Staff Papers Series

P79-13 April 1979

POPULATION EFFECTS OF COPPER-NICKEL DEVELOPMENT IN NORTHEAST MINNESOTA

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A Report to the Minnesota Environmental Quality Board., Regional Copper-Nickel Study

REIFS Report No. 6

April 1979

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ABSTRACT

Computer simulations of population changes associated with alternative copper-nickel mining development scenarios are presented in this report. Projected population changes for seven alternative development scenarios are examined in detail for a primary mining impact Study Area in St. Louis County, Minnesota.

ACKNOWLEDGEMENTS

The authors wish to thank Katherine Gustafson of the Minnesota State Planning Agency for invaluable advice and assistance. Leonard A. Laulainen, Jr. did the computer work for this study and made substantial contributions to the model. Royden Tull and Mark Donaldson of the Minnesota Environmental Quality Board, Regional Copper-Nickel Study, read and commented on an earlier draft.

We also wish to acknowledge financial support for this study from the Minnesota State Planning Agency and the U.S. Bureau of Mines. This report is being incorporated into a study of the economic effects of the minerals industry in Minnesota. It is part, also, of related work under the Minnesota Agricultural Experiment Station project on Infrastructure Development Alternatives in Rural Areas. Financial support of the Minnesota Agricultural Experiment Station has made possible the construction and implementation of the regional economic impact forecasting system used in this study.

SUMMARY AND CONCLUSIONS

Copper-nickel resources with potential for commercial development occur in St. Louis and Lake Counties in Northeast Minnesota. The area of potential mining development lies along a line extending from a point near Ely southwestward to a point a few miles south of Eveleth. A geographic study area which includes most known copper-nickel resources was defined by the staff at the Minnesota Environmental Quality Board, Regional Copper-Nickel Study to include 23 incorporated places in an area between Ely and Eveleth in St. Louis County. This paper presents results of an evaluation of the potential effects on Study Area population which may stem from resource development in this area.

Mining and processing of iron ores, primarily taconite, has been underway in the Study Area and its vicinity for many years. However, copper-nickel mining would be new to the area. Development of the Study Area copper-nickel resources remains uncertain since much depends on ore grades, management policy, capital investment requirements, and ore accessibility, all of which can affect the economic returns from mining enterprise. Perceived returns will vary by mine site and mine operator. Decisions to proceed with the development thus may result in one or more mines being open at a time in the future. Thus, assumptions concerning future development scenarios must take into account the number, size, and location of mines in operation at any one time.

Seven copper-nickel development scenarios prepared by the Regional Copper-Nickel Study staff are considered in this report. First, three single mine development scenarios are considered. These consist of a 20 million metric ton per year open pit mine, a 16.68 million metric ton per year open pit/underground combination mine, and a 12.35 million metric ton per year underground mine. All these operations are assumed to be fully integrated with concentrating mills and smelter/refineries. Each alternative complex is assumed to be the only copper-nickel development in the Study Area. Projected demographic effects from these development scenarios represent what can be expected from a minimal amount of copper-nickel development.

A second set of four scenarios for multiple-mine development is also considered. This set of scenarios has the potential for a larger range of population effects than the single-mine scenarios. Some mines in the multiple scenarios are assumed to be fully integrated operations while others lack a smelter/refinery facility. Multiple Alternative I is four mines with no smelter/refineries and with the first mine opening in 1985, the second in 1987, the third in 1993, and the fourth in 1996. Alternative II is four mines with smelter/refineries and with the first integrated operation opening in 1985, and the rest in 1986, 1990, and 1993. In Alternative III, an integrated operation opens in 1987, followed by a mine with no smelter/refinery in 1995. Finally, in Multiple Alternative IV, a mine (no smelter/refinery) opens in 1990 and another (again no smelter/refinery) opens in 1997.

The seven scenarios cover a wide range of possible development options. Examination of the projected population effects resulting from the scenarios reveals that single mine development may cause the Study Area population to increase by as much as 27 percent a few years after operation commences. On the other hand, in the multiple mine development scenarios, Study Area population may more than double. There are also significant differences in the projected population effects which are associated with the timing of development in the scenarios.

A principal reason for the effects over time concerns the Study Area taconite industry. Some development scenarios, particularly Multiple Alternatives III and IV, could have a stabilizing effect on Study Area population. Stabilization would only occur if increases in production per worker in the taconite industry were to take place. Should the projected productivity increases take place, the Study Area population would slowly decline, as shown in the baseline projection, unless copper-nickel development (or its equivalent) were to take place in creating new job openings. If the projected taconite industry productivity increases were not to occur, then the Study Area population total will not move downward over time as in the no copper-nickel development or baseline projection. Under these circumstances, Study Area population, without copper-nickel development, would be stable, or even increase slowly, while total population would increase in all the copper-nickel development scenarios.

POPULATION EFFECTS OF COPPER-NICKEL DEVELOPMENT IN NORTHEAST MINNESOTA*

Patrick D. Meagher and Wilbur R. Maki

INTRODUCTION

This report presents projections of population changes associated with Northeast Minnesota copper-nickel mining development. These projections were made using SIMLAB, an acronym for the University of Minnesota Regional Development Simulation Laboratory. SIMLAB is a computer-based regional socio-economic model.

Copper-nickel mining in Northeast Minnesota may commence as early as the mid-1980's. Significant quantities of resources with commerical potential have been located in the vicinity of Virginia as a result of drilling and other exploratory work. Copper-nickel mining would be new to the area and would be in addition to the extensive taconite mining already underway.

Evaluation of the demographic significance of additional mining activity in the immediate vicinity of known copper-nickel resource locations, and in the context of the larger Northeastern Minnesota region, is the overall objective of this study. Demographic significance is defined in terms of total population and its age-class distribution.

The projected demographic effects resulting from potential copper-nickel development are significant and depend on the magnitude and timing of copper-nickel development assumed in the alternative development scenarios used in this study. In the remainder of this chapter, the geographic Study Area is described, the study objectives are explained in detail, the copper-nickel development scenarios are explained, and an overview of results is presented.

In subsequent chapters, the study methodology, its principal assumptions, and its limitations are examined. The remainder of the paper is taken up with a detailed presentation and interpretation of results. Some technical details are relegated to the Appendix.

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* The Study Area includes 23 municipalities, 14 townships and four unorganized territories in St. Louis County, which is one of seven counties in the Arrowhead Development Region. The examination of population effects is confined to this Study Area.

The Study Area

Known Northeastern Minnesota copper-nickel resources are in Lake and St. Louis Counties. These resources occur approximately along a line extending from a point near Ely southwestward to a point a few miles south of Eveleth. The Study Area selected by the Minnesota Environmental Quality Board, Regional Copper-Nickel Study staff (see Figure 1.1) does not include Lake County since most economic effects from development of the Lake County sites would manifest themselves in St. Louis County. This would happen because few people or business firms which could be affected are located near the Lake County sites which are close to the wilderness of the Boundary Waters Canoe Area. Existing township boundaries define the Study Area within St. Louis County in order to facilitate data collection.

At present, there is no mining of Northeastern Minnesota copper-nickel resources. Significant quantities of resources have been located as a result of drilling and other exploratory work.[1/]

Available information on the location of the copper-nickel resources is summarized in Table 1.1. Areas including known copper-nickel mineralization identified in Figure 1.1 are numbered and data are presented by numbered area in Table 1.1.

All data are in terms of copper content only because the present and foreseeable future market outlook for nickel is uncertain. There may be a surplus of nickel for some time. It even may be more practical to recover nickel from undersea modules than by conventional mining.[2/] The market outlook for copper in the next decade, however, is quite good.[3/] Thus, if mining of Minnesota copper-nickel deposits occurs, it would be for the copper and any nickel recovered would be sold as a by-product.

Mining of iron ores, primarily taconite has been underway within the Study Area for many years. Hence, the copper-nickel mining, although new to the area, would be in addition to the extensive mining operations already there. An evaluation of the demographic significance of additional mining activity is the overall objective of the study. Details of the study objectives are presented next.

1/ Minnesota Department of Natural Resources, Mineral Resources of a Portion of the Duluth Complex and Adjacent Rocks in St. Louis and Lake Counties, Northeastern Minnesota, Division of Minerals, Minerals Exploration Section, Report 93, Hibbing, Minnesota, 1977.

2/ Commodities Research Unit, LTD, Survey of Four Metals, Final Report to the Minnesota State Government, December 1977. This document has no page numbers so table numbers are referenced. See Table 1.5 and accampanying discussion.

3/ Robin Adams, Why Copper Prices Are Going to Triple Over the Next Decade, Chase Econometric Associates Inc. Presented at the 1979 American Institute of Mining Engineers Meeting, New Orleans, LA, February 1979.

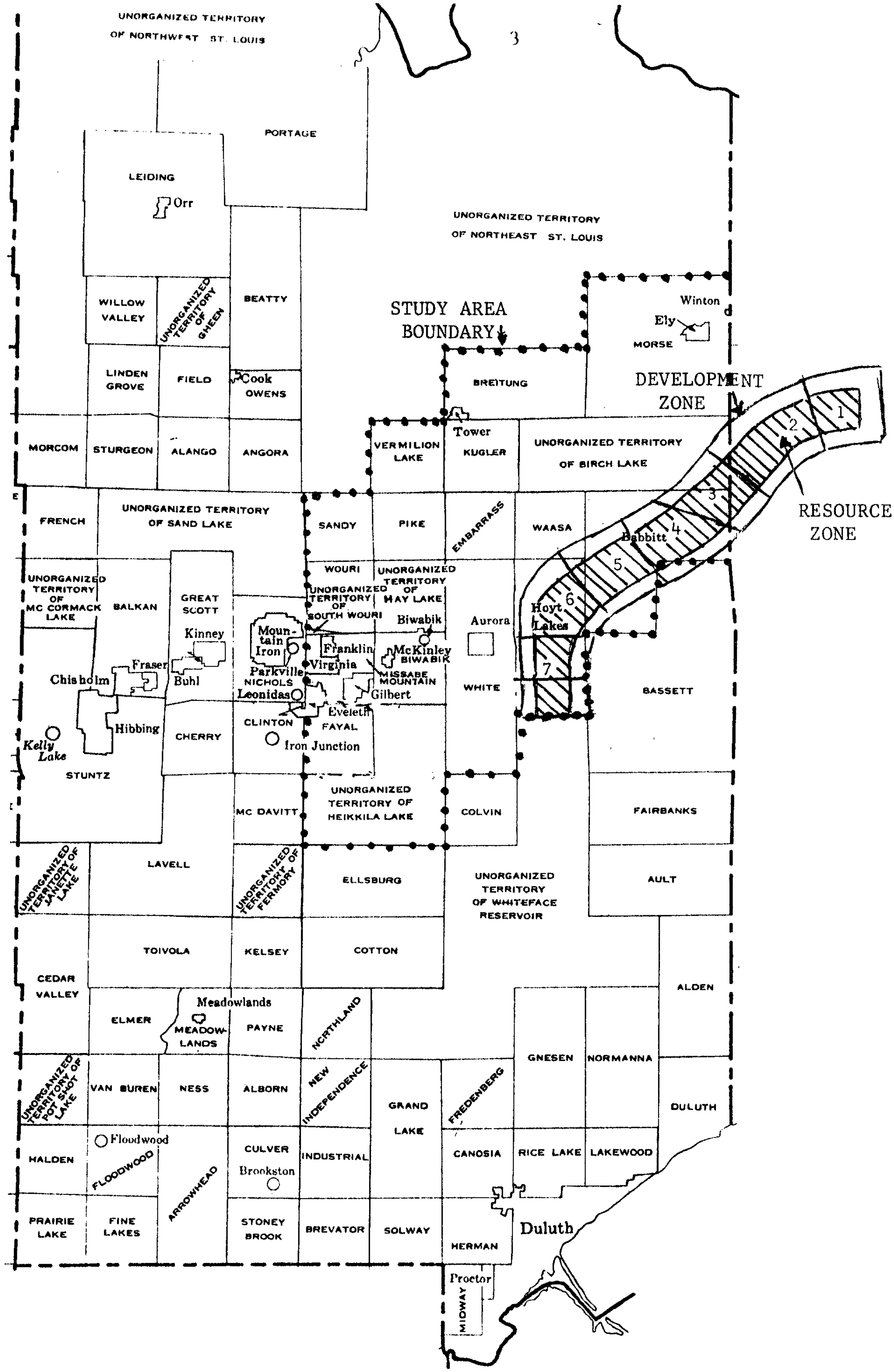


Fig. 1.1. Minor Civil Divisions and Primary Copper-Nickel Study Area, Northeast Minnesota, 1977.

Table 1.1

Estimated Northeast Minnesota Copper Ore Resources

Resource Zone	Near Surface[1/]	Above 1000 Feet[2/]	Below 1000 Feet[2/]
	(million metric tons)		
1	107.2	369.9	371.9
2	-----	339.6	1,614.7
2 & 3 [3/]	14.6	112.5	-----
3	245.8	18.9	76.1
4	183.4	49.1	545.2
5	38.1	73.4	232.8
6	59.6	52.0	48.9
7	-----	11.2	-----
TOTAL	647.7	1,026.8	2,889.6
AVERAGE COPPER GRADE (%)	0.34	0.66	0.66

1/ Estimated .25 to .50 percent copper.

2/ Estimated .50 percent copper.

3/ Copper resources in Zones 2 and 3 are underneath Birch Lake.

Source: Minnesota Environmental Quality Board, Regional Copper-Nickel Study.

Study Objectives

Should copper-nickel mining develop, it may cause changes in total study area population and its age distribution. These changes, in turn, would affect local government, transportation, housing, land use, schools, and business development. For example, public and private services cater to particular age groups. Children and young adults need schools. Families require housing, which, in turn, requires streets and utilities. Older people require more medical care than the rest of the population and they may need special services, such as nursing homes.

Given the potential for copper-nickel development, this paper presents projections of population changes associated with different development possibilities or scenarios which are explained in the next section. No attempt is made to forecast changes inthe geographic distribution of the Study Area population, however, inasmuch as geographic distribution can be affected by public policy decisions concerning zoning, utilities, and other matters which cannot be predicted.

Population changes are shown in the text to be related to the timing and magnitude of copper-nickel development. Alternative scenarios concerning development are explained next.

Copper-Nickel Development Scenarios

A development scenario is an assumption concerning possible future copper-nickel development. There are a number of possible minesites in the development zones shown in Figure 1.1. At least three different kinds of mines appear possible in view of what is known about the copper-nickel resources. These consist of an open pit mine producing 20 million metric tons of ore annually, a 11.33 million metric ton per year open pit mine operating in conjunction with a 5.35 million metric ton per year underground mine to produce 16.68 million metric tons per year of output, and a 12.35 million metric ton per year underground mine. Table 1.2 shows the estimated lifespan for each mine type given the quantity of copper-nickel resources known to be present in each development zone. A mine lifespan of twenty years or more would permit amortization of invested capital at the straight-line rate of five percent per year. This makes some sites relatively more attractive than others on economic grounds since they hold enough mineralization for a relatively long period of operation. A long period of operation helps assure mining companies that they could recover their investment in mining and processing facilities.

A long period of operation does not guarantee mine profitability. Profitability would vary among the potential minesites because of different ore grades, management policy, capital investment required, and ore accessibility. Profitability differences and different management views of the best time to risk a new venture suggest that the mines may be opened at different times. Thus, realistic development scenarios deal with alternative numbers of mines open at any one time. Unnecessary complexity can be avoided by examining a set of scenarios which demonstrate the range of possibilities.

Table 1.2

Life span (in years) per development zone assuming a given mine production per zone and all resources extractable.

Mine Type	Open Pit 20.00	Combination 11.33 (Open Pit)	5.35 a/ (Underground)	Underground 12.35
ZONE				
1	23.9	42.1	53.5	22.2
2	17.0	30.0	232.4	100.6
2&3	(3.8) b/	(6.8) b/	(7.3) c/	(3.2) c/
3	13.2	23.3	10.9	4.8
4	11.6	20.5	78.5	33.9
5	5.6	9.8	33.5	14.5
6	5.6	9.8	7.0	3.0
7	0.6	1.0	-----	-----

a/ These numbers are calculated assuming 23% of resource will be left in place for underground mining roof support.

b/ These figures show the number of mine production years lost because resource is underwater and within 600 feet of surface.

c/ These figures are the number of mine production years gained by assuming 40% (600-1000 foot level) of resource in this zone can be extracted by underground techniques.

Source: Minnesota Environmental Quality Board, Regional Copper-Nickel Study.

Table 1.3

Alternative multiple-mine scenarios for Study Area.

ALTER-NATIVE	DESCRIPTION	START PRODUCTION
I	Open pit mine/mill, no smelter/refinery in Study Area	1985
	Combination mine/mill, no smelter/refinery in Study Area	1987
	Underground mine/mill, no smelter/refinery in Study Area	1993
	Combination mine/mill, no smelter/refinery in Study Area	1996
II	Open pit mine/mill, with smelter/refinery in Study Area	1985
	Combination mine/mill, with smelter/refinery in Study Area	1986
	Underground mine/mill, with smelter/refinery in Study Area	1990
	Combination mine/mill, with smelter/refinery in Study Area	1993
III	Combination mine/mill, with smelter/refinery in Study Area	1987
	Underground mine/mill, no smelter/refinery in Study Area	1995
IV	Underground mine/mill, no smelter/refinery in Study Area	1990
	Combination mine/mill, no smelter/refinery in Study Area	1997

Source: Minnesota Environmental Quality Board, Regional Copper-Nickel Study.

In summary, the scenarios used in this study are as follows. First, single mine development scenarios are considered. These consist of a 20 million metric tons per year open pit mine, a 16.68 million metric tons per year open pit/underground combination mine, and a 12.35 million metric tons per year underground mine. All operations are assumed to be fully integrated with concentrating mills and smelter/refineries. Each alternative complex is assumed to be the only copper-nickel development in the Study Area. The projected effects from these development scenarios represent what can be expected from a minimal amount of copper-nickel development.

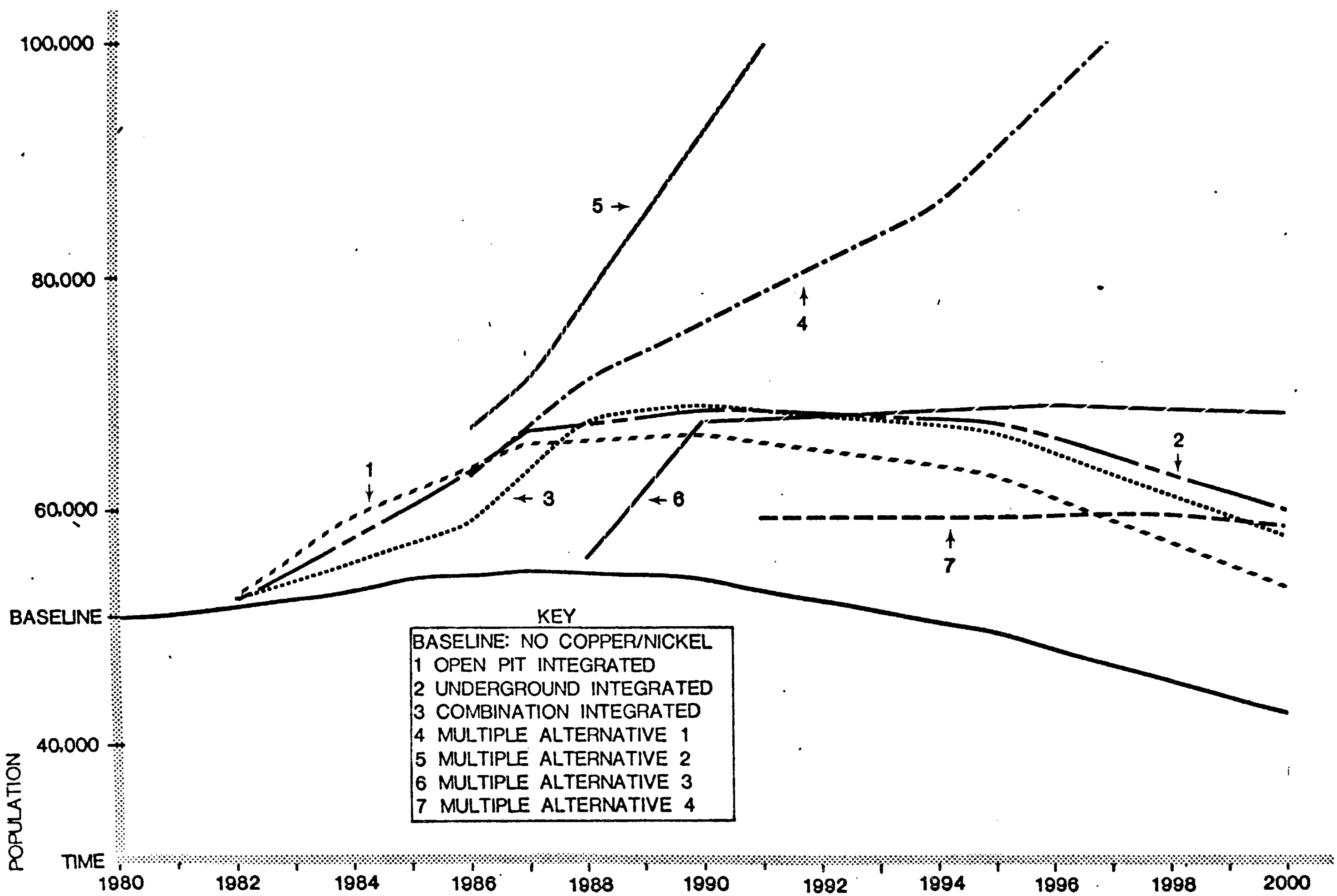
Second, the projected effects from multiple mine development scenarios are considered. This set of scenarios (see Table 1.3) has the potential for a larger range of effects than the single mine scenarios. In order to obtain the clearest view of the possible range of effects, some mines in the multiple scenarios are assumed to be fully integrated while others do not include a smelter/refinery.

Projections of Study Area total population associated with each of the seven development scenarios are summarized in Figure 1.2. The scenarios demonstrate a wide range of possible impacts. Each projection is examined in detail in the last section of this paper.

In the detailed examination much depends on an understanding of the methodology generating the projections. The methodology involves the use of computer simulation which is explained next.

Figure 1.2

Projected Study Area Population Associated With Alternative Copper-Nickel Development Scenarios



SIMLAB

SIMLAB is an acronym for the University of Minnesota Regional Development Simulation Laboratory, a regional socio-economic model developed for projecting the effects of events like copper-nickel development. SIMLAB is called a simulation model because it yields quantitative measures of the effects of given development situations. The model consists of a series of mathematical expressions representing regional inter-industry and inter-sectoral linkages between regional industries and their national and regional markets.

SIMLAB is implemented for a particular geographic region with data on production by regional industries, employment, earnings, labor force, and population. SIMLAB is calibrated to follow recent trends in these data. When the SIMLAB user supplies assumptions concerning future deviations from these trends, such as the appearance of new industry, SIMLAB responds with projections of study area industry production, employment, earnings, labor force, population, and a number of other socio-economic variables.

SIMLAB Assumptions

The principal assumption behind the SIMLAB population projections is that the study area labor force and population change in response to job opportunities. Thus, the projected population changes presented depict employment-related changes due to copper-nickel development. These changes are assumed to be the most important ones to consider. The employment changes, however, are not confined soley to employment in the copper-nickel industry. Rather, changes in employment in all Study Area industries are considered in the projected population change. Further details on how SIMLAB works and the technical assumptions involved inthe population projections can be found in the Appendix.

Limitations of SIMLAB Projections

An important limitation of SIMLAB projections is that they must be interpreted as projections of potential changes. The potential changes cannot become reality until homes are built and essential public services become available, events which require decisions by local public officials. Similarly, the projected employment changes upon which the population projections are based must be interpreted as potential changes to the extent that decisions by local officials concerning, for example, zoning and the environment, are required before study area industry expansion can occur.

POTENTIAL EFFECTS FROM COPPER-NICKEL DEVELOPMENT ON STUDY AREA POPULATION

Projections of potential population changes due to copper-nickel development presented in this paper are based on SIMLAB projections of employment. Three kinds of employment change or effects are determined simultaneously in the SIMLAB model. These are the direct, indirect, and induced effects.

Direct, Indirect, and Induced Effects of Copper-Nickel Development

Direct effects of copper-nickel development are defined to be employment at the mine/mill and smelter/refinery complex. Study Area firms selling supplies, materials, and services to the copper-nickel industry are also said to be directly affected by copper-nickel mining operations. Indirect effects include increased employment in Study Area firms selling goods and services to directly affected firms. Induced effects include increased employment in Study Area industries selling goods and services to households of copper-nickel employees and to households of directly and indirectly affected firms.

Interpretation of the direct impacts depends on how the mine workers become employed. If all come from outside the region to take mine employment, then they represent a net increase in area employment and earnings. They and their dependents represent a net increase in the area population as well. If mine employment simply results in a redistribution of the existing regional labor force, with vacated jobs left open for want of someone to fill them, then employment and population impacts are nominal. Or, if all mine jobs are filled from among the area unemployed, then there is a net direct increase in employment and earnings, but no net impact on population since no one would move into the region. A combination of all three possible events is likely. The SIMLAB model takes this into account. The model forecasts inmigration of new workers only if the existing regional labor force is not large enough to fill available openings. Available openings are forecast by occupation and compared with available workers by occupation so no special assumptions about occupational mobility are made. The key assumption is that all jobs are filled, by inmigration if necessary.

Once all jobs are filled and necessary inmigration takes place, the SIMLAB model projects changes in demographic characteristics, such as population and population age-sex distribution resulting from the inmigration. Births and deaths are also taken into account. In short, SIMLAB population projections are made using an age-cohort survival procedure which is explained in the Appendix.

At least two SIMLAB projections are needed to measure the potential impacts of copper-nickel development. One projection is called the baseline and the other is the development scenario.

Baseline Projection of Study Area Population

Baseline projections of population characteristics represent future regional development in the absence of copper-nickel development. Thus, the baseline projection provides a reference plane for impact estimates which are presented as deviations from the baseline. The SIMLAB procedure for generating the baseline is based on assumptions concerning the future expansion of the

Table 3.1

Baseline Population and Employment, Study Area, 1970-2000.

YEAR	POPULATION	TOTAL EMPLOYMENT	TACONITE EMPLOYMENT
	(numbers)		
1970	48,419	19,362	6,382
1977	51,194	24,334	7,752
1980	51,301	26,039	8,127
1981	51,579	26,660	8,257
1982	51,954	17,346	8,345
1983	52,523	28,027	8,435
1984	53,211	28,749	8,523
1985	54,396	29,581	8,601
1986	54,506	29,734	8,336
1987	54,950	29,982	8,080
1988	54,902	30,014	7,831
1989	54,622	29,874	7,590
1990	54,177	29,555	7,345
1995	49,611	27,056	5,234
2000	42,987	24,215	3,703

Table 3.2

Baseline Option,Total Population and Age Class Distribution, Study Area, 1970-2000.

Age Class	1970 Census	1977	1982	1984	1985	1986	1987	1990	1995	2000
					(number)					
1-5	4,670	4,111	4,789	5,248	5,457	5,651	5,785	5,867	4,638	2,856
6-17	13,231	11,403	9,085	8,902	9,105	9,071	9,169	9,236	9,761	9,170
18-24	3,845	6,461	6,486	6,138	5,958	5,490	5,141	3,899	2,714	654
25-34	4,683	5,676	7,777	9,186	10,029	10,484	10,994	10,345	6,629	2,421
35-59	14,554	15,525	15,710	15,647	15,752	15,726	15,781	16,837	18,256	18,278
60-64	2,388	3,042	2,738	2,619	2,576	2,572	2,578	2,546	2,403	2,853
65+	5,048	2,976	5,369	5,471	5,519	5,512	5,502	5,429	5,210	4,939
TOTAL	48,419	51,194	51,954	53,211	54,396	54,506	54,950	54,177	49,611	42,987

taconite industry and on historic trends in other socio economic variables.

Future development of the Study Area economy, in the absence of copper-nickel development, will be primarily dependent on the taconite industry. Projections of taconite expansion were based on industry estimates presented at Minnesota Energy Agency certificate of need hearings.4/ The baseline projection of Study Area population and taconite industry employment is presented in Table 3.1. A detailed baseline projection of Study Area population characteristics for selected years to the year 2000 is presented in Table 3.2.

Study Area population and employment are projected to increase until the mid-1980's as the taconite industry slowly expands. After 1986, even though taconite production will continue to expand, taconite employment will level off and begin to decline, given projected increases in taconite industry production per worker. The improved productivity per worker means fewer workers per ton of pellets produced because of new equipment, new mining technology, and/or mechanization of tasks now performed by workers.

The historical record shows that production per worker in the crude iron ore (which is not useable without concentration) industry increased 214 percent between 1957 and 1970.5/ This data includes but is not confined to, the existing taconite industry since some natural ores are also classified as crude ore and production of these is being phased out in Minnesota. Nonetheless, it is self-evident that production per worker can double in less than 20 years in the taconite industry.

The SIMLAB assumption that taconite industry production per worker will increase by 80 percent in the thirty year period 1970-2000 is modest in comparison.6/ Indeed, it could be too modest because the taconite industry is highly energy intensive. If energy prices were to increase greatly, the taconite industry may respond by investing in energy-saving technology. This technology may also reduce labor requirements.7/

4/ Information on future expansion of the taconite industry used in SIMLAB is from direct testimony and hearing transcripts from a rehearing on a certificate of need for the Minnesota Power and Light Company and the United Power Association before the Minnesota Energy Agency, 1977.

5/ U.S. Department of Labor, Bureau of Labor Statistics, Productivity Indexes for Selected Industries, 1976 Edition, Bulletin 1938, Table 4, U.S. Government Printing Office, Washington, D.C., 1977.

6/ SIMLAB assumptions concerning changes in productivity in various industries are the same as those made by the U.S. Department of Labor, Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985, Bulletin 1831, U.S. Government Printing Office, Washington, D.C., 1975.

7/ Peter J. Kakela,"Iron Ore: Energy, Labor and Capital Changes with Technology," Science, (202), 1151-1157.

SIMLAB does not forecast changes in production per worker. The SIMLAB user must specify these changes.[8/] SIMLAB forecasts the consequences of the assumed changes as shown earlier in Table 3.1. These consequences show declining employment in the taconite industry and fewer jobs for Study Area residents starting in the late 1980's.

Should changes in taconite worker productivity occur, then the projected 1995 Study Area population is about the same as it was in 1970. Population would peak in 1990 and then decline to 1995 because of the lagged population response to a mid-1980's peak in Study Area economic activity.

The baseline projection of Study Area population is one of two integral parts of the analysis of the potential effects of copper-nickel development. The second part is the development scenario. In the SIMLAB analyses, development scenarios are statements of assumptions concerning the appearance of new industry. When fed into the SIMLAB programs, the scenarios cause the generation of data representing the evolution of the regional economy under changed (from the baseline) circumstances. Since all other assumptions are fixed, differences in the two projections represent the projected development effects which are examined next.

Effects From A Single Mine/Mill Integrated With A Smelter/Refinery

Study Area population changes would result from both construction and operation of the single integrated mining enterprises. It is necessary to begin the analysis of population changes with potential effects from construction because the construction activity leads to an influx of people into the Study Area.

Potential Population Changes From Construction

Construction of alternative fully integrated mining operations is assumed to commence in 1982. This may be the earliest possible date given the time needed for planning and design and for review by appropriate government agencies. However, this assumption is not critical to the results presented here because, as can be seen in Table 3.3, the Study Area population will be fairly stable during the 1980's in the absence of copper-nickel development. Relative to the stable baseline, copper-nickel development commencing anytime in the 1980's would have nearly the same potential effects as those reported here.

SIMLAB simulations of the potential effects from construction of each alternative fully integrated single mine operation are presented in Table 3.3. The number of additional persons in each age-class is presented first, followed by the percentage increase over the baseline projection for the same year. The different alternatives have different potential effects and the projected

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8/ Forecast changes in worker productivity used in the copper-nickel study are from the U.S. Department of Labor, Bureau of Labor Statistics, The Structure of the U.S. Economy in 1980 and 1985, op. cit.

Table 3.3

Projected Population Changes By Age Class Resulting From Construction of Single Mine, Fully Integrated Facilities, Study Area, 1982-1986.[1/]

Age	1982						1984 Peak		1986 Peak		1985 Peak	
	Open Pit		Underground		Combination		Open Pit		Underground		Combination	
	Total (no.)	Relative (%)	Total (no.)	Relative (%)	Total (no.)	Relative (%)	Total (no.)	Relative (%)	Total (no.)	Relative (%)	Total (no.)	Relative (%)
1-5	0	0	0	0	0	0	93	1.8	131	2.3	175	3.2
6-17	158	1.7	83	1.0	113	1.2	1,687	18.9	1,151	12.7	1,510	16.6
18-24	92	1.4	50	.8	67	1.0	1,012	16.5	667	12.1	918	15.4
25-34	151	1.9	79	1.0	109	1.4	1,688	18.4	1,212	11.6	1,582	15.8
35-59	129	.8	70	.4	95	.6	1,558	10.0	1,169	7.4	1,530	9.7
60-64	14	.5	7	.2	10	.4	159	6.1	111	4.3	147	5.7
65+	0	0	0	0	0	0	16	.3	9	.2	25	.5
TOTAL	544	1.0	289	.6	394	.8	6,213	11.7	4,450	8.2	5,887	10.8

1/ All construction is assumed to commence in 1982. Percentage change is relative to baseline projection for the same year.

potential effects change from year to year during the construction phase. The construction phase lasts four years in the case of the open pit and combination operations and five years for the underground mine. Once initial site preparation is finished, the construction workforce would be increased, resulting in greater impacts than in the first year.

Greater impacts would occur after the first year of construction because the Study Area economy responds to the stimulus from construction with additional buildings, equipment, and employees in those Study Area industries serving the construction industry and the households of construction workers. By the time the construction workforce reaches a peak in two years in the open pit scenario, four years in the underground scenario, or three years in the combination scenario, the potential population impact from construction is substantial (table 3.3). Also, significant differences occur in peak year construction impact among the three scenarios.

For all three alternatives, population impacts would be relatively small and would scarcely exceed the workforce at the copper-nickel site in the first year of construction. Workforce forecasts assuming present-day construction worker productivity were prepared by Copper Nickel Study staff.[9/] These estimates were then adjusted in SIMLAB to reflect the level of construction worker productivity expected to prevail at the time of construction. Resulting 1982 first-year construction workforce projections are 298 in the open pit scenario, 178 in the underground scenario, and 229 in the combination scenario.

The largest first year workforce would be employed in construction of the open pit mine. A relatively large first year workforce can be employed in this scenario for stripping off overburden. As a result, first year effects on Study Area population are largest in the open pit scenario. The open pit mine in the combination scenario is much smaller, so fewer first-year workers are required for stripping. And, only a few workers are needed to begin the shaft for the underground part of the combination scenario. Thus, the effects from the combination scenario are smaller than in the open pit case. First-year effects are smallest in the underground scenario because only a relatively small workforce is needed to being the mine shaft.

After the first year, differences among the three alternative integrated scenarios persist because of differences in the magnitude and timing of construction activity. For example, construction in the open pit scenario has the largest peak impact because the scenario would require the largest expenditure and workforce in a single year. This would happen becuase the open pit scenario would require the largest and most expensive concentrating mill to process the largest volume of ore. Peak workforce forecasts are 2,542 workers in the open pit scenario in 1984, 1,987 workers in the underground scenario in 1986, and 2,050 workers in the combination scenario in 1985. Resulting peak year effects on Study Area population are shown in Table 3.3.

9/ Minnesota Environmental Quality Board, Regional Copper-Nickel Study.

The mining scenarios assume that full-scale operation begins the year after construction is finished. During the transition period, the lingering effects of the construction activity mingle with the emerging impacts of mine operation. In the computer simulations, a clear picture of mine operation effects begins to emerge during the second year of full-scale operation. The analysis of effects in this study resumes with the second year of mine operation.

Potential Population Changes From Mine Operation

SIMLAB forecasts of potential Study Area population changes for each of the three integrated mining scenarios in the second year of full-scale operation, as well as in 1990, 1995, and the year 2000 are shown in Table 3.4. The findings show that any of the three scenarios has potential for causing changes in the Study Area total population. In addition, there are projected changes in the number of persons in different age categories. Both these effects vary over time. And, it clearly makes a difference which fully integrated mining scenario is assumed to be in operation. These potential effects are discussed next, beginning with total Study Area population.

Analysis of the effects of mine operation begins in the second year of operation in order to allow time for the Study Area economy to respond to the commencement of mining operations. The second year of full-scale operation is assumed to be 1987 for the open pit and combination scenarios, and 1988 for the underground mine because it would take longer to construct. Second-year workforce estimates are 2,162 for the open pit scenario, 2,685 for the underground scenario, and 2,387 for the combination scenario. These differences in workforce, and the one-year delay for the underground mine, lead to different potential effects on Study Area population.

With the largest workforce, the underground scenario would have the largest impact on Study Area population were it not for the projected decline in taconite employment between 1987 and 1988. The taconite industry is projected to have 249 fewer employees in 1988 (see Table 3.1). In 1988, these persons are unemployed and available to fill jobs created by copper-nickel development, leaving fewer to be filled by incommuting and inmigration. In the other scenarios, in 1987, the 249 persons have jobs and openings created by copper-nickel development must be filled entirely by incommuting and inmigration. Thus, in the second year of operation, the open pit and combination scenarios, with a smaller workforce, have a larger potential effect on Study Area population. This effect can be expected to persist for years until the effects of the larger underground workforce overcome it. In Table 3.4 the effect lasts until 1995.

Over the entire period 1987-2000, the potential population effects of copper-nickel development slowly increase in all three scenarios. For example, in 1987 there may be 10,840 additional persons living in the Study Area in the event the open pit scenario becomes reality. By the year 1995, this number increases to 13,599. This happens because copper-nickel mining would have an increasing role in determining the level of economic activity in the Study Area and the number of jobs available. An increasing role for copper-nickel mining would occur if taconite industry employment levels off and then begins a slow decline because of worker productivity increases

Table 3.4

Projected Population Changes By Age Class Resulting From Operation of Alternative Single, Fully Integrated Copper-Nickel Mines, Study Area, 1987-1990.

Age Class	1987-1988 Open Pit Total (no.)	1987-1988 Open Pit Relative (pct.)	1987-1988 Underground[1/] Total (no.)	1987-1988 Underground[1/] Relative (pct.)	1987-1988 Combination Total (no.)	1987-1988 Combination Relative (pct.)	1990 Open Pit Total (no.)	1990 Open Pit Relative (pct.)	1990 Underground Total (no.)	1990 Underground Relative (pct.)	1990 Combination Total (no.)	1990 Combination Relative (pct.)
1-5	404	7.0	187	3.2	277	4.7	979	16.7	692	11.8	1,088	18.5
6-17	2,963	32.3	3,377	36.8	3,651	39.8	2,667	28.9	3,602	39.0	3,230	35.0
18-24	835	16.2	1,299	25.3	1,286	27.3	1,521	39.0	1,826	46.8	1,747	44.8
25-34	3,125	28.4	3,374	30.7	3,729	34.1	2,108	20.4	3,378	32.7	2,814	27.2
35-59	3,535	22.4	3,446	21.8	3,870	24.0	4,904	29.1	4,783	28.4	5,481	32.6
60-64	283	11.0	312	12.1	338	13.1	318	12.5	368	14.5	368	14.5
65+	-305	-5.5	-239	-4.3	-289	-5.3	-161	-3.0	-168	-3.1	-182	-3.4
TOTAL	10,840	19.7	11,756	21.4	12,862	23.4	12,336	22.8	14,481	26.7	14,546	26.8

Age Class	1995 Open Pit Total (no.)	1995 Open Pit Relative (pct.)	1995 Underground Total (no.)	1995 Underground Relative (pct.)	1995 Combination Total (no.)	1995 Combination Relative (pct.)	2000 Open Pit Total (no.)	2000 Open Pit Relative (pct.)	2000 Underground Total (no.)	2000 Underground Relative (pct.)	2000 Combination Total (no.)	2000 Combination Relative (pct.)
1-5	1,478	31.9	2,012	43.4	1,925	41.5	1,353	47.4	2,227	78.0	1,837	64.3
6-17	1,950	20.0	2,968	30.4	2,574	26.4	1,566	17.1	2,050	22.4	1,950	21.3
18-24	2,102	77.5	2,012	74.1	2,019	74.4	654	100.0	1,649	252.1	1,040	159.0
25-34	1,509	22.8	3,118	47.0	2,307	34.8	1,847	76.3	3,017	124.6	2,420	100.0
35-59	6,633	36.3	7,252	39.7	7,811	42.8	5,737	31.4	7,487	41.0	7,202	39.4
60-64	343	14.3	442	18.4	430	17.9	324	11.4	427	15.0	398	14.0
65+	67	1.3	128	2.5	101	1.9	100	2.0	232	4.7	153	3.1
TOTAL	13,599	27.4	18,022	36.3	17,167	34.6	11,581	26.9	17,089	39.8	15,000	34.9

1/ Underground scenario begins operation in 1988 because of a longer construction period.

Percentage change is relative to baseline projection for the same year.

as explained above. Should this happen, then copper-nickel development as assumed in the scenarios would have a significant sustaining effect on the Study Area population. These effects on total population would be accompanied by effects on the number of persons in different age categories which are examined next.

Like the effects on total population, the effects on the number of persons in different age categories vary with the scenario and over time. For example, as can be seen in Table 3.4, there are more preschool children ages 1-5 in the open pit scenario in 1987 but, there are more school children ages 6-17 in the combination scenario. And by 1990, there are more children ages 1-5 and 6-17 in the combination scenario. In addition, the number of of persons age 65 and over declines below baseline levels in all three scenarios (indicated by a minus sign in table 7). These results indicate that each mining scenario has the potential for a complex set of effects on the age composition of the Study Area population. The reasons for some of these effects are examined next.

During the second year of operation, there are more children ages 1 to 5 in the forecast for the open pit scenario because this scenario has the largest impact on the Study Area population during the construction phase (see table 6). This additional population results in more births than in the other scenarios and, therefore, there are more preschool children a few years later, a lingering effect from the construction phase peak.

Lingering effects from the construction phase are also the reason why the number of persons age 65 and over declines below baseline levels. During the construction phase in all three scenarios, the Study Area population increases. With a larger population, more people turn 65. Then, when construction is finished, some people become unemployed. The unemployed become a pool of potential outmigrants. But, according to the most recent Census,[10/] persons 65 and over are more likely than younger persons to be among any outmigrants from the Study Area. Thus, population changes resulting from construction of mining facilities and commencement of mining operations are likely to result in what amounts to displacement of older persons by younger people. This effect persists in Table 3.4 through 1990. By 1995, however, the effect disappears because it is swamped by the increasing number of persons turning 65 from the growing pool of additional persons whose presence in the Study Area is attributable to copper-nickel mining in any of the three scenarios.

10/ U.S. Department of Commerce, Bureau of the Census, Subject Reports, Migration Between State Economic Areas, PC)2)-2E, U.S. Government Printing Office, Washington, D.C., July 1972.

In 1987, the combination scenario has the largest effect on the number of school age children because it has the largest effect on the total population. By 1990, the underground scenario has the greatest effect on the age group because, it will be recalled from previous discussion, in the underground scenario workers are being absorbed from the taconite industry and there are more young children in these families than there would be in families of workers inmigrating to take jobs in other scenarios.[11/]

Effects From Multiple Mine Development

Northeastern Minnesota copper-nickel mining may involve development and operation of more than one open pit, underground, or combination open pit/underground mine complex. To consider the potential effects from multiple mine development four additional scenarios were evaluated using SIMLAB. These scenarios, which are summarized in Table 1.3, show the kind of mine involved, whether a smelter/refinery is assumed to be present, and the date on which production is assumed to begin. Other scenarios are possible, but the four selected serve to demonstrate the range of possible effects on Study Area population.

Possible effects from construction of the first mining operation in each multiple mine scenario have been excluded from this discussion. Construction impacts from the first operation in every case would be very nearly the same as those from construction of the single mine operations already discussed. Potential effects from construction of mining operations subsequent to the first operation are included in the multiple mine forecasts. This must be done in order to obtain a realistic view of potential effects from the multiple mine scenarios.

Alternative I: Four Mines Without Smelter/Refineries

Potential demographic effects from four mines, with no smelter/refineries located in the Study Area, are shown in Table 3.5. All forecasts are for the year following mine start-up in order to allow time for adjustments in the Study Area economy. Data in Table 8 reveal that this scenario has potential for generating extreme changes in the Study Area population. For example, by the year 1997, the forecast total population change due to copper-nickel mine development exceeds total population in the baseline. By the year 2000, the projected potential effect is almost twice the baseline total population. This seems extreme and raises a question regarding the accuracy of SIMLAB forecasts which is discussed next.

There is relatively little information available which can be used to test the validity of the SIMLAB forecasts, but the results of the four-mine simulations suggest that the forecasts are reasonable. The reasoning is as

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11/ This conclusion is drawn directly from the Census data on inmigrants. See, Migration Between State Economic Areas, op. cit.

Table 3.5

Projected Population Changes By Age Class Resulting From Multiple Mine Alternative I, Copper-Nickel Study Area, 1986-2000

Age Class	1986 Total (no.)	1986 Relative (pct.)	1988 Total (no.)	1988 Relative (pct.)	1994 Total (no.)	1994 Relative (pct.)	1997 Total (no.)	1997 Relative (pct.)	2000 Total (no.)	2000 Relative (pct.)
1-5	412	7.3	950	16.2	3,490	70.1	5,015	128.7	7,423	259.9
6-17	2,265	25.0	3,684	40.1	6,466	66.7	10,198	104.8	13,846	151.0
18-24	1,365	24.9	2,386	50.6	4,678	162.0	6,725	270.8	8,479	343.3
25-34	2,442	23.3	4,131	37.8	8,498	113.3	12,951	266.3	17,177	709.5
35-59	2,552	16.2	4,541	28.2	10,819	60.2	16,541	89.3	23,593	129.1
60-64	228	8.9	398	15.5	841	34.6	1,276	49.9	1,738	60.9
65+	39	.7	129	2.4	611	11.6	901	17.7	1,347	27.3
TOTAL	9,303	17.1	16,219	29.5	35,403		53,607	113.7	73,603	171.2

follows. In the year 1994, when the third mine is in operation (see Table 1.3), projected taconite industry employment is 6,440 persons and projected copper ores industry employment is 5,660 persons or slightly less. And at this point, the forecast potential impact is 35,400 persons, somewhat less than the projected baseline population. Now, as everyone in Minnesota knows, the taconite industry is the principal economic activity in the Study Area and it must support most of the population in the baseline scenario. In the Alternative I development scenario, taconite and copper ores share that role about equally so, it is reasonable to expect that the potential Study Area population would about double in the copper-nickel development scenario and this is the SIMLAB forecast. This result is repeated in 1997, when copper-nickel employment exceeds iron ores employment by 1,700 persons and the projected development scenario population impact is slightly more than the baseline population level.

However, the accuracy of the impact forecast for the year 2000 is doubtful. In this year, copper-nickel employment exceeds iron ores employment by 2,100 persons, and the projected population impact is nearly twice the baseline level. In fact, in the SIMLAB computer run, population continued to increase explosively after the year 2000 even though there is no further copper-nickel development in the scenario. The conclusion is that the SIMLAB model has limits. Up to the point where development scenarios cause population to double, it works reasonably well. After that, it does not make accurate projections. However, in this case the projections may be interpreted qualitatively as suggesting that construction and operation of four copper-nickel mines in the Study Area in an eleven-year time span has the potential for causing very extreme changes in population.

Alternative II: Four Mines With Smelter/Refineries

Potential demographic effects from four mines with smelter/refineries located in the Study Area are shown in Table 3.6. Although the timing of development in this scenario is slightly different (see Table 1.3), the principal reason for the slightly larger impacts relative to those in the previous scenario is the additional employment inthe smelter/refineries. As in the discussion of Alternative I, the forecast potential effects appear to be accurate up to the point where the impact about equals the baseline population. Thus, in this scenario, forecasts for 1994 and 2000 must be regarded as questionable. As in Alternative I, the results may be interpreted qualitatively as suggesting that there is a potential for extreme changes stemming from this much multiple mine development in the period of time specified by the scenario.

Alternative III: Two Mines, One Smelter/Refinery

Potential demographic effects from Alternative III are shown in Table 3.7. In this scenario, there would be two mines. Concentrate from one mine would be processed in a smelter/refinery located within the Study Area. Concentrate from the other mine would be shipped outside the Study Area. This scenario has significantly less potential for extreme effects than Alternatives I and II, as comparison with Tables 3.5 and 3.6 reveals. By the year 2000, employment in the copper ores industry would be about 4,400 persons, or only about

Table 3.6

Projected Population Changes By Age Class Resulting From Multiple Mine Alternative II, Study Area, 1986-2000.

Age	1986		1987		1991		1994		2000	
	Total (no.)	Relative (pct.)	Total (no.)	Relative (pct.)	Total (no.)	Relative (pct.)	Total (no.)	Relative (pct.)	Total (no.)	Relative (pct.)
1-5	256	4.5	631	10.9	3,553	61.8	6,991	140.5	17,460	611.3
6-17	3,508	38.7	3,993	43.5	9,615	103.1	14,928	154.0	46,069	502.4
18-24	2,147	39.1	2,470	48.0	6,338	175.8	9,519	329.7	28,712	1,162.4
25-34	3,546	33.8	4,303	39.1	11,794	121.5	19,282	257.1	53,419	2,206.5
35-59	3,332	21.2	4,284	27.1	13,116	76.4	22,842	127.1	67,740	370.6
60-64	336	13.1	402	15.6	1,095	43.2	1,821	74.8	5,336	187.0
65+	50	.9	93	1.7	507	9.4	852	16.2	2,624	53.1
TOTAL	13,175	24.2	16,176	29.4	46,018	86.1	76,235	150.3	221,360	514.9

Table 3.7

Projected Population Changes By Age Class Resulting From Multiple Mine Alternative III, Study Area, 1988-2000.

Age	1988		1990		1996		2000	
	Total (no.)	Relative (pct.)	Total (no.)	Relative (pct.)	Total (no.)	Relative (pct.)	Total (no.)	Relative (pct.)
1-5	256	4.3	757	12.9	2,109	49.4	2,981	104.4
6-17	3,376	36.8	3,263	35.3	3,298	33.7	3,589	39.1
18-24	1,245	26.4	1,647	42.2	2,666	101.1	3,159	127.9
25-34	3,376	30.9	2,981	28.8	3,492	61.5	5,421	223.9
35-59	3,616	22.4	4,699	27.9	8,082	43.9	9,053	49.5
60-64	313	12.2	344	13.4	501	20.2	614	21.5
65+	-260	-4.7	-182	-3.4	244	4.7	585	11.8
TOTAL	11,922	21.7	13,509	24.9	20,392	42.1	25,402	59.1

800 persons less than projected employment in the iron ores industry. However, in this scenario, approximately equal employment in the two mining industries does not generate the large potential effects that occurred in Alternatives I and II. The reason is that in Alternative III, copper-nickel development occurs much more slowly with more time elapsing between the opening of the first mine and the second. Slower development reduces the effects of expenditures by households of copper ores industry employees on Study Area employment and population, resulting in smaller impacts.

Alternative IV: Two Mines, No Smelter/Refineries

Potential impacts from Alternative IV are presented in Table 3.8. In this scenario, there are mines with concentrating mills and no smelter/refineries. Potential effects in this slow-growth situation are the smallest of the multiple mine sceanrios.

Table 3.8

Projected Population Changes By Age Class Resulting From Multiple Mine Alternative IV, Study Area, 1991-2000.

Age Class	1991		1995		1998		2000	
	Total (no.)	Relative (pct.)	Total (no.)	Relative (pct.)	Total (no.)	Relative (pct.)	Total (no.)	Relative (pct.)
1-5	83	1.4	638	13.8	1,346	38.0	1,815	63.6
6-17	1,672	17.9	2,077	21.3	2,448	25.5	2,503	27.3
18-24	614	17.0	1,519	56.0	1,947	80.3	2,162	87.5
25-34	1,682	17.3	1,977	29.8	2,955	74.0	3,552	146.7
35-54	1,667	9.7	3,131	17.2	4,417	23.8	5,011	27.4
60-64	151	6.0	231	9.6	325	12.3	373	13.1
65+	-124	-2.3	88	1.7	262	5.2	393	8.0
Total	5,745	10.7	9,661	19.5	13,700	29.9	15,809	36.8

POTENTIAL EFFECTS FROM COPPER-NICKEL DEVELOPMENT ON THE LARGER NORTHEAST MINNESOTA REGION

Potential effects from copper-nickel development would not necessarily be confined to the Study Area because a number of industries serving the mining industry, as well as some retailing and service industries serving Study Area households, are located outside in the larger Northeast Minnesota region.[12/] There is also the possibility that all potential effects on the Study Area may not be realized because of possible limitations to Study Area population expansion which have already been mentioned above. Thus, there is a potential for effects in the Northeast Minnesota region which surrounds the primary Study Area (see Figure 4.1). Accordingly a computer simulation with the open pit integrated operation scenario was made in order to generate information on the potential for effects outside the primary Study Area. Table 4.1 shows the resulting SIMLAB forecasts of population effects on the larger region due to operation of the single open pit integrated operation. The larger region represented in the Table 4.1 data includes Douglas County, Wisconsin because it is economically integrated with the Northeast Minnesota region.

Potential population effects in the larger region are somewhat greater. This can be seen by comparing Table 4.1 with the results for the open pit scenario in Table 3.4. Comparison reveals that in 1987, the projected effect from the open pit scenario on total population is 48 percent greater in the large region. Put in another way, the projected total effect on the larger region is 16,039 persons of which 10,840 or 68 percent may locate inside the smaller primary Study Area.

After 1987, differences in the effects on the smaller and larger regions diminish. In 1990, the effect on the larger region is 20 percent greater, in 1995 it is 17 percent greater, and in 2000 it is only 16 percent greater. This means that copper-nickel development will not have the same strong sustaining effect on the larger region that it has on the smaller primary Study Area. Relative to the volume of economic activity in the larger area, the effects from copper-nickel development are too small to absorb the negative effects from declining employment attributable to productivity changes in the taconite industry and in the manufacturing industry located primarily around Duluth.

12/ For example, a number of firms selling goods like hydraulic equipment, hoists, derricks, and parts for mining equipment are located in Duluth. See the Minnesota Department of Economic Development, Minnesota Directory of Manufacturers, 1975-1976, A Listing of Minnesota Manufacturers and Their Products, St. Paul, Minnesota.

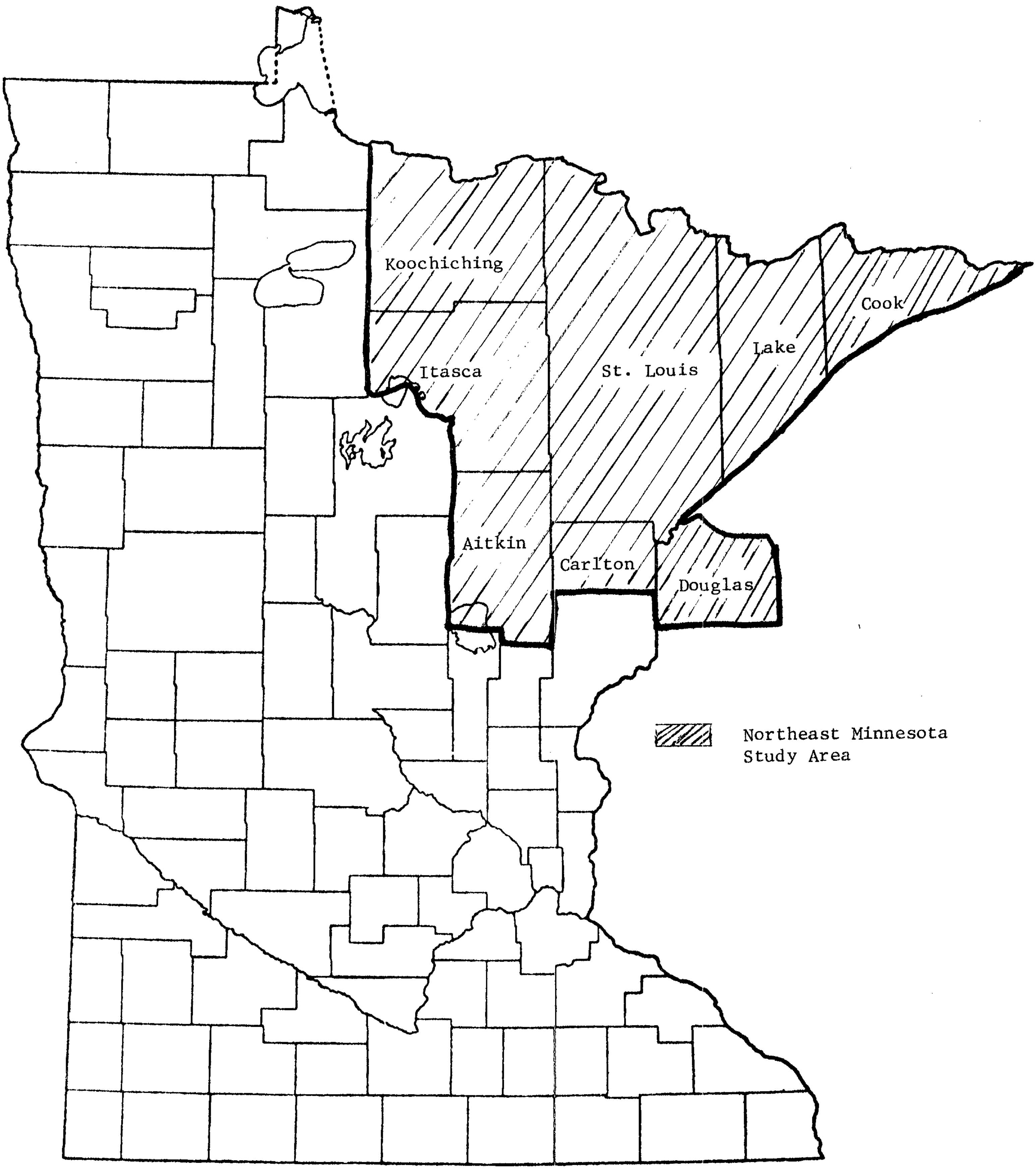


Figure 4.1. Substate Development Regions and Primary Study Area, Northern Minnesota and Douglas County, Wisconsin, 1979.

Table 4.1

Northeast Minnesota Region and Douglas County, Wisconsin, Copper-Nickel Mining Impacts on Population Characterists. Operation of Single Open Pit Mine with Concentrating Minn and Smelter/Refinery.

Age Class	1970 Baseline	1977 Baseline	1987 Baseline	1987 Impact	1990 Baseline	1990 Impact	1995 Baseline	1995 Impact	2000 Baseline	2000 Impact
1-5	35,070	33,329	43,015	275	44,309	1,153	38,605	1,681	27,651	1,635
6-17	97,108	80,704	70,812	4,638	72,606	3,265	75,433	2,267	70,350	1,548
18-24	38,064	47,859	38,706	1,610	33,188	1,876	28,111	2,101	23,132	1,082
25-34	37,439	45,450	80,901	4,810	79,452	2,639	56,463	1,508	28,141	2,178
35-59	104,520	101,272	106,335	4,653	115,597	5,780	13,869	7,891	138,026	6,561
60-64	18,099	20,072	17,746	421	17,034	372	15,032	396	15,459	335
65+	44,405	42,645	44,512	-368	44,288	-227	42,170	69	38,332	116
TOTAL	374,705	371,331	402,027	16,039	406,474	14,858	386,683	15,913	341,091	13,455

APPENDIX: SIMLAB METHODOLOGY

This Appendix introduces the University of Minnesota Regional Development Simulation Laboratory, called SIMLAB. SIMLAB is a computer-based regional socio-economic model developed for quantitative analysis of the socio-economic impacts of new industry development. It can also be used to analyze the effects of existing industry expansion or contraction. A key feature is an interactive control program which allows user modification of model variables.

SIMLAB Model Components

SIMLAB consists of a core input-output module which interacts with a series of other modules to form a regional simulation model with up to 107 industry groups. Fifty-two sectors of industrial detail were used in the copper-nickel study. Additional industry detail was unnecessary due to the limited number of different industries in the primary copper-nickel Study Area.

Relationships between SIMLAB modules are shown in Exhibit 1. The functions of the modules are as follows:

a. The market module links the Study Area economy with the National economy so that SIMLAB embraces an economic base theory of regional economic activity.

b. Investment module relationships measure and forecast spending by regional firms for plant and equipment.

c. Demand module relationships represent the consumption behavior of households and other non-industrial users of regional products and services. The behavior of industrial users is taken into account by the input-output based production module.

d. Employment module relationships link the volume of production in each sector to employment in each sector.

e. Value-added module relationships estimate the pool of funds from which depreciation, business taxes, and investment in new plant and equipment must be drawn.

f. Labor force module relationships represent the demographic and economic forces determining regional labor supply and demand.

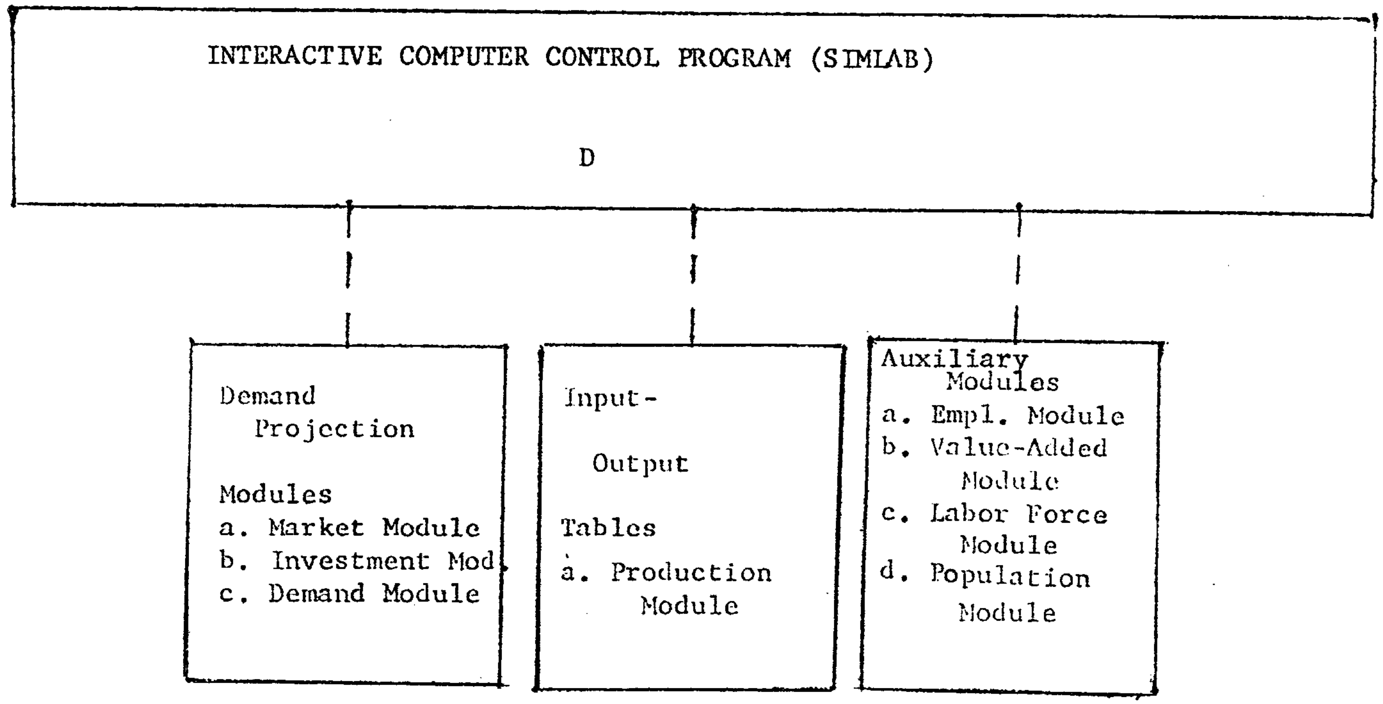
g. Population module relationships represent the demographic and economic forces determining changes in regional population.

h. The production module contains the core regional input-output model which interacts with the other modules.

The eight sets of relationships in SIMLAB are derived from a wide range of data. A reference manual is available in which assumptions, data sources

Exhibit 1

SIMLAB Module Types



and computational procedures used in deriving SIMLAB model variables and relationships are described.[1] A key SIMLAB assumption concerns the use of an input-output table in the Production Module.

Input-Output Tables

The SIMLAB production module includes the critically important measures of Study Area inter=industry linkages which permit a complete accounting of the effects of changes in the level of production in any regional industry. These linkages are represented by the input-output table. The Study Area input-output table was constructed using special computer programs.[2] Although these computer programs are unique, their general methodology is extensively discussed in published literature.[3] The resulting table has a total of 52 industries.

An illustrative input-output table is shown in Table 1 in which inter-industry linkages are shown for a hypothetical three-industry economy. All numerical values are given in millions of dollars. Thus, the $2 million listed under the manufacturing column and the services row means that $2 million worth of services are acquired by the manufacturing sector from the services sector for use in the production of manufactured goods. The manufacturing sector also purchases $4 million worth of agricultural products, $7 million worth of its own products, $6 million worth of labor services from households, and $5 million of imports from outside the region -- a total of $24 million worth of purchased inputs. The entry in the manufacturing row of the gross output column indicates that the output of the manufacturing sector was sold for a total of $24 million. Of the $24 million of product, $2 million was purchased by local households and $5 million was exported to buyers outside the area.

Since total manufacturing costs are listed as $24 million, it may seem as though the manufacturing industry made zero profit. This is not so because the primary inputs from the household sector are defined, in this illustration, to include stockholder's equity, or dividends, and retained earnings. Thus, the input-output table is a balance sheet of historical facts. Like a balance sheet, the illustrative input-output table summarizes the results of business activity carried on over one period of time defined to be one year for this study.

1/ Patrick D. Meagher and Wilbur R. Maki, A SIMLAB Users' Reference Manual, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, May 1979.

2/ Henry H. Hwang and Wilbur R. Maki, A Users' Guide to the Minnesota Two-Region Input-Output Computer Model, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, November 1976.

3/ W.I. Morrison and P. Smith, "Nonsurvey Input-Output Techniques at the Small Area Level: An Evaluation", Journal of Regional Science, Vol. 14, No. 1, 1974, pp. 1-14.

Table 1. Ilustrative Input-Output Table.

	Purchasing Sector					
	Intermediate Demand			Final Demand		
Producing Sector	Agri-culture	Manu-facturing	Services	House-holds	Exports	Gross Outputs
Agriculture	2	4	3	7	0	16
Manufacturing	5	7	5	2	5	24
Services	3	2	4	8	3	20
Households	4	6	7	0	3	21
Import	2	5	0	4	--	11
Total (gross) Outlay	16	24	20	21	11	92

Programmed into the SIMLAB system, the Study Area input-output table makes it possible to trace the effects on the economy of expansion by any existing or new industry. Once expansion gets underway, supplies and materials are purchased from regional supplying industries, adding a new component to interindustry transactions. When these industries expand their output, they require more intermediate goods from the industries supplying them. The input-output table prescribes how much the output of all industries supplying an expanding or new industry must increase. As already explained, this is the function of the production module in the SIMLAB system.

The illustrative table provides an example of how an input-output table prescribes how much the output of industries supplying an expanding or new industry must increase. There, each dollar's worth of agricultural production requires 31 cents worth (i.e., 5 ÷ 16 = .31) of manufactured products. This relationship is called a technical coefficient of production. Use of the technical coefficients of production is based on certain assumptions:

1. If the coefficients of production are to represent the mix of inputs used per unit of output in the production process, then the relative prices of all goods and services must remain fixed since microeconomic theory demonstrates that in a competitive economy the mix of inputs used by producers, and the mix of outputs produced, will vary with changes in relative prices. It is important to note, however, that it is relative prices or price ratios which matter, not the overall level of prices. If all prices double, relative prices are unaffected. Thus, to the extent that all prices move together, the constant relative price assumption is not entirely unrealistic.

2. Interpreting the coefficient as representing the value of goods a producing industry must purchase from a supplying industry to produce one dollar's worth of output implies that this relationship holds true at all levels of output. However, microeconomic theory demonstrates that changes in the scale of output may change the efficiency with which one or more inputs is utilized, changing the yield of product per unit of input. This phenomenon is referred to as economies of scale. Input-output analysis ignores economies of scale, an assumption which becomes generally more accurate as changes in scale of production become smaller.

Because relative prices and/or the scale of production generally change over periods of time, these assumptions of input-output analysis can cause errors in projections made using input-output information. Provided the commodity flow data in the input-output table is accurate, the technical coefficients are valid statements of historical fact. However, if the coefficients are used to analyze events in a later year, then the possibility of error arises either from changes in relative prices or from economies of scale. There is insufficient data on the Study Area economy to determine if relative prices have changed or if substantial economies of scale in Study Area industries are possible between the present and the year 2000, the period of time covered by the copper-nickel development scenarios. In the absence of evidence to the contrary, it is assumed that the coefficients will not change significantly. Indeed, in other input-output tables, the coefficients seem to represent relatively enduring characteristics of industrial production for reasons which are the subject of considerable research.[4/]

4/ Hollis B. Chenery and Paul G. Clark, Interindustry Economics, John Wiley and Sons, Inc., New York, 1959, Chapter 6 and Chapter 8.

Simulation of Alternative Futures

The SIMLAB user is responsible for formulating the assumptions about the future evolution of the Study Area economy. The reference manual provides a description of the effects the user can expect should he modify a model variable or parameter. Only those variables and parameters the user wishes to modify need be changed before a computer run. Others not changed by the user remain at values established during model construction. The interactive control program displays the entire data base upon request before the computer run begins.

Once the user makes his modifications, programmed interactions among the modules cause SIMLAB calculations to occur in a logical sequence consistent with the economic base theory of regional economic activity.[5] Economic base industries are those producing goods and services in excess of regional requirements for sale outside the region. Thus, an inflow of dollars on regional balance of payments account is generated. This inflow sustains regional economic activity and, if the inflow increases, the level of regional activity also increases. The taconite industry is an economic base industry for the primary copper-nickel Study Area. SIMLAB analysis of the Study Area economy reveals that in addition to the taconite industry, construction, apparel, logging, printing and publishing, machinery manufacturing, railway transportation, truck transportation, communications, wholesale and retail trade, and some services also are economic base industries. However, the taconite industry generates more than three times as much money inflow as all the other economic base industries. Thus, the national market for the steel produced from taconite exported from the Study Area has the critical role in determining the level of economic activity in the region.

A change in regional exports will lead to calculation, in the production module, of changes in regional output required if the change in the export component of final demand is to be met. Should these calculated changes cause regional plant capacity to be exceeded or should they require labor inputs in excess of available labor supply, SIMLAB will calculate the maximum output obtainable under the existing constraint. In the case of excess demand for labor, migration and commuting into the region will be estimated in the labor market and population modules. An excess supply of labor results in estimates of out-migration and regional population decline.

Impacts are measured by comparison of business-as-usual projections with results of computer runs incorporating user assumptions concerning change. Assumptions concerning the appearance of new industry require specification of inputs so a new transactions table, including the new industry, can be constructed before the computer run begins. For the copper-nickel study, the new industry inputs were estimated from data supplied by the Minnesota Environmental Quality Board, Regional Copper-Nickel Study staff. During the simulation runs, the resulting new set of Study Area inter-industry multipliers was introduced at the time copper-nickel mining was assumed to begin. In general, a new set of interindustry multipliers can be introduced at any point during the simulation run and as often as desired.

5/ Walter Isard, Methods of Regional Analysis: An Introduction to Regional Science, MIT Press, 1960, Chapter 6.

The computer print-outs display a number of socio-economic indicators on an annual basis. Industry detail printed out includes gross output, exports, employment earnings, intermediate purchases within the region, and value added. Total population and its age-sex composition is also included in the output. The remainder of this Appendix is devoted to a detailed explanation of the SIMLAB population module.

Population Module

The SIMLAB population module is an age-cohort survival model. Population module equations represent regional demographic characteristics. The population module calculations for each year in the simulation run occur after all other calculations have been completed because of the assumption that regional economic conditions as they affect employment determine trends in regional population characteristics. Results of the population module calculations provide the user with an opportunity to quickly and easily check the validity of his assumptions since detailed regional demographic data is readily available.[6/] Population module equations are as follows:

Regional Population by Age and Sex

$$RPOPUL_{a,s,t+1} = RPOPUL_{a,s,t} + BIRTH_{a,s,t+1} - DEATH_{a,s,t+1} + INMIG_{a,s,t+1} - OUTMIG_{a,s,t+1}$$

$a = 1, \ldots, 66 \qquad s = 1$, males; $s = 2$, females

Births by Sex, Region

$$BIRTH_{s,t+1} = \left[BIRTHR_{a',\,2,t+1} * POPUL_{a',\,2,t}\right] * MFBIRTHR_{s}$$

$s = 1, 2 \qquad a' = 14, \ldots, 50$

Total Births, Region

$$TBIRTH_{t+1} = \sum_{s=1}^{2} BIRTH_{s,t+1}$$

Birth Rate, Females Age 14-50, Region

$$BIRTHR_{a',2,t+1} = (1+PCHBIRTHR_{a',2,t+1}) * BIRTHR_{a',2,t}$$

$a' = 14, \ldots, 50$

6/ For example, see the U.S. Department of Commerce, Bureau of the Census, Current Population Reports, Population Estimates and Projections, Series P-25, Washington, D.C. In Minnesota, the State Planning Agency has extensive survey data on demographic characteristics.

Deaths, Age and Sex, Region

$$DEATH_{a,s,t+1} = DEATHR_{a,s,t+1} * POPUL_{a,s,t}$$

Total Deaths, Region

$$TDEATH_{t+1} = \sum_{a} \sum_{s} DEATH_{a,s,t+1}$$

Immigration By Age and Sex, Region

$$INMIG_{a,s,t+1} = NEMPDEPR_{t+1} * IPOPUL_{a,s,t+1}$$

$$+ \sum_{j=1}^{9} [(1-INCOMR_{j,t+1}) * (EMPLOYD_{j,t} - EMPLOYS_{j,t})]$$

subject to $EMPLOYD_{j,t} - EMPLOYS_{j,t} \geq 0$

Inmigrant Age-Sex Distribution, Region

$$INPOPUL_{a,s,t+1} = (1+PCHIPOPUL_{a,s,t+1}) * IPOPUL_{a,s,t}$$

subject to $\sum_{a} \sum_{s} IPOPUL_{t+1} = 1$

Inmigrating Employee Dependent Rate

$$EMPDEPR_{t+1} = (1+PCHEMPDEPR_{t+1}) * EMPDEPR_{t}$$

Outmigration By Age and Sex

$$OUTMIG_{a,s,t+1} = OEMPDEPR_{t+1} * OPOPUL_{a,s,t} * \sum_{j=1}^{9} [(1-OUTCDMR_{j,t+1})$$

$$* (EMPLOYS_{j,t} - EMPLOYD_{j,t})]$$

$a = 1, \ldots, 66 \qquad s = 1, 2 \qquad j = 1, \ldots, 9$

subject to $EMPLOYS_{j,t} - EMPLOYD_{j,t} \geq 0$

Outmigrant Age-Sex Distribution, Region

$$POPUL_{a,s,t+1} = (1+PCHOPOPUL_{a,s,t+1}) * OPOPUL_{a,s,t}$$

subject to $\sum_{a} \sum_{s} OPOPUL_{a,s,t+1} = 1$

Regional Population. Regional population by age and sex in the current period, $RPOPUL_{a,s,t+1}$, equals regional population by age and sex in the previous period, $RPOPUL_{a,s,t}$, plus current period births, $BIRTH_{a,s,t+1}$, minus deaths, $DEATH_{a,s,t+1}$, plus inmigration, $INMIG_{a,s,t+1}$, minus outmigration, $OUTMIG_{a,s,t+1}$.

Births, by Sex. Regional current period births by sex, $BIRTH_{s,t+1}$, equals the regional fertility rate for each 1,000 females between the ages of 14 and 50, $BIRTHR_{a',2,t+1}$, multiplied by the number of females between the ages of 14 and 50 in the previous period, $POPUL_{a',2,t}$; with the result of this multiplication multiplied by proportion of new babies which are female and the proportion which are males, $MFBIRTHR_s$.7/ Use of the number females ages 14 to 50 in the previous period, $POPUL_{a',2,t}$, is necessary in order to make the SIMLAB model recursive. This may result in a slight though not significant overestimate of the number of births since some previous period females ages 14 to 50 have died. To some extent this error may be offset by not including births to current period inmigrating females. Not including births to current period inmigrating females is also necessary in order to make the SIMLAB model recursive.

Total Births, Region. Total regional births, $TBIRTH_{t+1}$, equals the sum of male and female babies born, $BIRTH_{s,t+1}$.

Birth Rate. The current period fertility rate per 1,000 females between ages 14 to 50, $BIRTHR_{a',2,t+2}$, equals one plus the current period percentage change in the birth rate, $PCHBIRTHR_{a',2,t+1}$, multiplied by the birth rate in the previous period, $BIRTHR_{a',s,t}$.8/ With different assumptions concerning $PCHBIRTHR_{a',2,}$ the SIMLAB user can simulate the effects of different fertility levels on regional labor force and population

Deaths, Age and Sex. Regional deaths by age and sex in the current period, $DEATH_{a,s,t+1}$, equal the regional current period death rate by age and sex, $DEATHR_{a,s,t+1}$, multiplied by previous period regional population by age and sex, $POPUL_{a,s,t}$.9/ Use of the previous period value of the variable $POPUL_{a,s,t}$, instead of the current-period value is necessary in order to make the SIMLAB model recursive.

7/ Minnesota data on births is from the State Department of Health. This data is available for each county.

8/ Values of the variable $PCHBIRTHR_{a',2}$ used by SIMLAB in the absence of user assumptions to the contrary are consistent with the Census "Series II" population projections for the United States.

9/ In MInnesota, death rates by age and sex for each county are obtained from the State Department of Health.

Total Deaths, Region. Total current period regional deaths, $TDEATH_{t+1}$, equal the sum of current period deaths by age and sex, $DEATH_{a,s,t+1}$.

Inmigration, By Age and Sex. Regional current period inmigration by age and sex, $INMIG_{a,s,t+1}$, equals the number of dependents per worker, $NEMPDEPR_{t+1}$, multiplied by the age-sex distribution of regional inmigrants in the five year period before the most recent Census, $IPOPUL_{a,s,t+1}$, multiplied by a quantity which is the previous period regional demand for workers by occupation in excess of those available from the regional population, $EMPLOYD_{j,t}-EMPLOYS_{j,t}$, adjusted for incommuting by occupation, $1-INCOMR_{j,t+1}$. Thus, regional inmigration is assumed to occur in response to unfilled job openings. The SIMLAB program is written so that only positive or zero levels of worker excess demand are admissible.

In-migrant, Age-Sex Distribution. The regional inmigrant age-sex distribution, $IPOPUL_{a,s,t+1}$, equals one plus the percentage change in the age-sex component, $PCHIPOPUL_{a,s,t+1}$, multiplied by the age-sex distribution in the previous period, $IPOPUL_{a,s,t}$. In the absence of user assumtpions, the variable $PCHIPOPUL_{a,s,t+1}$ is set to zero. Values of the variable $IPOPUL_{a,s,t+1}$ are from the U.S. Census of Population.[10/] Use of these values involves the assumption that persons who inmigrate to the region in response to future unfilled job openings will have the same age-sex characteristics as those who found the region sufficiently attractive to move there during the five years prior to the 1970 Census.

In-migrating, Employee-Dependent Rate. The inmigrating employee dependent rate, $EMPDEPR_{t+1}$, is the number of persons the average inmigrating worker brings with him. The current period value of the dependent rate equals one plus the current period percentage change inthe rate, $PCHEMPDEPR_{t+1}$, multiplied by the previous period rate, $EMPDEPR_{t}$. The variable $PCHEMPDEPR_{t+1}$ is set to zero in simulation runs unless the user specifies otherwise. Values of $EMPDEPR_{t+1}$ may be obtained from survey work. Alternatively, Census data on household size can be used as approximate estimates of the value of $EMPDEPR_{t+1}$ and projections of household size can be used to estimate future values of $PCHEMPDEPR_{t+1}$.[11/] These data are only surrogate estimates of the inmigrating employee dependent rate because the household characteristics of the job seeker who would move may depend onthe region he or she is moving to; and upon

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10/ U.S. Bureau of the Census, Subject Reports, Migration Between State Economic Areas, PC(2)-2E, Washington, D.C., July 1972.

11/ Projections of the number of persons per household in Minnesota are available from the Minnesota State Planning Agency, Office of the State Demographer, Minnesota Population Projections 1970-2000, St. Paul, Minnesota, November, 1975.

the region he or she is moving from. Household characteristics of the job seeker may also depend on his or her education and occupation. Thus, SIMLAB users should consider possibilities for independent verification of assumptions concerning the employee dependent rate.[12]

Out-migration, By Age and Sex. Outmigration by age and sex, $OUTMIG_{a,s,t+1}$, equals the outmigrating worker dependent rate, $OEMPDEPR_{t+1}$, multiplied by the regional population age-sex distribution, $RPOPUL_{a,s,t}$; and this product is multiplied by a quantity which is the previous period regional supply of workers in each occupation who are in excess of regional demand, $EMPLOYS_{j,t} - EMPLOYD_{j,t}$, adjusted for current period outcommuting by occupation, $(1-OUTCOMR_{j,t+1})$. Thus, regional outmigration is assumed to occur in response to a shortage of job openings relative to the number of persons in each occupation who are seeking work. The SIMLAB program is written so that only positive or zero levels of excess supply of workers are admissible. Because of a similar restriction on excess demand for workers, explained above, there can only be either inmigration or outmigration or no migration of workers in a given occupation during any given year. However, inmigration of workers in one occupation and outmigration of those in another is permitted by the model.

This migration theory works for Minnesota. In SIMLAB runs on Minnesota data a fraction of persons age 20 to 24 and of those age 66 and over are subtracted in each year. These adjustments are made to take into account college-going, military service, and retirement to other areas. Correct values of the adjustments are determined by trial and error in comparison with Census and the State Planning Agency population survey data already cited.

Out-migrant Age-Sex Distribution. The regional outmigrant age-sex distribution, $OPOPUL_{a,s,t+1}$, equals one plus the percentage change in each age-sex component, $PCHOPOPUL_{a,s,t+1}$, multiplied by the age-sex distribution in the previous period, $OPOPUL_{a,s,t}$. In the absence of user assumptions, the variable $PCHOPOPUL_{a,s,t+1}$ is set to zero. Values of the variable $OPOPUL_{a,s,t+1}$ are from the Census.[13] Use of these values involves the assumption that persons who outmigrate from the region because of an excess supply of workers in their occupations will have the same age-sex characteristics as those who left the region during the five years prior to the 1970 Census.

12/ In Minnesota, a 1977 State Planning Agency population survey provided estimates of county and sub-county population characteristics (consistent with the 1970 Census of Population estimates), through which SIMLAB demographic curves are fitted by adjusting the dependent rate and other variables.

13/ U.S. Bureau of the Census, Subject Reports, Migration Between State Economic Areas, op. cit.