,020	249,598 (- 8.9%)[5]	282,855 (+ 3.2%)
15	911,675	1,093,901 (+20.0%)	888,391 (- 2.6%)[7]
17	1,334,080	3,827,655 (+ 187%)	2,662,229 (+99.0%)
18	1,104,370	1,150,410 (+ 4.2%)	950,003 (-14.0%)
19	6,139,019	1,215,322 (-80.2%)[6]	1,211,114 (-80.3%)[6]
20	989,820	---	1,251,968 (+26.5%)
Total - Census Division 19	7,415,052	9,596,422 (+29.4%)	8,211,021 (+10.7%)

1 Estimate calculated from the 141 segments available for estimating change.

2 Estimate calculated from the total sample of 206 segments.

3 Part of census division 1 was grouped with census division 12 for estimating change.

4 In census division 7, only agricultural land was surveyed.

5 Part of census division 14 was grouped with census division 13 for estimating change.

6 Most part of census division 19 was not in the target population.

7 Census division 7 was grouped with census division 15 for estimating levels.

Hence, we can use the following equation

$$\frac{\text{cv(current estimate)}}{\text{target cv}} = \frac{\sqrt{n_{future}}}{\sqrt{n\ current}}$$

$$\text{to calculate } n_{future} = \left(\frac{\text{cv(estimate)}}{\text{target cv}}\right)^2 \times n_{current} .$$

The sample sizes estimated from that method are presented in tables 1, 2 and 3 of Appendix D. The tables can be read as follows. Assume that the cv of an estimate of absolute change from the pilot survey is of the order of 25% and that we would like to obtain a maximum cv of 10%. We read from table 1 the figure at the intersection of the 8th row and the 5th column, which gives us 769 EAs as the sample size required to obtain the target cv.

Table 1 gives sample sizes needed to improve the cv of the estimates of absolute change, table 2 is for the estimates of relative change and table 3, the estimates of level. Cases where the sample size required was larger than the number of EAs in the province (1932 EAs) are indicated by dashes (---).

The results presented in these three tables apply to the target population covered by the pilot survey. Nonetheless, by assuming that the same variations for the characteristics of interest hold in the population of the province outside the target population, we can extend the results of tables 1, 2 and 3 to the whole province.

Extrapolating and extending the results for Manitoba to other provinces is difficult. To do so, we would have to assume that the variations for characteristics of interest (totals for activity/cover classes, change ratio) are similar in other provinces which is not likely to be true.

10. CONCLUSION

From the tables of Appendix C showing absolute change and level estimates, we can see that most of these estimates have very high coefficients of variation (over 25%). Consequently, it appears difficult to estimate areas accurately from the sample used in this survey. Moreover, tables 1 and 3 of Appendix D show that to obtain precise estimates for some types of change that we could describe as "rare" (in that their frequency is very low), we would have to survey almost the whole province, which is very costly.

On the other hand, the estimates of relative change calculated from the sample have low coefficients of variation. By looking at table 2 of Appendix D, we can conclude that an accurate estimation of relative change seems possible from a sample.

We will summarize the observations in the preceding paragraphs by saying that the current sample design does not allow us to estimate accurately the area changed or even the areas under different activity or cover classes. But it is adequate to measure relative change, i.e. percentage change between two time points.

Thus, we recommend that other sample designs and sampling units be investigated for estimating land use, specially as EAs from the Census of Agriculture may not be adequate sampling units (although the only ones available at the time).

APPENDIX A

List of Activity Classes

Code	Description
1	Annual tillage crops and forage
2	Grazing
3	Other agricultural activities
4	Summerfallow
5	Former agricultural activities
6	Productive land - forest
7	Productive land - wildlife
8	Productive land - recreation
9	Other site activities
10	No perceived activity

List of cover classes and grouped cover classes

Not grouped		Grouped	
Code	Description	Code	Description
1	Tall trees	1	Tall trees
2	Small trees and shrubs	2	Small trees and shrubs
3	Cereal grains	3	Crops
4	Oilseeds		
5	Improved grass or legumes		
6	Other close grown crops		
7	Corn		
8	Beans		
9	Vegetables		
10	Other row crops		
11	Unimproved grasslands	4	Unimproved grasslands
12	Denuded surfaces	5	Denuded surfaces
13	Constructed cover	6	Constructed cover
14	Water	7	Water
15	Summerfallow	8	Summerfallow

APPENDIX B

Table 1: Population and Sample Sizes (first-stage units : EAs and second-stage units: Segments)

Type of EA \ Census Division		01	02	06	07	12	13	14	15
Agricultural	#	1	3	5	7	9	11	13	15
	N	38	57	24	38	26	37	22	74
	n	16	25	10	15	11	16	10	32
	m	22	25	12	19	11	16	10	33
Non-Agricultural	#	2	4	6	8	10	12	14	16
	N	17	9	6	8	5	19	4	7
	n	6	4	3	3	2	8	2	3
	m	8	4	3	3	2	8	2	3

Table 1 (cont'd)

Type of EA \ Census Division		16	17	18	19	20	21	TOTAL
Agricultural	#	17	19	21	--	24	--	
	N	34	70	57	0	32	0	509
	n	15	30	25	-	14	-	219
	m	15	38	31	-	21	-	253
Non-Agricultural	#	18	20	22	23	25	26	
	N	5	18	20	29	8	31	186
	n	2	7	9	12	4	13	78
	m	2	16	9	18	4	14	96
Grand Total							N	695
							n	297
							m	349

# = stratum number
N = population size (no. of EA's)
n = sample size (no. of EA's)
m = No. of sampled segments

Table 2: Revised Population and Sample Sizes.

Stratum	Ag. or Non Ag.	Census Division (CD)	N_h	1970/1984 Change n_h	1984 Level n_h	1970/1984 Change Number of Segments	1984 Level Number of Segments
1	A	1	38	10	10	12	13
2	N-A	1	17	1*	3	1	4
3	A	2	57	19	24	19	24
4	N-A	2	9	3	3	3	3
5	A	6	24	0	0	0	0
6	N-A	6	6	0	0	0	0
7	A	7	38	4	5	4	6
8	N-A	7	8	0	1*	0	1
9	A	12	26	10	10	10	10
10	N-A	12	5	1*	2	1	2
11	A	13	37	14	15	14	15
12	N-A	13	19	5	5	5	5
13	A	14	22	6	9	6	9
14	N-A	14	4	1*	2	1	2
15	A	15	74	10	21	11	22
16	N-A	15	7	2	2	2	2
17	A	16	34	0	0	0	0
18	N-A	16	5	0	0	0	0
19	A	17	70	12	24	17	29
20	N-A	17	18	2	3	6	8
21	A	18	57	13	24	16	30
22	N-A	18	20	6	6	6	6
23	N-A	19	29	4	4	7	8
24	A	20	32	0	3	0	7
25	N-A	20	8	0	0	0	0
26	N-A	21	31	0	0	0	0
Total			**695**	**123**	**176**	**141**	**206**

where * indicates a stratum which needs collapsing.

N_h = number of primary stage units (EAs) in the population in stratum h.

n_h = number of primary stage units in the sample in stratum h.

APPENDIX C

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 ACTIVITY CLASSES

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF ACTIVITY CLASSES

	1984 CLASSES							
	CROPS & FORAGE		GRAZING		OTH AG ACT		SUMMERFALLOW	
	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE
1970 CLASSES								
CROPS & FORAGE	2714987.2	11.8	.	.	193.0	65.3	.	.
GRAZING	42155.1	66.5	1155929.1	32.5	.	.	7745.9	94.8
OTH AG ACT	3964.7	58.6	875.6	100.0	75907.8	14.4	924.0	100.0
SUMMERFALLOW	.	.	.	.	.	.	195660.0	20.6
PROD LD-FOREST	116033.5	39.6	32785.3	33.2	19477.4	40.8	5995.7	57.9
PROD LD-RECR	.	.	.	.	.	.	.	.
OTH SITE ACT	.	.	.	.	.	.	.	.
NO PERC ACT	141.4	100.0	563.2	100.0	45.6	100.0	.	.
TOTAL	2877281.9	11.5	1190153.1	32.2	95623.9	14.1	210325.6	19.8

Table 1. Table of estimates of absolute change.

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 ACTIVITY CLASSES.

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF ACTIVITY CLASSES

	1984 CLASSES							
	PROD LD-FOREST		PROD LD-RECR		OTH SITE ACT		NO PERC ACT	
	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE
1970 CLASSES								
CROPS & FORAGE	.	.	.	.	4902.2	62.6	.	.
GRAZING	.	.	.	.	.	.	.	.
OTH AG ACT	.	.	.	.	39.6	100.0	.	.
SUMMERFALLOW	.	.	.	.	.	.	.	.
PROD LD-FOREST	2033550.9	16.9	.	.	7278.2	57.7	981.7	100.0
PROD LD-RECR	.	.	7529.0	66.7	.	.	.	.
OTH SITE ACT	.	.	.	.	67486.5	35.3	.	.
NO PERC ACT	.	.	.	.	.	.	3129269.1	25.1
TOTAL	2033550.9	16.9	7529.0	66.7	79706.5	33.3	3130250.8	25.1

Table 1. (Cont'd)

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 ACTIVITY CLASSES

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF ACTIVITY CLASSES

	1984 CLASSES	
	TOTAL	
	AREA	CV
	ESTIMATE	ESTIMATE
1970 CLASSES		
CROPS & FORAGE	2720082.5	11.8
GRAZING	1205930.2	33.1
OTH AG ACT	81711.7	14.0
SUMMERFALLOW	195660.0	20.6
PROD LO-FOREST	2216102.7	16.6
PROD LO-RECR	7529.0	66.7
OTH SITE ACT	67486.5	35.3
NO PERC ACT	3130019.2	25.1
TOTAL	9600421.6	12.5

Table 1. (Cont'd)

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 ACTIVITY CLASSES

NUMBER OF segments INCLUDED IN THE ESTIMATION†

TABLE OF ACTIVITY CLASSES

	1984 CLASSES								
	CROPS & FORAGE	GRAZING	OTH AG ACT	SUMMERFALLOW	PROD LD-FOREST	PROD LD-RECR	OTH SITE ACT	NO PERC ACT	TOTAL
	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG
1970 CLASSES									
CROPS & FORAGE	105	.	3	.	.	.	11	.	106
GRAZING	6	90	.	2	.	.	.	.	90
OTH AG ACT	3	1	82	1	.	.	1	.	83
SUMMERFALLOW	.	.	.	67	.	.	.	.	67
PROD LD-FOREST	30	13	9	6	115	.	6	1	115
PROD LD-RECR	.	.	.	.	.	9	.	.	9
OTH SITE ACT	.	.	.	.	.	.	66	.	66
NO PERC ACT	1	1	1	.	.	.	.	81	81
TOTAL	110	90	86	69	115	9	69	81	141

† i.e., number of segments with non-zero areas in a given cell.

Table 2.

RURAL LANDUSE SURVEY --- MANITOBA PILOT PROJECT

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 COVER CLASSES

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF COVER CLASSES

	1984 CLASSES							
	TALL TREES		SMALL TREES		CEREALS		OILSEEDS	
	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE
1970 CLASSES								
TALL TREES	3253693.7	19.7	18595.5	43.0	26767.9	54.1	5396.5	96.9
SMALL TREES	.	.	1650521.3	33.0	2705.7	59.1	3345.1	75.8
CROPS	.	.	12.2	100.0	1439554.3	14.6	442762.5	15.2
UNIMP GRASS	.	.	.	.	4900.0	95.5	.	.
DENUD SURF	.	.	.	.	.	.	.	.
CONST COVER	.	.	.	.	.	.	.	.
WATER	.	.	.	.	.	.	.	.
SUMMERFALLOW	.	.	.	.	.	.	.	.
TOTAL	3253693.7	19.7	1669128.9	32.6	1473927.8	14.3	451504.1	15.4

Table 3. Table of estimates of absolute change.

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 COVER CLASSES

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF COVER CLASSES

	1984 CLASSES							
	IMP GRASS & LEG		OTH CL GR CROPS		CORN		VEGETAB	
	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE
1970 CLASSES								
TALL TREES	58569.5	66.6	300.9	100.0	.	.	.	.
SMALL TREES	22542.1	31.8	511.9	77.5	.	.	.	.
CROPS	669156.3	13.6	154111.7	31.9	7868.4	92.0	42.3	100.0
UNIMP GRASS	36501.5	68.8	753.7	100.0	.	.	.	.
DENUD SURF	.	.	.	.	.	.	.	.
CONST COVER	.	.	.	.	.	.	.	.
WATER	.	.	.	.	.	.	.	.
SUMMERFALLOW	.	.	.	.	.	.	.	.
TOTAL	786769.4	15.5	155678.1	31.6	7868.4	92.0	42.3	100.0

Table 3. (Cont'd)

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 COVER CLASSES

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF COVER CLASSES

	1984 CLASSES							
	OTH ROW CROPS		UNIMP GRASS		DENUD SURF		CONST COVER	
	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE
1970 CLASSES								
TALL TREES	.	.	30061.7	35.1	1527.8	77.3	802.5	75.2
SMALL TREES	.	.	4162.4	87.5	3783.9	93.4	45.6	100.0
CROPS	7905.7	56.2	3068.2	80.7	78.8	100.0	1205.0	70.1
UNIMP GRASS	.	.	1294892.3	30.9	.	.	2819.2	89.6
DENUD SURF	.	.	.	.	10842.4	25.6	.	.
CONST COVER	.	.	.	.	.	.	106568.7	20.8
WATER	.	.	.	.	.	.	.	.
SUMMERFALLOW	.	.	.	.	.	.	.	.
TOTAL	7905.7	56.2	1332174.5	30.5	16232.9	28.5	110631.0	22.1

Table 3. (Cont'd)

RURAL LANDUSE SURVEY --- MANITOBA PILOT PROJECT

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 COVER CLASSES

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF COVER CLASSES

	1984 CLASSES					
	WATER		SUMMERFALLOW		TOTAL	
	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE
1970 CLASSES						
TALL TREES	.	.	5254.1	63.8	3400970.0	19.1
SMALL TREES	.	.	1665.6	63.9	1689283.5	32.2
CROPS	500.8	96.1	.	.	2726266.0	11.7
UNIMP GRASS	.	.	7745.9	94.8	1347602.6	31.3
DENUD SURF	.	.	.	.	10042.4	25.6
CONST COVER	.	.	.	.	104948.8	21.1
WATER	148038.4	15.2	.	.	148038.4	15.2
SUMMERFALLOW	.	.	195660.0	20.6	195660.0	20.6
TOTAL	148539.2	15.1	210325.6	19.8	9600421.6	12.5

Table 3. (Cont'd)

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 COVER CLASSES

NUMBER OF segments INCLUDED IN THE ESTIMATION†

TABLE OF COVER CLASSES

	1984 CLASSES															
	TALL TREES	SMALL TREES	CEREALS	OILSEEDS	IMP GRASS & LEG	OTH CL GR CROPS	CORN	VEGE-TAB	OTH ROW CROPS	UNIMP GRASS	DENUD SURF	CONST COVER	WATER	SUMMERFALLOW	TOTAL
	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG
1970 CLASSES															
TALL TREES	119	7	12	2	13	1	.	.	.	12	2	2	.	4	119
SMALL TREES	.	100	4	3	12	2	.	.	.	2	3	1	.	3	102
CROPS	.	1	86	64	98	49	3	1	10	3	1	9	2	.	107
UNIMP GRASS	.	.	2	.	3	1	.	.	.	99	.	4	.	2	99
DENUD SURF	.	.	.	.	.	.	.	.	.	.	27	.	.	.	27
CONST COVER	.	.	.	.	.	.	.	.	.	.	.	108	.	.	106
WATER	.	.	.	.	.	.	.	.	.	.	.	.	30	.	30
SUMMERFALLOW	.	.	.	.	.	.	.	.	.	.	.	.	.	67	67
TOTAL	119	104	87	65	103	51	3	1	10	99	29	107	32	69	141

Table 4.

† i.e., number of segments with non-zero areas in a given cell.

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 COVER CLASSES (GROUPED)

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF COVER CLASSES

	1984 COMPRESSED CLASSES							
	TALL TREES		SMALL TREES		CROPS		UNIMP GRASS	
	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE
1970 CLASSES								
TALL TREES	3253693.7	19.7	10595.5	43.0	91034.8	45.2	30061.7	35.1
SMALL TREES	.	.	1650521.3	33.0	29104.8	30.8	4162.4	87.5
CROPS	.	.	12.2	100.0	2721401.2	11.8	3068.2	80.7
UNIMP GRASS	.	.	.	.	42155.1	66.5	1294892.3	30.9
DENUD SURF	.	.	.	.	.	.	.	.
CONST COVER	.	.	.	.	.	.	.	.
WATER	.	.	.	.	.	.	.	.
SUMMERFALLOW	.	.	.	.	.	.	.	.
TOTAL	3253693.7	19.7	1669120.9	32.6	2883695.8	11.4	1332174.5	30.5

Table 5. Table of estimates of change

RURAL LANDUSE SURVEY --- MANITOBA PILOT PROJECT

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 COVER CLASSES (GROUPED)

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF COVER CLASSES

	1984 COMPRESSED CLASSES							
	DENUD SURF		CONST COVER		WATER		SUMMERFALLOW	
	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE	AREA ESTIMATE	CV ESTIMATE
1970 CLASSES								
TALL TREES	1527.8	77.3	802.5	75.2	.	.	5254.1	63.8
SMALL TREES	3783.9	93.4	45.6	100.0	.	.	1665.6	63.9
CROPS	78.8	100.0	1205.0	70.1	500.8	96.1	.	.
UNIMP GRASS	.	.	2819.2	89.6	.	.	7745.9	94.8
DENUD SURF	10842.4	25.6	.	.	.	.	.	.
CONST COVER	.	.	106568.7	20.8	.	.	.	.
WATER	.	.	.	.	148038.4	15.2	.	.
SUMMERFALLOW	.	.	.	.	.	.	195660.0	20.6
TOTAL	16232.9	28.5	110631.0	22.1	148539.2	15.1	210325.6	19.8

Table 5. (Cont'd)

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 COVER CLASSES (GROUPED)

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF COVER CLASSES

	1984 COMPRESSED CLASSES	
	TOTAL	
	AREA	CV
	ESTIMATE	ESTIMATE
1970 CLASSES		
TALL TREES	3400970.0	19.1
SMALL TREES	1689283.5	32.2
CROPS	2726266.0	11.7
UNIMP GRASS	1347602.6	31.3
DENUD SURF	10842.4	25.6
CONST COVER	104948.8	21.1
WATER	148039.4	15.2
SUMMERFALLOW	195660.0	20.6
TOTAL	9600421.6	12.5

Table 5. (Cont'd)

RURAL LANDUSE SURVEY --- MANITOBA PILOT PROJECT

ESTIMATES OF CHANGE BETWEEN 1970 AND 1984 COVER CLASSES (GROUPED)

NUMBER OF segments INCLUDED IN THE ESTIMATION †

TABLE OF COVER CLASSES

	1984 CLASSES								
	TALL TREES	SMALL TREES	CROPS	UNIMP GRASS	DENUD SURF	CONST COVER	WATER	SUMM-EPFA-LLOW	TOTAL
	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG	NOSEG
1970 CLASSES									
TALL TREES	119	7	23	12	2	2	.	4	119
SMALL TREES	.	100	14	2	3	1	.	3	102
CROPS	.	1	106	3	1	9	2	.	107
UNIMP GRASS	.	.	6	99	.	4	.	2	99
DENUD SURF	.	.	.	.	27	.	.	.	27
CONST COVER	.	.	.	.	.	107	.	.	106
WATER	.	.	.	.	.	.	30	.	30
SUMMERFALLOW	.	.	.	.	.	.	.	67	67
TOTAL	119	104	111	99	29	107	32	69	141

†i.e., number of segments with non-zero areas in a given cell.

Table 6.

ESTIMATES OF LEVEL FOR 1984 ACTIVITY CLASSES

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF ACTIVITY CLASSES

	AREA	CV
	ESTIMATE	ESTIMATE
1984 CLASSES		
CROPS & FORAGE	2947154.9	9.7
GRAZING	852537.9	25.0
OTH AG ACT	100883.9	12.8
SUMMERFALLOW	272734.9	17.7
PROD LO-FOREST	2646805.7	17.9
PROD LO-RECR	5974.2	58.5
OTH SITE ACT	89892.7	26.3
NO PERC ACT	2520103.2	32.8
TOTAL	9422135.0	13.8

Table 7. Table of estimates of level

ESTIMATES OF LEVEL FOR 1984 ACTIVITY CLASSES

NUMBER OF INCLUDED IN THE ESTIMATION †

TABLE OF ACTIVITY CLASSES

	NOSEG
1984 CLASSES	
CROPS & FORAGE	163
GRAZING	131
OTH AG ACT	126
SUMMERFALLOW	106
PROD LO-FOREST	171
PROD LO-RECR	14
OTH SITE ACT	98
NO PERC ACT	124
TOTAL	206

Table 8.

† i.e., number of segments with non-zero areas in a given cell.

ESTIMATES OF LEVEL FOR 1984 COVER CLASSES

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF COVER CLASSES

	AREA	CV
	ESTIMATE	ESTIMATE
1984 CLASSES		
TALL TREES	3238344.2	22.7
SMALL TREES	1662058.2	33.9
CEREALS	1570152.9	11.8
OILSEEDS	434716.8	12.6
IMP GRASS & LEG	754908.1	13.1
OTH CL GR CROPS	176984.9	22.4
CORN	4125.3	84.3
BEANS	1588.4	100.0
VEGETAB	661.2	94.2
OTH ROW CROPS	10011.1	41.6
UNIMP GRASS	1052071.1	22.8
DEIMD SURF	23688.6	30.5
CONST COVER	109746.4	17.8
WATER	123295.3	35.5
SUMMERFALLOW	272734.9	17.7
TOTAL	9422135.0	13.8

Table 9. Table of estimates of level.

ESTIMATES OF LEVEL FOR 1984 COVER CLASSES

NUMBER OF segments INCLUDED IN THE ESTIMATION†

TABLE OF COVER CLASSES

	NOSEG
1984 CLASSES	
TALL TREES	174
SMALL TREES	156
CEREALS	134
OILSEEDS	96
IMP GRASS & LEG	155
OTH CL GR CROPS	75
CORN	4
BEANS	1
VEGETAB	2
OTH ROW CROPS	16
UNIMP GRASS	148
DENUD SURF	39
CONST COVER	159
WATER	49
SUMMERFALLOW	106
TOTAL	206

Table 10.

† i.e., number of segments with non-zero areas in a given cell.

RURAL LANDUSE SURVEY --- MANITOBA PILOT PROJECT

ESTIMATES OF LEVEL FOR 1984 COVER CLASSES (GROUPED)

AREA ESTIMATES (IN HECTARES) AND COEFFICIENTS OF VARIATION (%)

TABLE OF COVER CLASSES

	AREA	CV
	ESTIMATE	ESTIMATE
1984 COMPRESSED CLASSES		
TALL TREES	3238344.2	22.7
SMALL TREES	1662058.2	33.9
CROPS	2953148.6	9.7
UNIMP GRASS	1052071.1	22.8
DENUD SURF	23608.6	30.5
CONST COVER	109746.4	17.8
WATER	123295.3	35.5
SUMMERFALLOW	272734.9	17.7
TOTAL	9422135.0	13.8

Table 11. Table of estimates of level.

ESTIMATES OF LEVEL FOR 1934 COVER CLASSES (GROUPED)

NUMBER OF segments INCLUDED IN THE ESTIMATION †

TABLE OF COVER CLASSES

	NOSEG
1934 CLASSES	
TALL TREES	174
SMALL TREES	156
CROPS	166
UNIMP GRASS	148
DENUD SURF	39
CONST COVER	159
WATER	49
SUMMERFALLOW	106
TOTAL	206

Table 12.

† i.e., number of segments with non-zero areas in a given cell.

Table 13

Table of relative change ratio ($\hat{R}^a$) between 1984 and 1970 and coefficient of variation ($CV(\hat{R})$) for activity classes.

	Activity Class	$\hat{R}^a$	C.V. $(\hat{R})$ (%)
1	Annual tillage crops and forage	1.0578	2.55
2	Grazing	0.9870	1.64
3	Other agricultural activities	1.1703	9.76
4	Summerfallow	1.0750	4.07
5	Former agricultural activities	---*	---
6	Productive land - Forest	0.9176	2.52
7	Productive land - Wildlife	---	---
8	Productive land - Recreation	1.0000	0.25
9	Other site activities	1.1811	6.36
10	No perceived activity	1.0001	0.05

* --- = no area in this class in sampled segments

Table 14

Table of relative change ratio ($\hat{R}^a$) between 1984 and 1970 and coefficient of variation ($CV(\hat{R})$) for cover classes.

	Cover Class	$\hat{R}^a$	C.V. (%) $(\hat{R})$
1	Tall Trees	0.9567	1.64
2	Small trees and shrubs	0.9881	1.00
3	Crops	1.0578	2.54
4	Unimproved grasslands	0.9886	1.48
5	Denuded surfaces	1.4972	24.57
6	Constructed cover	1.0541	1.84
7	Water	1.0034	0.32
8	Summerfallow	1.0750	4.07

APPENDIX D

Table 1

Table of sample size needed (in number of EAs) in Manitoba as a function of the C.V. of the estimate of absolute change from the pilot survey and of desired level of C.V. (Estimates of absolute change based on an initial sample size of 123).

CV of Estimate	Desired C.V.								
	1%	2%	5%	7%	10%	15%	20%	25%	30%
1%	123	31	5	3	2	1	1	1	1
2%	492	123	20	10	5	3	2	1	1
5%	>1932*	769	123	63	31	14	8	5	4
7%	---	1509	242	123	61	27	16	10	7
10%	---	>1932	492	251	123	55	31	20	14
15%	---	---	1107	565	277	123	70	45	31
20%	---	---	>1932	1004	492	219	123	79	55
25%	---	---	---	1569	769	342	192	123	85
30%	---	---	---	>1932	1107	492	277	177	123
35%	---	---	---	---	1507	670	377	241	167
40%	---	---	---	---	>1932	875	492	315	219
45%	---	---	---	---	---	1107	623	399	277
50%	---	---	---	---	---	1367	769	492	342
55%	---	---	---	---	---	1654	930	595	413
60%	---	---	---	---	---	>1932	1107	708	492
65%	---	---	---	---	---	---	1299	831	577
70%	---	---	---	---	---	---	1507	964	670
75%	---	---	---	---	---	---	1730	1107	769
80%	---	---	---	---	---	---	>1932	1260	875
85%	---	---	---	---	---	---	---	1422	987
90%	---	---	---	---	---	---	---	1594	1107
95%	---	---	---	---	---	---	---	1776	1233
100%	---	---	---	---	---	---	---	>1932	1267

*There is a maximum of 1932 EAs in Manitoba.

Note: The sample size in terms of number of segments is approximately the same as we select an average of 1 segment per EA in Manitoba.

Table 2

Table of sample size needed (in number of EAs) in Manitoba as a function of the C.V. of the estimate of relative change from the pilot survey and of desired level of C.V. (Estimates of relative change based on an initial sample size of 123).

CV of Estimate	Desired C.V.												
	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
0.5%	123	31	14	8	5	4	2	2	1	1	1	1	1
1.0%	492	123	55	31	20	14	8	5	4	3	2	2	2
1.5%	1107	277	123	70	45	31	18	12	8	6	5	4	3
2.0%	>1932	492	219	123	79	55	31	20	14	11	8	7	5
2.5%	---	769	342	193	123	86	48	31	22	17	12	10	8
3.0%	---	1107	492	277	178	123	70	45	31	23	18	14	12
4.0%	---	>1932	875	492	315	219	123	79	55	41	21	25	20
5.0%	---	---	1367	769	492	342	193	123	86	63	48	38	31
6.0%	---	---	>1932	1107	709	492	277	178	123	91	70	55	45
7.0%	---	---	---	1507	965	670	377	242	168	123	95	75	61
8.0%	---	---	---	>1932	1260	877	492	315	219	161	123	98	79
9.0%	---	---	---	---	1595	1107	623	399	277	204	156	123	100
10.0%	---	---	---	---	>1932	1367	769	492	342	252	193	152	123

*There is a maximum of 1932 EAs in Manitoba.

Table 3

Table of sample size needed (in number of EAs) in Manitoba as a function of the C.V. of the estimate of level from the pilot survey and of desired level of C.V. (Estimates of level based on an initial sample size of 176).

CV of Estimate	Desired C.V.								
	1%	2%	5%	7%	10%	15%	20%	25%	30%
1%	176	44	7	4	2	1	1	1	1
2%	704	176	29	15	7	4	2	2	1
5%	>1932	1100	176	90	44	20	11	7	5
7%	---	>1932	345	176	87	39	22	14	10
10%	---	---	704	360	176	79	44	29	20
15%	---	---	1584	809	396	176	99	64	44
20%	---	---	>1932	1437	704	313	176	113	78
25%	---	---	---	>1932	1100	489	275	176	122
30%	---	---	---	---	1584	704	396	253	176
35%	---	---	---	---	>1932	958	539	345	240
40%	---	---	---	---	---	1252	704	451	313
45%	---	---	---	---	---	1584	891	570	396
50%	---	---	---	---	---	>1932	1100	704	489
55%	---	---	---	---	---	---	1331	852	592
60%	---	---	---	---	---	---	1584	1014	704
65%	---	---	---	---	---	---	1859	1190	826
70%	---	---	---	---	---	---	>1932	1380	958
75%	---	---	---	---	---	---	---	1584	1100
80%	---	---	---	---	---	---	---	1802	1252
85%	---	---	---	---	---	---	---	>1932	1413
90%	---	---	---	---	---	---	---	---	1584
95%	---	---	---	---	---	---	---	---	1765
100%	---	---	---	---	---	---	---	---	>1932