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Intercensal county population estimates for Montana by a multiple regression technique

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INTERCENSAL COUNTY POPULATION ESTIMATES FOR MONTANA BY A MULTIPLE REGRESSION TECHNIQUE

by

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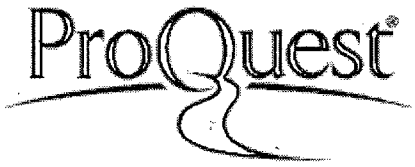

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TABLE OF CONTENTS

	Page
LIST OF TABLES	iii
Chapter	
I. INTRODUCTION	1
II. AVAILABLE DATA	5
Births and Deaths Automobile Registrations School Enrollment	
III. METHODOLOGY	12
IV. LIMITATIONS AND ACCURACY	17
V. CONCLUSION	21
Future Use	
Appendixes	
A. COHORT SURVIVAL METHOD OF ESTIMATING COUNTY PUBLIC SCHOOL ENROLLMENTS	24
B. RATIO OF ESTIMATED POPULATIONS TO CENSUS TOTALS FOR MONTANA COUNTIES 1950 AND 1960. COLUMNS 3 AND 4 INDICATE THE PERCENTAGE OF ERROR	26
C. BIMD-06 "MULTIPLE REGRESSION AND CORRELATION ANALYSIS NO. 1" IBM-7090 PRINT-OUT USING SAMPLE SIZE OF 112 WITH 6 VARIABLES EACH, THE DEPENDENT VARIABLE BEING CENSUS POPULATION 1950 AND 1960.	28
D. ESTIMATED COUNTY POPULATIONS FOR YEAR 1950 THROUGH 1960, AND CENSUS TABULATIONS FOR 1950 AND 1960	30
BIBLIOGRAPHY	46

LIST OF TABLES

Table		Page
1.	Brief Outline of Methods Being Tested for States or Counties in 1960.	3
2.	Relationship of Resident-Nonresident Births and Deaths in Selected Montana Counties, 1959.	7
3.	Distribution of County Percentage of Errors, 1950 and 1960	13
4.	Ten Montana Counties Showing the Largest Percentage of Error in 1950 and 1960.	14
5.	Correlation Coefficients for 1950 and 1960 Variables . . .	19
6.	Flathead County Public School Enrollment Projection by Cohort Survival Method.	25

CHAPTER I

INTRODUCTION

Every ten years the U. S. Bureau of the Census makes a careful count of every man, woman and child in the United States. The data available in these census reports are of great value, but problems exist in determining what happens to the population within the ten-year span of time between censuses. For example, World War II required tremendous shifts of population among geographic areas, yet the decennial census showed only the net difference between data for 1940 and for 1950. The Bureau of the Census publishes annual post-censal state estimates which fill this information gap on the state level. It does not, however, make estimates for political divisions smaller than a state. While state estimates are valuable, local data, at least to the county level, are also vital in many cases. Different areas within a state may have quite different patterns of population change.

Estimated county populations are of interest to a variety of persons. Local governments desire these data for planning as well as for evaluating past events. Businessmen, especially local merchants, are interested in knowing what past markets have been and what potential markets may be within their area. Prospective firms desire these data for labor force information. State and federal governments

often use population estimates for fund allocation. These are but a few of the many uses of intercensal county population estimates.

Population estimates are of three types, intercensal, postcensal, or future estimates, depending upon the time period involved. Intercensal estimates are based on data from the years between two consecutive censuses. Postcensal estimates are based on data from the time a census is taken up to the present. Future estimates are projections into the future.

This thesis attempts to provide a method of producing meaningful data for political divisions of the state on an intercensal basis; that is, between the years 1950 and 1960. Montana counties are the logical political divisions to use for this purpose. A look at the map of Montana will show that no major Montana city overlaps county boundaries. Even more important, county boundaries have not been changed since the 1940's, while city limits are continually modified. Moreover, most official data such as vital statistics (births and deaths) and school enrollments are kept on a county basis.

As in any problem, the first task here is to define the objective. In this case, it is to develop a reasonable, simple, and easily understood method of estimating annual Montana county populations for July 1, 1950 through July 1, 1960 which will produce data accurate enough to be useful. No detailed breakdown of county characteristics in terms of the age, sex, marital status, education, or occupation of inhabitants is attempted, since such information is virtually impossible to obtain except in a complete census.

Montana counties vary widely in their total populations. Thirty-five of them have less than 10,000 inhabitants; only two have

more than 50,000 residents. Some county populations have been increasing over the last decade, others have remained stable, and still others have shown declines. In some counties, single industries, such as mining in Silver Bow, have decisive effects upon total population. Others have a more diversified economy. These are only some of the difficulties in estimating Montana county populations; others will be discussed in the following chapters.

In seeking a method of estimating intercensal county populations several of the more commonly accepted estimating techniques were considered. The following table represents a brief outline of methods currently being tested.

TABLE I

BRIEF OUTLINE OF METHODS BEING TESTED FOR STATES OR COUNTIES IN 1960

Method	Estimating Procedure	Basic Indicator
1. Census Bureau Method II	Component method: For migration, school-cohort procedure comparing expected population, based on previous census plus births, with actual population.	For migration: school data
2. Census Bureau Method I	Component method: For migration, change in local school-age population compared with change in national school-age population.	For migration: school data
3. Vital rates method	Censal ratio (birth rate and death rate)	Births and deaths
4. Composite method: Bogue-Duncan variation	Censal ratio by age	--
Age Group		
0-4	Ratio of children under 5 to women 18-44	Births
5-17	School enrollment ratio	School data
18-44	Fertility ratio (births to women) and sex ratio	Births
45-64	Death rate	Deaths
65 and over	Death rate	Deaths

TABLE 1--Continued

Method	Estimating Procedure	Basic Indicator
5. Composite method: Census Bureau variation		
Age Group		
0-4	Component Method II	School data
5-17	Component Method II	School data
18-44	Component Method II	School data
45-64	Censal ratio (death rate)	Deaths
65 and over	Censal ratio (death rate)	Deaths
6. Age or grade progression method*	Component method: one-year school-age or grade "survival" rate for migration	For migration: school data
7. Censal ratio method using school data/	Censal ratio	School data

*States only.
/Counties only.

Source: Jacob S. Siegel, "Status of Research on Methods of Estimating State and Local Population," adaption of a paper read at the annual meeting of the American Statistical Association, 1960, following p. 1, as cited in Predicting Population Changes in Small Areas," Bureau of Business and Economic Research, University of Maryland, Vol. 14, No. 4, March 1961.

Most of the methods in Table 1 are satisfactory for estimating the population of areas with over 100,000 persons. The most populated county in Montana, Yellowstone, with less than 80,000 persons, falls short of this 100,000 minimum. Therefore another technique of estimating Montana county populations is needed.

CHAPTER II

AVAILABLE DATA

The first question that occurs in estimating population is what data are available. Unless reliable data can be found, it is extremely difficult to make meaningful estimates of county populations. The most dependable source of information, as we have seen, is the decennial Census of Population taken by the federal government, which gives a detailed breakdown of population according to such characteristics as age, sex, and employment. In our case, the information it provides on distribution of county population is important, for it includes both the statistics with which this study begins (1950) and those with which it ends (1960).

Data necessary to make intercensal estimates must be acquired from sources which meet the following criteria:

1. Accurate records must be available, preferably published in annual reports.
2. Data must be available by county.
3. Uniform methods of collecting and recording data must be employed. Different methods may be used for different types of data as long as the method used for the particular statistic remains consistent over the period.

4. Data must represent a relatively large percentage of the total population to which it relates.

State tabulations of births, deaths, motor vehicle registrations, school enrollments and registered voters were considered as sources of data because they seemed best to fit the criteria listed above.

Voter registration was eliminated because accurate records for the early 1950's were not available and because the number of persons registering to vote depends more on political interest than on size of population. Although motor vehicle registrations were used, truck registrations were omitted, since they are more representative of business or employment activity than of population size.

The following variables were found to satisfy the criteria listed above and were used to estimate county intercensal populations:

1. Births
2. Deaths
3. Passenger automobile registrations
4. Elementary school enrollments
5. High school enrollments

Births and Deaths

The most reliable collector of information on births and deaths in Montana is the State Board of Health. According to a nationwide study made by the U. S. Bureau of the Census in 1950, Montana registration of births was 99.5 per cent complete; that is, five or less out of every 1000 births go unrecorded. The Board's

registration of deaths is even more complete, since a death certificate must be filed before a permit for burial or removal can be issued.[1]

Both live birth and death data are recorded annually in two separate tabulations--by place of residence and by place of occurrence. In this thesis the place of residence was used. Not all Montana counties have adequate hospital facilities, nor are these facilities distributed in a manner that permits easy access to them by all residents of a particular county. The following table shows some of the wide divergencies between the resident-nonresident relationship for births and deaths occurring in selected counties during the calendar year 1959.

TABLE 2

RELATIONSHIP OF RESIDENT-NONRESIDENT BIRTHS AND DEATHS IN SELECTED MONTANA COUNTIES, 1959

County	Deaths by Place of Occurrence	Deaths by Place of Residence	Births by Place of Occurrence	Births by Place of Residence
Blaine	44	85	144	240
Chouteau	44	70	71	186
Hill	178	151	768	610
Lewis and Clark	388	321	730	712
Jefferson	32	44	1	71
Judith Basin	7	22	None	66

Source: 1959 Annual Statistical Supplement, Montana State Board of Health.

[1] 1959 Annual Statistical Supplement, Montana State Board of Health, Helena, Montana, 1960, p. 1.

For births, the place of residence is the usual residence of the child's mother; for deaths, it is the usual residence of the deceased, regardless of the length of his stay in a hospital or other institution. An exception to this rule appears for persons institutionalized by legal action for long periods of time, such as mental patients and criminals which are residents of the respective institution.

Automobile Registrations

Passenger automobiles in Montana must be licensed every year if they are operated on public roads within the state. New cars must be registered within three days after purchase, and autos owned by persons gainfully employed in Montana must be re-licensed upon entry regardless of when their out-of-state license expires. Thus, with few exceptions, all automobiles owned or operated by persons residing in Montana are registered. The remaining question is whether data for distribution by county exists. Automobiles are an item of personal property and are taxed by the county government. If a person falsifies his place of residence to reduce the tax burden, he is liable for the tax assessed by the county in which he actually resides in addition to the tax already paid. The key factor here is the taxpayer's residence at the time of licensing, January 1 to February 15. If he moves to another county after this date or after he acquires the license, there is no tax or license adjustment.

Annual passenger automobile registrations are collected by the Registrar of Motor Vehicles at Deer Lodge, Montana. Summary tabulations supplied by the Registrar's office show all automobiles

registered in every county for the entire year--January 1 through December 31. Re-registrations occurring during the first month and one-half are sensitive to present residents, while most registrations after this period represent new car purchases and in-migrations. Out-migrations are not considered during the current year but are evident in the next year's tabulations; thus the maximum time lag is only one year. Automobiles registered in Montana that are bought or sold during the year are given a transfer of title and not re-registered by the new owner. This fact prevents the inflation of data because of sales transactions.

School Enrollment

Montana law requires that all children must attend school until they have completed the eighth grade or have passed their sixteenth birthday. Exceptions to this are few; therefore school enrollment data represent a fairly large segment of total population. The Montana Department of Public Instruction compiles a tabulation of original public school enrollments for the school year--September through June. Original enrollments as used here are not restricted to the head count at the start of the year, but rather include the total number of students enrolled in a given county during the entire school year. If a student transfers to another county during the year, he is eliminated from the first county's original enrollment and added to that of the second. For this reason, original enrollment tabulations by county are not published by the State Department of Public Instruction until after the school year is completed. This practice created a problem regarding 1960 enrollments that will be discussed later.

Over 12 per cent[2] of the total number of elementary and high school students in Montana attended private schools in 1959; therefore it was essential that these students be included in school enrollments. Fortunately the Department of Public Instruction, in its annual Montana Educational Directory, publishes a list of all private schools and their enrollment as of approximately September 10. No additions are made for new students entering during the year as in public school enrollments; thus this information is not, strictly speaking, comparable with public school enrollment. The Montana Educational Directory lists the total public school enrollment as of the same date (September 10), but these data cannot be used because they do not include one-room schools, which serve a total of between 6000 and 8000 students. Neither is there an adjustment for students who attend public schools in counties other than that of residence.

As was pointed out earlier, original public school enrollments for the year 1960-1961 will not be tabulated until about September 1961; hence, a method of estimating these enrollments had to be devised. The cohort-survival method was used because of its general acceptance by school administrators and its reasonably high degree of accuracy. This method is explained in Appendix A. Once the estimated county public school enrollment was computed, it was added to the private school enrollment of September 1960 as shown in the Montana Educational Directory to arrive at the total county school enrollment for the year.

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[2] 1959 Data: $\frac{19409 \text{ Private School Enrollment}}{161060 \text{ Total School Enrollment}} = 12\%$

In summary, school enrollments are a combination of two tabulations that are not strictly comparable. Because of the additions during the year, public school data might be considered inflated in relation to opening enrollment in private schools. The 1950 total school enrollment of 117,415, or approximately 20 per cent of the total state population, represented a significant portion of Montana residents, and therefore it is important to include school enrollments as a factor even in light of the inequalities involved. Given the data available and the necessity of establishing a reasonably simple procedure, however, this method of arriving at school enrollments should give data which are relatively accurate and consistent over the time period 1950 through 1960.

CHAPTER III

METHODOLOGY

Assuming that the five variables explained earlier have a direct relationship to population, a method was sought that would correlate these data with county populations. The idea of using multiple regression analysis to estimate Washington's county intercensal populations was advanced by Crosetti and Schmitt in 1956.[3] Of the several methods tested, the one utilizing multiple regression analysis was by far the most accurate. This fact is not the sole justification for utilizing this method for Montana, however. Washington and Montana have many county characteristics in common. Washington counties vary from 2,872 to 935,014 people, a range similar to Montana's of 894 to 79,016, but on a larger scale. Both states have a large number of agricultural counties with small populations. These similarities and the fact that the data available for Montana counties lend themselves readily to regression analysis warranted the use of this method in this thesis. Because of the large amount of data involved--the five independent plus the dependent (1950 and 1960 census populations) variables for each of Montana's 56 counties--an electronic computer could best process these data. The Division of

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[3]Albert Crosetti and Robert Schmitt, "A Method of Estimating the Intercensal Population of Counties," Journal of the American Statistical Association, Vol. 51, No. 276 (December 1956), p. 587.

Biostatistics of the University of California at Los Angeles School of Medicine, through the Western Data Processing Center, furnished the computer program, BIMD-06. An IBM-7090 calculated the following regression formula on the basis of the relationship among the 672 variables (5 independent and 1 dependent variable for each of 56 counties for the years 1950 and 1960):

$P = 146.53064 + 17.55936A + 21.65683B + .76651C - 1.96737D + 6.97568E$

where A is live births, B is deaths, C is automobile registrations, D is total elementary school enrollments and E is total high school enrollments. Print-out of relevant data is shown in Appendix B.

Using the multiple regression formula, the variables for all counties for the years 1950 through 1960 were then processed on another machine, the IBM-650 at the Montana Highway Commission Computer Laboratory in Helena, to arrive at the final output as shown in Appendix D. The computed county populations for 1950 and 1960 were then compared with the respective census tabulations and the following differences recorded:

TABLE 3

DISTRIBUTION OF COUNTY PERCENTAGE OF ERRORS
1950 AND 1960

Year	0 to .0499	.0500 to .0999	.1000 to .1499	.1500 to .1999	Over .2000
1950	25	14	10	4	3 (.202) (.231) (.261)
1960	20	19	13	4	None
Total	45	33	23	8	3
Percent of total	40	29	21	7	3

The mean error for 1950 is .075; for 1960, .076. The standard deviations of the differences are .060 for 1950 and .045 for 1960. The standard deviation for all the differences of the two years is .053.

This margin of error analysis is open to question since the sample does not represent the entire eleven-year period but only two years, 1950 and 1960. The 1950 and 1960 county variables were used to compute the formula that was applied to the same variables to arrive at computed population tabulations. These in turn were compared with actual census data to arrive at the above margins of error.

Another question was whether or not the counties showing the highest margin of error in 1950 also showed high margins in 1960. The following table indicates that only two counties, Deer Lodge and McCone, are on both lists.

TABLE 4

TEN MONTANA COUNTIES SHOWING THE LARGEST PERCENTAGE OF ERROR IN 1950 AND 1960

County	1950	1960	County	1960	1950
Jefferson	26.1%	11.1%	Treasure	19.0%	2.8%
Powell	23.1	5.9	Rosebud	17.9	4.3
*Deer Lodge	20.2	12.1	Mineral	17.0	4.2
*McCone	18.6	13.6	Liberty	15.1	1.5
Madison	17.8	9.2	Petroleum	13.9	9.4
Powder River	15.3	8.0	Phillips	13.9	1.4
Pondera	15.3	3.8	*McCone	13.6	18.6
Sanders	13.9	.6	*Deer Lodge	12.1	20.2
Golden Valley	13.2	10.1	Richland	12.0	1.3
Roosevelt	11.9	1.4	Fallon	11.5	3.5

Source: Appendix C

Appendix D indicates that most counties with large percentages of error have relatively small populations. The absolute error--percentage of error times total county population--is thereby normally small in relation to the total state population. For example, the 26.1 per cent in Jefferson County amounts to 830 people, whereas a 3.4 per cent error in Yellowstone County amounts to 1864 persons.

Earlier, it was stated that the method used here is a modification of that employed by Crosetti and Schmitt, who used live births, public school enrollments and registered vehicles to compute a multiple regression formula relating to Washington's 39 counties. This formula was used by them to arrive at a percentage of the total state population which resided in a given county. They then divided the estimated annual total state population, as furnished by the U. S. Bureau of the Census, among the counties on the basis of this percentage for each intercensal year.

In this thesis the five variables--births, deaths, passenger automobile registrations, total elementary school enrollments and total high school enrollments--were used to calculate a multiple regression formula. This formula was applied directly to the variables rather than to the counties' respective percentages of state totals to arrive at county populations which, when added together, estimate the state total. It will be possible to compare these estimates with those prepared by the U. S. Bureau of the Census when its revised intercensal tabulations for Montana are released.

In summary, by the use of BIMD-06, "Multiple Regression and Correlation Analysis No. 1," and of the county variables for 1950 and 1960, the multiple regression formula is:

$P = 146.53064 + 17.55936A + 21.65683B + .76651C - 1.96737D + 6.97568E$

This formula was then applied to the county variables for all years 1950 through 1960 to arrive at annual county total populations as tabulated in Appendix D. Computed populations for 1950 and 1960 were compared with actual census totals and the margin of error tabulated in Appendix B.

CHAPTER IV

LIMITATIONS AND ACCURACY

As a practical research tool, regression analysis has been used for about forty years[4], but its first application in demography did not occur until 1954[5], only two years before Crosetti and Schmitt applied the technique to intercensal county population estimates for the State of Washington. Since then little has been published relating this technique to demographic problems, though in other fields such as agricultural and timber management it has been used with considerable success.[6]

Multiple regression analysis does not necessarily produce a high degree of mathematical precision; it considers the correlation between the given variables and, recognizing that some relationships differ, it attempts to produce statistics that will approximate the mean of the total being sampled. The term "regression" was initially used in connection with the discovery that very tall or very short parents tend to have children who are on the average less tall or short than their parents. This was described as a tendency to "regress toward the

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[4]Mordecia Ezekiel and Karl A. Fox, Methods of Correlation and Regression Analysis (New York: John Wiley & Sons, Inc., 1959), p. 435.

[5]Albert Crosetti and Robert Schmitt, "Accuracy of the Ratio-Correlation Method of Estimating Postcensal Population," Land Economics, 30 (1954), p. 279.

[6]Ezekiel, op. cit., pp. 436-440.

mean." Although BIMD-06 is one of the most advanced methods currently available for producing a formula, it is still regression analysis and subject to considerable lack of precision. Regression analysis will produce statistics that represent the average, but rarely will it produce exact data for a particular sample space.

In estimating county population, this lack of precision is unavoidable in view of the wide differences in correlation between actual populations and independent variables. If all the facts were known the weights attached to the same variable might differ from county to county. For example, in 1960 Madison County showed 15 per cent of its population in elementary school; Yellowstone County, 19 per cent; and Valley County, 20 per cent. The state average was 18 per cent. Therefore any formula must be general enough to apply to the majority of counties.

In 1960 Montana's county populations ranged from 894 to 79,016 persons. The arithmetic average was 12,406 and the median was 7,194. Forty-nine per cent of the total population resided in seven counties, while the least populated 35 counties accounted for only 23 per cent. Variables differ from county to county and from year to year within the same county. Using average data, it is difficult to estimate state populations where the totals are large. It is even more difficult to estimate, with any degree of reliability, populations of counties which vary as much as Montana's, particularly when many of them have very small populations. With this in mind, let us first analyze the assumptions upon which the estimates are made and then review the degree of accuracy that can be expected.

The variables have all been collected by State of Montana agencies, each of which uses basically consistent and accurate methods for the entire period, 1950 through 1960. The relationship between independent variables and population is shown in the following table of correlation coefficients for 1950 and 1960. Coefficients for the interim years cannot be computed, since only estimated populations are available for the period 1951 through 1959.

TABLE 5

CORRELATION COEFFICIENTS FOR 1950 AND 1960 VARIABLES

Variable	Holding A Constant	Holding B Constant	Holding C Constant	Holding D Constant	Holding E Constant	Holding F Constant
A. Births	1.00	0.93	0.97	0.98	0.96	0.99
B. Deaths	0.93	1.00	0.92	0.93	0.94	0.96
C. Auto. Reg.	0.97	0.92	1.00	0.99	0.99	0.98
D. Population	0.98	0.93	0.99	1.00	0.99	0.98
E. Elem. School	0.96	0.94	0.99	0.99	1.00	0.99
F. High School	0.99	0.96	0.98	0.98	0.99	1.00

Source: Western Data Processing Center IBM Print-out

The mathematician acquainted with regression analysis is referred to Appendix C, "BIMD-06 Print-out," for a sophisticated measurement of accuracy. A simpler method is available by referring to Table 3, "Distribution of County Percentage of Errors, 1950 and 1960." Assuming that 1950 and 1960 data are representative of all years included in the eleven-year period, we can be reasonably sure 95 per cent of the time of

having less than a 15 percentage of error between the actual and the estimated county population. Using the same assumption and raising the acceptable margin of error, we can claim that in 70 per cent of the estimates the computed population will be within 10 per cent of the actual population. Considering that the estimates of population are prepared by using averages of all 56 counties, this is a reasonable degree of accuracy.

It was hoped that Montana county estimates made by multiple regression analysis could be checked by using 1940 and 1960 data to compute 1950 populations, which in turn could have been compared with the 1950 census, but comparable base data were not available. In 1940 vital statistics (births and deaths) were recorded only by place of occurrence and not by place of residence. As shown in Table 2, "Relationship of Resident-Nonresident Births and Deaths in Selected Montana Counties, 1959," the wide variance between resident and nonresident data prohibit any degree of comparability.

CHAPTER V

CONCLUSION

It appears that multiple regression analysis can provide useful county population estimates if one is willing to accept a reasonable percentage of error. The results obtained for certain Montana counties which have experienced major population fluctuations during the past ten years indicate that this method of annual county estimates is reasonably accurate. For example, in the late 1950's, construction of an Air Force Base near Glasgow (Valley County) resulted in the migration of many new workers into a comparatively stable county. After the construction was completed, Air Force personnel and their families moved in to take the place of workers moving out. Thus it would seem logical to expect a sharp increase in county population beginning with the start of construction and continuing through 1960. The following are the census figures for 1950 and 1960 and the estimates for 1957 through 1959 for Valley County:

1950	11,353
1957	12,961
1958	14,434
1959	16,834
1960	17,080

Another example is that of Silver Bow County, for which the estimates show a declining population beginning in 1957, after a steady increase in earlier years. State Employment Service figures show that mining employment in the county reached its peak in 1956 and then started to

decline rapidly. The apparent time lag between the employment peak and the population peak represents a combination of the inability of the variables to respond to out-migrations in the current year and of the reluctance of people to move shortly after losing their jobs.

These two examples, while they are not necessarily representative of the experiences of all counties, demonstrate that the estimating technique is reasonably sensitive to population change independent of the overall 1950-1960 net change. Also, in general, estimates for counties that experienced little or no major fluctuation in economic activity or employment patterns do not show major population changes.

While care was taken to assure accuracy in the collecting of base data and in the mathematical computations that followed, it must be emphasized that these computed populations are only estimates. Whenever basic conditions change, experiential probability is affected.

Furthermore, the assumption of stability in mass data, or of relationships between the characteristics of mass data, is open to serious question when making estimates of population for counties whose populations are as small as those of many Montana counties.

The population estimates as computed by multiple regression analysis and enumerated in Appendix D indicate a high degree of sensitivity to known population changes such as shown for Valley and Silver Bow Counties. There are of course, estimates that produce greater error; but in general, most appear well within acceptable limits. It is impossible to make precise judgments of the accuracy of intercensal estimates, but assuming the intercensal data are as accurate as the 1950 and 1960 estimates which appear in Appendix D, the results obtained by multiple regression probably are the best

available at the present time. Currently the State Board of Health is conducting a study of intercensal county population estimates using a combination of the Bureau of the Census Method II and the Vital Rates Method. According to their statisticians, the preliminary returns do not indicate the degree of accuracy obtained by multiple regression analysis.

Future Use. The use of multiple regression analysis was advocated by Crosetti and Schmitt in computing postcensal county population estimates and for this purpose the method appears to have considerable merit. Once the Montana county data used as variables are available, approximately in the middle of the year after that being estimated, it should be possible to apply the same multiple regression formula to arrive at postcensal county estimates. Annual postcensal estimates could continue until 1970, at which time they could be computed, intercensally, using the 1970 census data. The twenty-year span of data would also facilitate judging the accuracy of the method by using 1950 and 1970 data to compute 1960 estimates, which in turn would be compared with the actual county populations for that year.

APPENDIX A

COHORT SURVIVAL METHOD OF ESTIMATING COUNTY PUBLIC SCHOOL ENROLLMENTS

The method used is basically that advocated by Professor Sletten[7] with the exception that I have used the average survival ratio for only three years rather than for ten years, in the belief this method will provide a more sensitive indicator of short range changes.

By advancing individual class enrollments through the school grades it is possible to estimate future enrollments. For example, if over a three-year period the average percentage of 4th graders that went on to the 5th grade was 98.7, then the projection of next year's 5th grade total is merely a process of applying this percentage to the current 4th grade enrollment. It should be noted that 1st grade enrollments cannot be predicted this way. I have applied the ratio between 1953 births and 1960 grade 2 enrollments to the 1954 births to arrive at 1st grade totals for 1960.

The 1960-61 public school enrollment projection for Flathead County is used as an example of the method used:

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[7]Vernon O. Sletten, "Enrollment Estimates in Montana Public Schools," The Research Record, Vol. VII, No. 2 (Missoula: Montana State University, 1961), pp. 2-6.

TABLE 6

FLATHEAD COUNTY PUBLIC SCHOOL ENROLLMENT
PROJECTION BY COHORT SURVIVAL METHOD

	Actual 1959-60	3 Year Average Survival Ratio	Projected 1960-61
1953 Births (788) as a ratio of 1960 Grade 2 (740) 1954 Births (887)		.94	
Grade 1	798	.9276	834
2	693	.9339	740
3	703	.9480	647
4	677	.9627	666
5	672	.9315	652
6	666	1.0186	626
7	725	.9564	678
8	571	1.0223	693
Total Public Elementary School Enrollment			5536
Total Private Elementary School Enrollment			456
Total Flathead County Elementary School Enrollment			5992
Grade 9	625	.9356	584
10	547	.8836	585
11	494	.8641	483
12	Graduated		427
Total Public High School Enrollment (No Private High School Enrollment in Flathead County)			2079

Source: Montana State Department of Public Instruction

It should be further noted that, as in the 6th and 8th grade classes, the survival ratio is in excess of 1:1. This is not necessarily an error, since between the close of one school year and the opening of the next, new students might move into the area, providing a higher enrollment in the cohort than was recorded the previous year.

APPENDIX B

RATIO OF ESTIMATED POPULATIONS TO CENSUS TOTALS FOR MONTANA COUNTIES 1950 AND 1960. COLUMNS 3 AND 4 INDICATE THE PERCENTAGE OF ERROR

	1950 Ratio	1960 Ratio	1950 Percentage of Error	1960 Percentage of Error
Beaverhead	1.098	1.007	.098	.007
Big Horn	1.049	.939	.004	.061
Blaine	.997	.970	.003	.030
Broadwater	1.076	.899	.076	.101
Carbon	1.081	.909	.081	.091
Carter	1.111	.957	.111	.043
Cascade	1.036	.954	.036	.045
Chouteau	.927	1.059	.073	.059
Custer	1.039	.988	.039	.012
Daniels	.961	1.048	.039	.048
Dawson	1.014	.991	.014	.009
Deer Lodge	1.202	1.121	.202	.121
Fallon	1.035	.885	.035	.115
Fergus	.980	1.041	.020	.041
Flathead	1.080	.989	.080	.011
Gallatin	1.052	1.015	.052	.015
Garfield	.888	.956	.112	.044
Glacier	1.041	.969	.041	.031
Golden Valley	.868	.899	.132	.101
Granite	1.103	1.089	.103	.089
Hill	1.023	.923	.023	.077
Jefferson	1.261	1.117	.261	.111
Judith Basin	.886	.941	.114	.059
Lake	1.031	.911	.031	.089
Lewis and Clark	.974	.910	.026	.090
Liberty	.985	.849	.015	.151
Lincoln	1.127	1.096	.111	.096
Madison	1.178	1.092	.178	.092
McCone	1.186	1.136	.186	.136
Meagher	1.008	.679	.008	.071
Mineral	1.042	.830	.042	.170
Missoula	1.052	.965	.052	.035
Musselshell	1.106	.898	.106	.102
Park	.980	.960	.020	.040
Petroleum	1.094	.861	.094	.139
Phillips	1.014	.861	.014	.139

APPENDIX B--Continued

	1950 Ratio	1960 Ratio	1950 Percentage of Error	1960 Percentage of Error
Pondera	.847	.962	.153	.038
Powder River	1.153	1.080	.153	.080
Powell	1.231	.941	.231	.059
Prairie	.917	.892	.083	.108
Ravalli	1.104	.931	.104	.069
Richland	.987	.880	.013	.120
Roosevelt	.881	1.014	.119	.014
Rosebud	1.043	.821	.043	.179
Sanders	1.139	1.006	.139	.006
Sheridan	.961	.893	.039	.107
Silver Bow	1.026	.950	.026	.050
Stillwater	1.068	1.101	.068	.101
Sweet Grass	1.066	.901	.066	.099
Teton	1.083	1.046	.083	.046
Toole	1.006	.971	.006	.029
Treasure	.972	.810	.028	.190
Valley	1.004	.914	.004	.086
Wheatland	.942	1.050	.058	.050
Wibaux	.901	1.098	.099	.098
Yellowstone	1.034	1.033	.034	.033
Sum	57.950	54.258	4.181	4.233
Mean	1.035	.969	.075	.076
Standard Deviation			.060	.045

APPENDIX C

BIMD-06 "MULTIPLE REGRESSION AND CORRELATION ANALYSIS NO. 1" IBM-7090 PRINT-OUT USING SAMPLE SIZE OF 112 WITH 6 VARIABLES EACH, THE DEPENDENT VARIABLE BEING CENSUS POPULATION 1950 AND 1960

Coefficient of Determination	0.9955
Multiple Correlation Coefficient	0.9977

Sum of Squares Attributable to Regression	85744829.00000
Sum of Squares of Deviation From Regression	99359232.00000
Variance of Estimate	937351.24219
Standard Error of Estimate	968.16901
Intercept (A Value)	146.53064

ANALYSIS OF VARIANCE FOR THE MULTIPLE LINEAR REGRESSION

Source of Variation	DF	Sum of Squares	Mean Squares	F Value
Due to Regression	5	85744829.000	68595863.00000	4683.554
Deviation About Regression	106	99359232.000	937351.24219	
Total	111	86132951.000		

Variable Number	Mean	Standard Deviation	Regression Coefficient	Std. Error of Reg. Coe.
1	296.19643	387.72013	17.55936	1.25341
2	109.77678	138.99930	21.65683	2.17119
3	3922.02676	5225.67749	0.76651	0.16780
5	1896.01785	2421.21591	-1.96737	0.45545
6	616.38393	752.42841	6.97568	1.37618
4	11300.76782	14094.28857		

APPENDIX C--Continued

Variable Number	Computed T Value	Partial Corr. Coe.	Variance Added	Prop. Variance
1	14.00927	0.80573	83779166.000	0.97267
2	9.97464	0.69574	83108477.000	0.01508
3	4.56796	0.40547	72151100.000	0.00654
5	-4.31959	-0.38681	2342828.625	0.00011
6	5.06887	0.44162	24084493.750	0.00109

Using the intercept (146.53064) as the constant and the regression coefficients listed above, the following formula was derived.

P = 146.53064 + 17.55936A + 21.65683B + .76651C - 1.96737D + 6.97568E

where A = Live births
B = Deaths
C = Automobile registrations
D = Elementary school enrollments
E = High school enrollments

APPENDIX D

ESTIMATED COUNTY POPULATIONS FOR YEARS 1950 THROUGH 1960,
AND CENSUS TABULATIONS FOR 1950 AND 1960

County	Year	Census Population	Estimated Population	Ratio
Beaverhead	50	6671	6073	1.098
	51		6798	
	52		6481	
	53		7465	
	54		7045	
	55		7054	
	56		7304	
	57		7399	
	58		7659	
	59		8169	
	60	7194	7143	1.007
Big Horn	50	9824	9365	1.049
	51		9645	
	52		9459	
	53		9007	
	54		8804	
	55		8924	
	56		9397	
	57		10533	
	58		10236	
	59		9060	
	60	10007	10657	.939
Blaine	50	8516	8541	.997
	51		8450	
	52		8379	
	53		8126	
	54		8673	
	55		8918	
	56		7839	
	57		7778	
	58		8416	
	59		8139	
	60	8091	8342	.970

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Broadwater	50	2922	2716	1.076
	51		2730	
	52		2757	
	53		2888	
	54		2645	
	55		3062	
	56		3237	
	57		3034	
	58		2914	
	59		3218	
	60	2804	3119	.899
Carbon	50	10241	9470	1.081
	51		9176	
	52		9285	
	53		8349	
	54		8990	
	55		9275	
	56		9018	
	57		9630	
	58		8778	
	59		9095	
	60	8317	9154	.909
Carter	50	2798	2518	1.111
	51		2679	
	52		2384	
	53		2725	
	54		2202	
	55		2374	
	56		2321	
	57		2066	
	58		2262	
	59		2110	
	60	2493	2605	.957
Cascade	50	53027	51157	1.036
	51		53146	
	52		56440	
	53		56698	
	54		60666	
	55		61358	
	56		65592	
	57		69104	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Cascade (continued)	58		71563	
	59		73200	
	60	73418	76923	.954
Chouteau	50	6974	7520	.927
	51		7261	
	52		6833	
	53		7610	
	54		7478	
	55		8053	
	56		7741	
	57		7895	
	58		7206	
	59		7497	
	60	7348	6939	1.059
Custer	50	12661	12184	1.039
	51		13503	
	52		13406	
	53		13172	
	54		13228	
	55		13655	
	56		14279	
	57		14919	
	58		14331	
	59		13409	
	60	13227	13386	.988
Daniels	50	3946	4107	.961
	51		4360	
	52		4279	
	53		4205	
	54		4181	
	55		4511	
	56		3966	
	57		4582	
	58		4090	
	59		4086	
	60	3755	3584	1.048
Dawson	50	9092	8970	1.014
	51		9305	
	52		9625	
	53		11046	
	54		11361	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Dawson (continued)	55		12649	
	56		12139	
	57		13368	
	58		12785	
	59		12608	
	60	12314	12428	.991
Deer Lodge	50	16553	13769	1.202
	51		14951	
	52		15589	
	53		16358	
	54		16958	
	55		17128	
	56		18038	
	57		20095	
	58		18778	
	59		17519	
	60	18640	16634	1.121
Fallon	50	3660	3537	1.035
	51		3920	
	52		3600	
	53		3879	
	54		3830	
	55		4318	
	56		4304	
	57		3964	
	58		4144	
	59		3805	
	60	3997	4517	.885
Fergus	50	14015	14304	.980
	51		14594	
	52		14291	
	53		14287	
	54		14157	
	55		14422	
	56		15212	
	57		14415	
	58		13982	
	59		14397	
	60	14018	13462	1.041
Flathead	50	31495	29152	1.080
	51		32077	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Flathead (continued)	52		32413	
	53		31416	
	54		33078	
	55		34950	
	56		33796	
	57		35599	
	58		32905	
	59		33652	
	60	32965	33331	.989
Gallatin	50	21902	20810	1.052
	51		20501	
	52		20723	
	53		20325	
	54		21037	
	55		23899	
	56		23786	
	57		24918	
	58		25205	
	59		26041	
	60	26045	25666	1.015
Garfield	50	2172	2445	.888
	51		2064	
	52		2264	
	53		1992	
	54		2289	
	55		1806	
	56		1821	
	57		2080	
	58		1961	
	59		2387	
	60	1981	2073	.956
Glacier	50	9645	9263	1.041
	51		9903	
	52		9552	
	53		9844	
	54		10414	
	55		11939	
	56		12209	
	57		13235	
	58		11174	
	59		11067	
	60	11565	11932	.969

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Golden Valley	50	1337	1539	.868
	51		1431	
	52		1383	
	53		1352	
	54		1483	
	55		1501	
	56		1218	
	57		1376	
	58		1487	
	59		1435	
	60	1203	1338	.899
Granite	50	2773	2513	1.103
	51		2545	
	52		3044	
	53		2835	
	54		2996	
	55		3053	
	56		3469	
	57		3312	
	58		3412	
	59		3285	
	60	3014	2767	1.089
Hill	50	14285	13967	1.023
	51		15383	
	52		14818	
	53		15834	
	54		17075	
	55		17250	
	56		17866	
	57		19985	
	58		19866	
	59		19864	
	60	18653	20216	.923
Jefferson	50	4014	3184	1.261
	51		3379	
	52		3322	
	53		3676	
	54		3611	
	55		3529	
	56		3554	
	57		4300	
	58		3543	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Jefferson (continued)	59		3798	
	60	4297	3849	1.117
Judith Basin	50	3200	3611	.886
	51		3192	
	52		3430	
	53		3681	
	54		3496	
	55		3336	
	56		2930	
	57		3379	
	58		3261	
	59		3089	
	60	3085	3278	.941
Lake	50	13835	13414	1.031
	51		12866	
	52		12909	
	53		12771	
	54		12956	
	55		13480	
	56		12388	
	57		13519	
	58		12640	
	59		13262	
	60	13104	14382	.911
Lewis and Clark	50	24540	25207	.974
	51		25200	
	52		26284	
	53		26039	
	54		24803	
	55		25985	
	56		26900	
	57		28239	
	58		29166	
	59		29714	
	60	28006	30760	.910
Liberty	50	2180	2213	.985
	51		2500	
	52		2382	
	53		2566	
	54		3293	
	55		3568	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Liberty (continued)	56		3205	
	57		3060	
	58		2707	
	59		2984	
	60	2624	3091	.849
Lincoln	50	8693	7713	1.127
	51		9256	
	52		9074	
	53		9137	
	54		9919	
	55		11249	
	56		12450	
	57		12039	
	58		10923	
	59		11865	
	60	12537	11442	1.096
Madison	50	5998	5090	1.178
	51		5741	
	52		5505	
	53		5839	
	54		5284	
	55		5416	
	56		5483	
	57		5267	
	58		5119	
	59		5707	
	60	5211	4770	1.092
McCone	50	3258	2747	1.186
	51		3331	
	52		3277	
	53		3421	
	54		3125	
	55		3354	
	56		3331	
	57		3101	
	58		3057	
	59		3242	
	60	3321	2922	1.136
Meagher	50	2079	2062	1.008
	51		2107	
	52		2505	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Meagher (continued)	53		2171	
	54		2044	
	55		2241	
	56		2392	
	57		2528	
	58		2675	
	59		2763	
	60	2616	2817	.929
Mineral	50	2081	1998	1.042
	51		2186	
	52		2089	
	53		2653	
	54		2553	
	55		3013	
	56		3085	
	57		3219	
	58		3176	
	59		3392	
	60	3037	3660	.830
Missoula	50	35493	33720	1.052
	51		32125	
	52		33617	
	53		34604	
	54		36106	
	55		38998	
	56		41386	
	57		44809	
	58		42081	
	59		45123	
	60	44663	46285	.965
Musselshell	50	5408	4888	1.106
	51		4885	
	52		4937	
	53		4433	
	54		5066	
	55		5067	
	56		5367	
	57		5511	
	58		5022	
	59		5234	
	60	4888	5442	.898

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Park	50	11999	12248	.980
	51		12059	
	52		11364	
	53		12564	
	54		13098	
	55		12959	
	56		12441	
	57		13077	
	58		14017	
	59		14052	
	60	13168	13711	.960
Petroleum	50	1026	938	1.094
	51		1039	
	52		925	
	53		955	
	54		1038	
	55		1045	
	56		941	
	57		876	
	58		882	
	59		1039	
	60	894	1038	.861
Phillips	50	6334	6245	1.014
	51		6377	
	52		6981	
	53		6469	
	54		7639	
	55		6852	
	56		7192	
	57		6850	
	58		6321	
	59		6758	
	60	6027	6999	.861
Pondera	50	6392	7547	.847
	51		7531	
	52		7736	
	53		8110	
	54		7386	
	55		7935	
	56		7891	
	57		8715	
	58		8047	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Pondera (continued)	59		7651	
	60	7653	7955	.962
Powder River	50	2693	2336	1.153
	51		2214	
	52		1892	
	53		1952	
	54		2539	
	55		2522	
	56		2308	
	57		2272	
	58		2082	
	59		2378	
	60	2485	2300	1.080
Powell	50	6301	5118	1.231
	51		6168	
	52		6219	
	53		6565	
	54		6556	
	55		6370	
	56		6981	
	57		7064	
	58		7123	
	59		8568	
	60	7002	7438	.941
Prairie	50	2377	2592	.917
	51		2202	
	52		2793	
	53		2482	
	54		2723	
	55		2426	
	56		2690	
	57		2595	
	58		2724	
	59		2219	
	60	2318	2599	.892
Ravalli	50	13101	11865	1.104
	51		11508	
	52		11912	
	53		11320	
	54		12024	
	55		11553	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Ravalli (continued)	56		11982	
	57		12659	
	58		13229	
	59		13074	
	60	12341	13254	.931
Richland	50	10366	10505	.987
	51		10710	
	52		11246	
	53		10268	
	54		11511	
	55		11762	
	56		12005	
	57		12197	
	58		11877	
	59		12458	
	60	10504	11942	.880
Roosevelt	50	9580	10870	.881
	51		11650	
	52		12403	
	53		13476	
	54		14220	
	55		13668	
	56		14149	
	57		13129	
	58		12039	
	59		11135	
	60	11731	11572	1.014
Rosebud	50	6570	6301	1.043
	51		5601	
	52		6291	
	53		5828	
	54		5595	
	55		6000	
	56		6336	
	57		6143	
	58		6068	
	59		5905	
	60	6187	7532	.821
Sanders	50	6983	6131	1.139
	51		6637	
	52		7047	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Sanders (continued)	53		7720	
	54		6980	
	55		7157	
	56		8837	
	57		8708	
	58		7814	
	59		7758	
	60	6880	6838	1.006
Sheridan	50	6674	6947	.961
	51		7009	
	52		7541	
	53		8155	
	54		7085	
	55		7480	
	56		7186	
	57		7337	
	58		6939	
	59		6873	
	60	6458	7234	.893
Silver Bow	50	48422	47177	1.026
	51		50882	
	52		50486	
	53		54138	
	54		54848	
	55		55828	
	56		58518	
	57		60229	
	58		52769	
	59		50444	
	60	46454	48903	.950
Stillwater	50	5416	5073	1.068
	51		5231	
	52		4942	
	53		5515	
	54		5942	
	55		5480	
	56		5893	
	57		5652	
	58		5389	
	59		5465	
	60	5526	5021	1.101

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Sweet Grass	50	3621	3395	1.066
	51		3393	
	52		3186	
	53		3746	
	54		3694	
	55		3882	
	56		3851	
	57		3692	
	58		3619	
	59		3704	
	60	3290	3650	.901
Teton	50	7232	6676	1.083
	51		7036	
	52		7203	
	53		7206	
	54		8308	
	55		7175	
	56		7048	
	57		7359	
	58		7260	
	59		7374	
	60	7295	6977	1.046
Toole	50	6867	6823	1.006
	51		7323	
	52		7130	
	53		7496	
	54		7835	
	55		8748	
	56		8225	
	57		8124	
	58		7894	
	59		8029	
	60	7904	8143	.971
Treasure	50	1402	1443	.972
	51		1229	
	52		1324	
	53		1356	
	54		1230	
	55		1532	
	56		1578	
	57		1452	
	58		1656	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Treasure (continued)	59		1431	
	60	1345	1661	.810
Valley	50	11353	11309	1.004
	51		12439	
	52		12134	
	53		12837	
	54		12173	
	55		12121	
	56		12461	
	57		12961	
	58		14434	
	59		16834	
	60	17080	18679	.914
Wheatland	50	3187	3383	.942
	51		3486	
	52		3689	
	53		3185	
	54		3419	
	55		3346	
	56		3741	
	57		3300	
	58		3404	
	59		3073	
	60	3026	2882	1.050
Wibaux	50	1907	2116	.901
	51		1652	
	52		2171	
	53		2017	
	54		1824	
	55		1581	
	56		1579	
	57		1920	
	58		1718	
	59		1761	
	60	1698	1546	1.098
Yellowstone	50	55875	54011	1.034
	51		53543	
	52		55309	
	53		61810	
	54		64295	
	55		66076	

APPENDIX D--Continued

County	Year	Census Population	Estimated Population	Ratio
Yellowstone (continued)	56		72480	
	57		73608	
	58		72802	
	59		76206	
	60	79016	76459	1.033
State of Montana	50	590966	570815	1.035
	51		588112	
	52		598260	
	53		615573	
	54		632807	
	55		652831	
	56		673344	
	57		698175	
	58		676635	
	59		688405	
	60	674720	694282	.972

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