GASOLINE CONSUMPTION BY SNOWMOBILES IN MINNESOTA: UPDATING THE 1992 GASOLINE CONSUMPTION MODEL

FINAL REPORT

Submitted to:

Minnesota Department of Administration

by

Michael S. Lewis, Research Fellow
and
Dr. Dorothy H. Anderson, Ph.D.

University of Minnesota
Department of Forest Resources
115 Green Hall
1530 N. Cleveland Avenue
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VEHICLES TRANSPORTING SNOWMOBILES FUEL CONSUMPTION DATA

Table 1. Response to: "During the winter of 1996-1997, how many **total miles** did you put on **AUTOMOBILE(s)** (e.g., cars and trucks) owned by you to haul this snowmobile to developed (maintained), signed snowmobile trailheads in Minnesota?" (1996/1997 Minnesota Snowmobile Use Survey)

Note: This table includes zero (0) responses (e.g., 52.1 percent indicated they did NOT put any miles on autos they owned to haul the snowmobile in question to a developed snowmobile trailhead located in Minnesota). The mean and median statistics presented at the bottom of this table include these zero (0) responses.

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
(Miles)	.00000	504	51.6	52.1	52.1
	2.00000	2	.2	.2	52.3
	3.00000	1	.1	.1	52.4
	5.00000	2	.2	.2	52.6
	9.00000	1	.1	.1	52.7
	10.00000	10	1.0	1.0	53.7
	20.00000	9	.9	.9	54.6
	24.00000	3	.3	.3	55.0
	30.00000	6	.6	.6	55.6
	38.00000	1	.1	.1	55.7
	40.00000	2	.2	.2	55.9
	50.00000	11	1.1	1.1	57.0
	60.00000	11	1.1	1.1	58.2
	70.00000	3	.3	.3	58.5
	75.00000	1	.1	.1	58.6
	80.00000	3	.3	.3	58.9
	84.00000	1	.1	.1	59.0
	85.00000	1	.1	.1	59.1
	100.00000	31	3.2	3.2	62.3
	110.00000	2	.2	.2	62.5
	120.00000	1	.1	.1	62.6
	125.00000	1	.1	.1	62.7
	140.00000	2	.2	.2	62.9
	150.00000	11	1.1	1.1	64.0
	160.00000	1	.1	.1	64.2
	170.00000	1	.1	.1	64.3
	180.00000	1	.1	.1	64.4
	200.00000	35	3.6	3.6	68.0
	220.00000	1	.1	.1	68.1
	225.00000	1	.1	.1	68.2
	240.00000	3	.3	.3	68.5
	250.00000	9	.9	.9	69.4
	256.00000	1	.1	.1	69.5
	263.00000	1	.1	.1	69.6
	275.00000	1	.1	.1	69.7
	300.00000	32	3.3	3.3	73.0
	315.00000	1	.1	.1	73.1
	320.00000	3	.3	.3	73.5
	340.00000	1	.1	.1	73.6
	350.00000	3	.3	.3	73.9
	360.00000	1	.1	.1	74.0
	375.00000	1	.1	.1	74.1
	380.00000	1	.1	.1	74.2
	400.00000	26	2.7	2.7	76.9
	425.00000	3	.3	.3	77.2
	440.00000	1	.1	.1	77.3

Table 1 (cont.)

(Miles)	450.00000	2	.2	.2	77.5
	480.00000	1	.1	.1	77.6
	500.00000	30	3.1	3.1	80.7
	512.00000	1	.1	.1	80.8
	550.00000	2	.2	.2	81.0
	554.00000	1	.1	.1	81.1
	600.00000	16	1.6	1.7	82.7
	630.00000	1	.1	.1	82.9
	640.00000	1	.1	.1	83.0
	650.00000	3	.3	.3	83.3
	700.00000	10	1.0	1.0	84.3
	720.00000	1	.1	.1	84.4
	740.00000	1	.1	.1	84.5
	750.00000	4	.4	.4	84.9
	800.00000	22	2.3	2.3	87.2
	900.00000	9	.9	.9	88.1
	910.00000	1	.1	.1	88.2
	1000.00000	28	2.9	2.9	91.1
	1010.00000	1	.1	.1	91.2
	1200.00000	11	1.1	1.1	92.4
	1260.00000	1	.1	.1	92.5
	1400.00000	5	.5	.5	93.0
	1500.00000	7	.7	.7	93.7
	1550.00000	1	.1	.1	93.8
	1600.00000	1	.1	.1	93.9
	1800.00000	3	.3	.3	94.2
	2000.00000	21	2.1	2.2	96.4
	2200.00000	2	.2	.2	96.6
	2400.00000	1	.1	.1	96.7
	2402.00000	1	.1	.1	96.8
	2500.00000	4	.4	.4	97.2
	2540.00000	1	.1	.1	97.3
	2800.00000	1	.1	.1	97.4
	2880.00000	1	.1	.1	97.5
	3000.00000	10	1.0	1.0	98.6
	3200.00000	2	.2	.2	98.8
	3300.00000	1	.1	.1	98.9
	3500.00000	1	.1	.1	99.0
	4000.00000	1	.1	.1	99.1
	5000.00000	4	.4	.4	99.5
	7000.00000	1	.1	.1	99.6
	7500.00000	1	.1	.1	99.7
	8000.00000	1	.1	.1	99.8
	10000.00000	1	.1	.1	99.9
	10880.00000	1	.1	.1	100.0
	.	9	.9	Missing	
	Total	977	100.0	100.0	

Mean 376.288 Median .000 Std dev 909.342

Valid cases 968 Missing cases 9

Table 2. Response to: "During the winter of 1996-1997, how many **total miles** did you put on **AUTOMOBILE(s)** (e.g., cars and trucks) owned by you to haul this snowmobile to developed (maintained), signed snowmobile trailheads in Minnesota?" (1996/1997 Minnesota Snowmobile Use Survey)

Note: This table *excludes* zero (0) responses. As a result, the mean and median statistics presented at the bottom of this table excludes responses of zero (0). Only those respondents who indicated they used an auto owned by them to haul the snowmobile in question to a developed snowmobile trailhead located in Minnesota were included in this analysis.

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
(Miles)	2.00000	2	.4	.4	.4
	3.00000	1	.2	.2	.6
	5.00000	2	.4	.4	1.1
	9.00000	1	.2	.2	1.3
	10.00000	10	2.2	2.2	3.4
	20.00000	9	1.9	1.9	5.4
	24.00000	3	.6	.6	6.0
	30.00000	6	1.3	1.3	7.3
	38.00000	1	.2	.2	7.5
	40.00000	2	.4	.4	8.0
	50.00000	11	2.4	2.4	10.3
	60.00000	11	2.4	2.4	12.7
	70.00000	3	.6	.6	13.4
	75.00000	1	.2	.2	13.6
	80.00000	3	.6	.6	14.2
	84.00000	1	.2	.2	14.4
	85.00000	1	.2	.2	14.7
	100.00000	31	6.7	6.7	21.3
	110.00000	2	.4	.4	21.8
	120.00000	1	.2	.2	22.0
	125.00000	1	.2	.2	22.2
	140.00000	2	.4	.4	22.6
	150.00000	11	2.4	2.4	25.0
	160.00000	1	.2	.2	25.2
	170.00000	1	.2	.2	25.4
	180.00000	1	.2	.2	25.6
	200.00000	35	7.5	7.5	33.2
	220.00000	1	.2	.2	33.4
	225.00000	1	.2	.2	33.6
	240.00000	3	.6	.6	34.3
	250.00000	9	1.9	1.9	36.2
	256.00000	1	.2	.2	36.4
	263.00000	1	.2	.2	36.6
	275.00000	1	.2	.2	36.9
	300.00000	32	6.9	6.9	43.8
	315.00000	1	.2	.2	44.0
	320.00000	3	.6	.6	44.6
	340.00000	1	.2	.2	44.8
	350.00000	3	.6	.6	45.5
	360.00000	1	.2	.2	45.7
	375.00000	1	.2	.2	45.9
	380.00000	1	.2	.2	46.1
	400.00000	26	5.6	5.6	51.7
	425.00000	3	.6	.6	52.4
	440.00000	1	.2	.2	52.6

Table 2 (cont.)

(Miles)	450.00000	2	.4	.4	53.0
	480.00000	1	.2	.2	53.2
	500.00000	30	6.5	6.5	59.7
	512.00000	1	.2	.2	59.9
	550.00000	2	.4	.4	60.3
	554.00000	1	.2	.2	60.6
	600.00000	16	3.4	3.4	64.0
	630.00000	1	.2	.2	64.2
	640.00000	1	.2	.2	64.4
	650.00000	3	.6	.6	65.1
	700.00000	10	2.2	2.2	67.2
	720.00000	1	.2	.2	67.5
	740.00000	1	.2	.2	67.7
	750.00000	4	.9	.9	68.5
	800.00000	22	4.7	4.7	73.3
	900.00000	9	1.9	1.9	75.2
	910.00000	1	.2	.2	75.4
	1000.00000	28	6.0	6.0	81.5
	1010.00000	1	.2	.2	81.7
	1200.00000	11	2.4	2.4	84.1
	1260.00000	1	.2	.2	84.3
	1400.00000	5	1.1	1.1	85.3
	1500.00000	7	1.5	1.5	86.9
	1550.00000	1	.2	.2	87.1
	1600.00000	1	.2	.2	87.3
	1800.00000	3	.6	.6	87.9
	2000.00000	21	4.5	4.5	92.5
	2200.00000	2	.4	.4	92.9
	2400.00000	1	.2	.2	93.1
	2402.00000	1	.2	.2	93.3
	2500.00000	4	.9	.9	94.2
	2540.00000	1	.2	.2	94.4
	2800.00000	1	.2	.2	94.6
	2880.00000	1	.2	.2	94.8
	3000.00000	10	2.2	2.2	97.0
	3200.00000	2	.4	.4	97.4
	3300.00000	1	.2	.2	97.6
	3500.00000	1	.2	.2	97.8
	4000.00000	1	.2	.2	98.1
	5000.00000	4	.9	.9	98.9
	7000.00000	1	.2	.2	99.1
	7500.00000	1	.2	.2	99.4
	8000.00000	1	.2	.2	99.6
	10000.00000	1	.2	.2	99.8
	10880.00000	1	.2	.2	100.0
	Total	464	100.0	100.0	

Mean 785.015 Median 400.000 Std dev 1185.530

Valid cases 464 Missing cases 0

Table 3. Respondents' estimates of miles-per-gallon (MPG) for automobile(s) they owned which were used to haul the snowmobile in question to developed snowmobile trailheads in Minnesota. (1997/1997 Minnesota Snowmobile Use Survey)

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
(MPG)	2.00000	1	.1	.2	.2
	8.00000	4	.4	.9	1.1
	9.00000	7	.7	1.5	2.6
	10.00000	50	5.1	10.9	13.5
	11.00000	10	1.0	2.2	15.7
	12.00000	48	4.9	10.5	26.1
	13.00000	23	2.4	5.0	31.2
	14.00000	45	4.6	9.8	41.0
	15.00000	94	9.6	20.5	61.4
	16.00000	34	3.5	7.4	68.8
	17.00000	33	3.4	7.2	76.0
	18.00000	29	3.0	6.3	82.4
	19.00000	7	.7	1.5	83.9
	20.00000	44	4.5	9.6	93.5
	21.00000	2	.2	.4	93.9
	22.00000	6	.6	1.3	95.2
	23.00000	3	.3	.7	95.9
	24.00000	4	.4	.9	96.7
	25.00000	11	1.1	2.4	99.1
	26.00000	1	.1	.2	99.3
	28.00000	2	.2	.4	99.8
	30.00000	1	.1	.2	100.0
	.	518	53.0	Missing	
	Total	977	100.0	100.0	

Mean	15.224	Median	15.000	Std dev	3.875
Valid cases	459	Missing cases	518		

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EXECUTIVE SUMMARY

Six years ago, as part of a comprehensive project to identify gasoline consumption by snowmobiles within Minnesota, researchers at the University of Minnesota conducted a 1990/1991 study of registered Minnesota snowmobile use. Survey data and other data collected as part of this project were used to calculate total recreational gasoline consumption by snowmobiles within Minnesota during the 1990/1991 snowmobile use season. University researchers also developed a Winter Algorithm which provides estimates of gasoline consumed by Minnesota snowmobilers using developed trails. Estimates derived from this algorithm were incorporated into a more comprehensive model which can be used to estimate total recreational gasoline consumption by snowmobiles within Minnesota for future snowmobile use seasons. Results of this project are documented in a report to the Minnesota Department of Natural Resources, Trails and Waterways Unit (Vlaming, Anderson, and Flekke; 1992).

Because participation rates for snowmobiling can change over time, it was recommended that additional seasons of snowmobile use data be collected to test the long term validity of the model developed at the University of Minnesota. The purpose of this study was to collect up-to-date information on snowmobile use in Minnesota in an effort to: (1) update the Minnesota snowmobile gasoline consumption model and (2) provide the Minnesota State Legislature with up-to-date figures concerning gasoline consumption by snowmobiles within Minnesota.

Our goals were to:

1. Update the Winter Algorithm which provides estimates of gasoline consumed by Minnesota snowmobilers using developed snowmobile trails in Minnesota.
2. Determine the total amount of gasoline consumed by snowmobiles within Minnesota during the 1996/1997 winter use season.
3. Update the Minnesota snowmobile gasoline consumption model which can be used to estimate total recreational gasoline consumption by snowmobiles within Minnesota for future snowmobile use seasons.

To achieve these goals we:

a. Replicated the 1990/1991 Minnesota Snowmobile Use Survey in an effort to collect up-to-date data on snowmobile use for the 1996/1997 snowmobile season.

b. Identified late January 1997 snow depth information for the Grand Marais, Minnesota area.

c. Re-assessed fuel efficiency (miles-per-gallon) of the major snowmobile brands used in Minnesota.

d. Re-calculated the Winter Algorithm using results obtained from tasks a-c above.

e. Re-assessed out-of-state snowmobile use in Minnesota.

In mid-October, 1997, a sample of 1,385 registered snowmobilers was sent a survey card (appendix B) asking about the use of a snowmobile they owned during the 1996/1997 winter use season. A 72 percent survey response rate was achieved. Questions asked of study participants included:

- Total number of miles put on the snowmobile.
- Total number of days the snowmobile was used.

- Total number of days the snowmobile was used for recreation in Minnesota.
- Total number of days the snowmobile was used for agricultural or farming purposes.
- Total number of days the snowmobile was used on developed (maintained), signed snowmobile trails located in Minnesota and the average number of miles snowmobiled per day on those trails.
- Total number of days the snowmobile was used on developed (maintained), signed snowmobile trails located outside of Minnesota and the average number of miles snowmobiled per day on those trails.
- An estimate of miles-per-gallon for the snowmobile in question.

In addition to these questions, study participants were asked how many total miles they put on automobiles (e.g., cars and trucks) they owned to haul the snowmobile in question to developed (maintained), signed snowmobile trailheads located in Minnesota. As part of this question, study participants were asked to provide an estimate of miles-per-gallon for their automobile(s). Because the focus of this report is on gasoline consumption by snowmobiles only, responses to these two questions are not summarized herein.

Survey results indicate that the average amount of gasoline consumed per snowmobile while using developed snowmobile trails in Minnesota was 47.5 gallons. Average non-trail recreational gasoline consumption per snowmobile in Minnesota was calculated to be 9.0 gallons. To determine total recreational gasoline consumption by all snowmobiles within Minnesota for the 1996/1997 season, this information was combined with information concerning the number of registered Minnesota snowmobiles (276,813), estimates of the maximum number of nonregistered snowmobiles in Minnesota (96,885), as well as an estimate of total gasoline consumed by non-resident snowmobilers visiting the state (3,017,262 gallons). ***For the 1996/1997 winter use season, actual total recreational gasoline consumption by all snowmobiles within Minnesota ranged from a minimum of 18,657,196 gallons to a maximum of 24,131,199 gallons.***

The Winter Algorithm developed in 1992 reflects data collected through the 1990/1991 winter use season. With the addition of 1996/1997 use season data, the algorithm was re-calculated as follows:

Updated Winter Algorithm:

GCPV = 15.1051 + (.8972 * GMsnow)

(GCPV=predicted gasoline consumption per snowmobile--on developed trails only)
(GMsnow=January 25th snow depth in the Grand Marais area)

According to the Minnesota State Climatology Office, the January 25, 1998 snow depth in the Grand Marais, Minnesota area was 16 inches. Using this figure, the updated Winter Algorithm estimates gasoline consumption on developed trails in Minnesota to be 29.5 gallons per snowmobile for the 1997/1998 snowmobile use season. To estimate total recreational gasoline consumption by all snowmobiles within Minnesota for the 1997/1998 use season, this information was combined with current information concerning the average amount of nontrail recreational gasoline consumed per snowmobile (9.0 gallons) in Minnesota, the number of registered Minnesota snowmobiles (276,813), estimates of the maximum number of

nonregistered snowmobiles in Minnesota (96,885), and the estimate of total gasoline consumed by non-resident snowmobilers visiting the state (3,017,262 gallons). ***It is estimated that for the 1997/1998 winter use season, total recreational gasoline consumption by all snowmobiles within Minnesota will range from a minimum of 13,674,563 gallons to a maximum of 17,404,635 gallons.***

According to the Minnesota State Climatology Office, the *average* January 25th snow depth for the Grand Marais, MN area over the past 30 years is 18.7 inches. Using this figure, the updated Winter Algorithm estimates gasoline consumption on developed trails in Minnesota to be 31.9 gallons per snowmobile for an average winter use season.

Assuming:

1. The number of registered snowmobiles remains constant at 276,813.
2. The maximum percentage of nonregistered snowmobiles is 35 percent of the total number of registered snowmobiles.
3. Nontrail recreational consumption levels are the same as the current 1996/1997 rate of 9.0 gallons per vehicle.
4. The estimated out-of-state consumption figure remains at the 1996/1997 use season level of 3,017,262 gallons.

It is estimated that for an average winter use season, total recreational gasoline consumption by all snowmobiles within Minnesota will range from a minimum of 14,338,913 gallons to a maximum of 18,301,510 gallons.

BACKGROUND AND STUDY PURPOSE

Snowmobiling is a growing winter activity in Minnesota that accounts for a significant portion of the state's winter tourism revenues. In early October 1997, the Minnesota Department of Natural Resources (DNR) reported a total of 276,813 registered snowmobiles in the state. This is up nearly 44 percent from 1990. To meet the demand of this growing population of winter enthusiasts, the state provides approximately 18,000 miles of snowmobile trails.

Snowmobile facilities in Minnesota are provided primarily through two legislatively authorized funding mechanisms: (1) snowmobile registration fees and (2) "unrefunded gasoline tax" receipts attributed to non-highway snowmobile use. The unrefunded gasoline tax is collected on all gasoline sold within Minnesota. The vast majority of this revenue is used to support the state's road system, but certain activities, including snowmobiling, have been legislatively permitted to make a claim on a portion of this revenue consistent with the amount of gasoline each activity consumes, excluding use of Minnesota roads.

Six years ago, as part of a comprehensive project to identify gasoline consumption by snowmobiles within Minnesota, researchers at the University of Minnesota conducted a 1990/1991 study of registered Minnesota snowmobile use. Survey data and other data collected as part of this project were used to calculate total recreational gasoline consumption by snowmobiles within Minnesota during the 1990/1991 snowmobile use season. University researchers also developed a Winter Algorithm which provides estimates of gasoline consumed by Minnesota snowmobilers using developed trails. Estimates derived from this algorithm were incorporated into a more comprehensive model which can be used to estimate total recreational gasoline consumption by snowmobiles within Minnesota for future snowmobile use seasons. Results of this project are documented in a report to the Minnesota Department of Natural Resources, Trails and Waterways Unit (Vlaming, Anderson, and Flekke; 1992).

Because participation rates for snowmobiling can change over time, it was recommended that additional seasons of snowmobile use data be collected to test the long term validity of the model developed at the University of Minnesota. The purpose of this study was to collect up-to-date information on snowmobile use in Minnesota in an effort to: (1) update the Minnesota snowmobile gasoline consumption model and (2) provide the Minnesota State Legislature with up-to-date figures concerning gasoline consumption by snowmobiles within Minnesota.

STUDY GOALS

Our goals were to:

1. Update the Winter Algorithm which provides estimates of gasoline consumed by Minnesota snowmobilers using developed snowmobile trails in Minnesota.

2. Determine the total amount of gasoline consumed by snowmobiles within Minnesota during the 1996/1997 winter use season.

3. Update the Minnesota snowmobile gasoline consumption model which can be used to estimate total recreational gasoline consumption by snowmobiles within Minnesota for future snowmobile use seasons.

To achieve these goals we:

a. Replicated the 1990/1991 Minnesota Snowmobile Use Survey in an effort to collect up-to-date data on snowmobile use for the 1996/1997 snowmobile season.

b. Identified late January 1997 snow depth information for the Grand Marais, Minnesota area.

c. Re-accessed fuel efficiency (miles-per-gallon) of the major snowmobile brands used in Minnesota.

d. Re-calculated the Winter Algorithm using results obtained from tasks a-c above.

e. Re-assessed out-of-state snowmobile use in Minnesota.

SURVEY METHODS

In an effort to gather data about Minnesota registered snowmobiles and trail use levels during the 1996/1997 winter use season, a sample of 1,500 registered snowmobiles was randomly selected by the Minnesota DNR. The sample, which is representative of registered snowmobiles across all regions of Minnesota, was randomly selected from the state's snowmobile registration file on October 6, 1997.

Owners of each snowmobile identified in the sample were sent a letter (appendix A) and survey card (appendix B). The survey card asked study participants about the use of their snowmobile during the 1996/1997 winter use season. Question topics included:

(1) Total number of miles put on the snowmobile (TMILES).

(2) Total number of days the snowmobile was used (TDAYS).

(3) Total number of days the snowmobile was used for recreation in Minnesota (DAYSREC).

(4) Total number of days the snowmobile was used for agricultural or farming purposes (DAYSFARM).

(5) Total number of days the snowmobile was used on developed (maintained), signed snowmobile trails located in Minnesota and the average number of miles snowmobiled per day on those trails (DAYSWIMN and MILEWIMN, respectively).

(6) Total number of days the snowmobile was used on developed (maintained), signed snowmobile trails located outside of Minnesota and the average number of miles snowmobiled per day on those trails (DAYSOUMN and MILEOUMN, respectively).

(7) An estimate of miles-per-gallon for the snowmobile in question (MPG).

In addition to being asked questions concerning use of their snowmobile, study participants were asked how many total miles they put on automobiles (e.g., cars and trucks) they owned to haul the snowmobile in question to developed (maintained), signed snowmobile trailheads located in Minnesota. As part of this question, study participants were asked to provide an estimate of miles-per-gallon for their automobile(s).

Because the focus of this project and report is on gasoline consumption by snowmobiles only, responses to these two questions are not summarized herein.

Two follow-up mailings were sent to nonrespondents: (1) A postcard reminder thanking individuals for their participation and explaining the importance of completing the survey (appendix C) and (2) distribution of a second survey card accompanied by a letter (appendix D) reemphasizing the importance of contributing to the study effort. Because such a high response rate (over 70 percent) was achieved, contacting a sample of nonrespondents via a phone survey was deemed unnecessary.

Completed surveys were keypunched into a digital form compatible for use with SPSS/PC+ (Statistical Package for the Social Sciences). Frequency analysis and computation of basis statistics (e.g., means, medians, etc.) were computed for each question topic.

RESULTS

1996/1997 Minnesota Snowmobile Use Survey

Of the original sample of 1,500 registered snowmobilers sent a survey card, 4.9 percent (n=73) proved to be undeliverable. Another 42 snowmobiles were excluded from the sample because the machine reportedly was not owned by the registered snowmobiler during the 1996/1997 snowmobile use season. Hence, the final sample size for the study was 1,385 snowmobiles. Of those 1,385 snowmobile owners sent a survey card, 72 percent (n=991) completed and returned their survey by mail. Fourteen survey cards were received following completion of this report--as such, the database used in this analysis includes only 977 of the 991 study respondents. Responses to the survey questions are summarized in appendix E.

Updating the Winter Algorithm

It is believed there is a somewhat direct relationship between snow accumulations in late January and total snowmobile use levels for any given winter season (Regnier, 1988). In 1992, to examine this hypothesis, researchers at the University of Minnesota collected past snowmobile use data from the DNR (dating back to 1984) and conducted a 1990/1991 study of registered Minnesota snowmobile use. For each winter season in which snowmobile use data was collected, an official January 25th snow depth from the Minnesota State Climatology Office was identified for Grand Marais, Brainerd, and the Twin Cities (these three locations were determined to be representative of typical Minnesota snowmobiling regions). The data were subjected to correlation and regression analysis and a very strong association was found between the amount of gasoline consumed per snowmobile and the January 25th snow depth for the Grand Marais, MN area. Using these findings, University researchers developed a Winter Algorithm (equation 1) which can be used to predict gasoline consumption by Minnesota snowmobilers using developed snowmobile trails located in Minnesota (Vlaming, Anderson, Flekke; 1992).

Equation 1: 1992 Winter Algorithm

$$GCPV = 15.5047 + (.8482 * GMsnow)$$

(GCPV=predicted gasoline consumption per snowmobile--on developed trails only)
(GMsnow=January 25th snow depth in the Grand Marais, MN area)

The Winter Algorithm provides an equation for predicting gasoline consumption per snowmobile (on developed trails only) for any given season based on January 25th snow depth information for the Grand Marais, MN area. The data used to create this algorithm is presented in table 1.

Table 1. Data used to create the Winter Algorithm developed in 1992.

	Dependent Variables: Gasoline Consumed While Using Developed Snowmobile Trails in Minnesota		**Independent Variable:** January 25th Snow Depth
Use Season	Per Snowmobile (gallons)	By All Snowmobiles (millions of gallons)	Grand Marais, MN area (inches)
1984/1985	20.5	4.1615	4
1985/1986	31.9	5.7739	18
1986/1987	18.6	3.1620	15
1988/1989	51.0	9.3840	43
1989/1990	36.4	6.6976	18
1990/1991	39.8	7.6303	26

Source: Vlaming, Anderson, and Flekke; 1992.

The Winter Algorithm, as defined in Equation 1, reflects data collected prior to the 1996/1997 Minnesota Snowmobile Use Survey. The January 25, 1997 snow depth identified by the Minnesota State Climatology Office for the Grand Marais, MN area was 32 inches. Using equation 2, the average amount of gasoline consumed per snowmobile while using developed snowmobile trails in Minnesota was calculated to be 47.5 gallons for the 1996/1997 use season.

Equation 2: Minnesota Trail Only Consumption =

$$\frac{\text{DAYSWIMN} * \text{MILEWIMN}}{\text{MPG}}$$

DAYSWIMN = Respondent's indicated number of days spent snowmobiling on developed trails located in Minnesota.
MILEWIMN = Respondent's indicated average number of miles per day spent snowmobiling on developed trails located in Minnesota.
MPG = Respondent's indicated miles-per-gallon figure.

After adding this new information to the dataset in table 1, the algorithm was re-computed (equation 3). With the addition of 1996/1997 use season data, the correlation coefficient between the late January snow depth in the Grand Marais area and the amount of gasoline consumed per snowmobile is .914, significant to the .001 level. This implies a very strong association between the two variables.

Equation 3: Updated Winter Algorithm

$$GCPV = 15.1051 + (.8972 * GMsnow)$$

(GCPV=predicted gasoline consumption per snowmobile–on developed trails only)
(GMsnow=January 25th snow depth in the Grand Marais, MN area)

Limitations of the Winter Algorithm

At this point in time, the primary limitation of the Winter Algorithm is the number of years of data used to develop the equation--only seven seasons of use data. It is strongly recommended that additional surveys of registered Minnesota snowmobile use be conducted in the future. Each year, as new data is collected, the algorithm can be refined. Several more years of data are needed to further establish the validity of the algorithm as a tool for determining gasoline consumption by snowmobiles on developed trails.

In addition to the above, it should be noted that the Winter Algorithm can only be used to predict total gasoline consumption by Minnesota snowmobile use on developed (maintained), signed snowmobile trails located throughout the state. It cannot be used to predict total gasoline consumed within the state by all snowmobilers. This estimate requires the addition of data concerning nonregistered and out-of-state snowmobilers, as well as data concerning nontrail recreational snowmobile use.

Finally, the algorithm is not affected by gasoline prices, snowfall in other areas of the state, snow depths throughout the season, distribution of snowmobile ownership, intervening or competing opportunities, and distance traveled-to-snow depth ratios (distance decay modeling). These are all factors that may or may not have a potential influence on the degree of error produced by the algorithm.

Fuel Efficiency

Responses to the 1990/1991 Minnesota Snowmobile Use Survey indicated that the average fuel efficiency of snowmobiles in Minnesota was 13.7 miles-per-gallon (Vlaming, Anderson, and Flekke; 1992). That figure was supported by both industry and Minnesota United Snowmobilers Association (MNUSA) estimates and was chosen to be the standard fuel efficiency figure for computing gasoline consumption for use seasons prior to the 1990/1991 survey (1984/1985-1989/1990).

From the 1996/1997 Minnesota Snowmobile Use Survey, average fuel efficiency per snowmobile was identified to be 12.9 miles-per-gallon. Representative from MNUSA were not surprised by this figure, stating that over the past several years the trend has been to purchase more powerful machines that are not extremely fuel efficient. However, MNUSA representatives believe this to be a temporary trend. Within five years, they expect to see more snowmobilers purchasing fuel efficient models.

Consultation with manufacturer representatives concerning "newer" machine estimates for miles-per-gallon (MPG) ranged from 8-15 MPG for high performance machines to 15-20 MPG for their higher economy models. Each of the manufacturer representatives contacted thought that the figure of 12.9 MPG obtained from the 1996/1997 survey was realistic. In particular, one representative stated that estimating MPG for snowmobiles is dependent upon a number of factors such as varying terrain, snow conditions, and rider preferences for speed and/or the amount of snow cover. Consequently, the representative was supportive of research asking a sample of snowmobilers to provide their own estimates. Each of the snowmobile manufacturer representatives contacted agreed that the current snowmobile market is beginning to see a shift away from purchasing more powerful machines. Right now, it appears as if snowmobilers are increasingly looking for more fuel efficient machines that can travel further on one tank of gasoline.

Out-Of-State Snowmobile Use

Surrounding States

To estimate snowmobile use in Minnesota by out-of-state visitors, state agency officials were contacted in Wisconsin, Iowa, South Dakota, and North Dakota. The following is a summary of information obtained from each of these four states. Unfortunately, each state indicated they had no research data concerning the extent to which their residents snowmobile in Minnesota. Therefore, only estimates of out-of-state snowmobile use in Minnesota are provided. If exact figures are needed, a survey of these four adjacent states would need to be completed.

Wisconsin: Larry Freidig of the Wisconsin Department of Natural Resources reported 202,000 snowmobiles were registered in Wisconsin during the 1996/1997 snowmobile use season. However, he had no idea how many of these machines were used in Minnesota. In 1992, Mr. Freidig "guessed" that Wisconsin snowmobilers probably consumed about 200,000 gallons of gasoline while visiting Minnesota--at that time, there were approximately 155,000 registered snowmobiles in Wisconsin (Vlaming, Anderson, and Flekke; 1992). With the addition of 47,000 registered snowmobiles from 1990/1991 to 1996/1997, we estimate approximately 260,000 gallons of gasoline were consumed by Wisconsin snowmobilers visiting Minnesota last season.

Iowa: Elonda Bacon of the Iowa Department of Natural Resources reported 34,600 snowmobiles were registered in Iowa during the 1996/1997 season. For the 1990/1991 season, it was estimated that approximately 20 percent of the 22,020 registered snowmobilers in Iowa snowmobile in Minnesota--an average of 5 days and 100 miles per day (Vlaming, Anderson, and Flekke; 1992). Ms. Bacon indicated that these figures probably had not changed. Keeping this in mind, it was estimated that 6,920 Iowans (20 percent of 34,600) snowmobiled in Minnesota last season.

South Dakota: Dan Simon, Snowmobile Program Coordinator for the South Dakota Department of Game, Fish and Parks, reported 11,884 snowmobiles were registered in South Dakota during the 1996/1997 season. He could not make a guess as to the number of South Dakotans snowmobiling in Minnesota last season. However, he thought the estimates used for the 1990/1991 use season (27,500 trips to Minnesota based on 7,300 registered snowmobiles) seemed reasonable (Vlaming, Anderson, and Flekke; 1992). With the addition of 4,584 registered snowmobiles from 1990/1991 to 1996/1997, we estimate that snowmobilers from the state of South Dakota made about 44,768 trips to Minnesota last season.

North Dakota: Cheryl Obrigewitch, Snowmobile Program Assistant for the state of North Dakota, reported 19,921 snowmobiles were registered in North Dakota during the 1996/1997 season. Unfortunately, she indicated the state has no data on the number of resident snowmobilers leaving the state to snowmobile in Minnesota.

Based upon the information received from the surrounding four state area, we made rough guesstimates of the amount of gasoline consumed by out-of-state snowmobiles in Minnesota during the 1996/1997 snowmobile use season:

Wisconsin	Guess = *260,000 gallons*
Iowa	500 miles traveled x 6,920 snowmobiles = 3,460,000 miles/12.9 MPG = *268,217 gallons*

South Dakota — 44,768 trips x 100 miles/trip = 4,476,800 miles/12.9 MPG = *347,038 gallons*

North Dakota — Guess = *200,000 gallons*

Canada

Canadian snowmobile use within Minnesota was not determined. Assuming regional snow conditions are the same in both Canada and northern Minnesota, the primary draw of Canadian snowmobilers to Minnesota lies not in the abundance of quality snowmobile experiences, but in Canada's economic situation where often Canadians cross the border in search of lower priced goods.

Canadian snowmobile consumption of gasoline within Minnesota can be determined through a partnership with United States Customs on the Minnesota/Canada border. All Canadians entering or leaving Minnesota must stop at customs. Either a survey of those Canadians with snowmobiles or simple odometer readings taken at entrance and upon leaving Minnesota could provide accurate gasoline consumption figures for these international visitors to Minnesota.

Minnesota

The 1996/1997 Minnesota Snowmobile Use Survey asked study participants to indicate the number of days they spent on snowmobile trails located outside of Minnesota as well as provide an estimate of the average number of miles traveled per day on those trails. Using equation 4, responses indicate that the average amount of gasoline consumed per snowmobile while out-of-state was 10.9 gallons. Total gasoline consumption by registered Minnesota snowmobilers outside the state was calculated to be *3,017,262 gallons* (e.g., 10.9 gallons per vehicle * 276,813 registered snowmobiles).

Equation 4: Trail Consumption by Minnesota Snowmobiles Outside of Minnesota =

$$\frac{(\text{DAYSOUMN} * \text{MILEOUMN})}{\text{MPG}}$$

DAYSOUMN	=	Respondent's indicated number of days spent snowmobiling on developed trails located outside of Minnesota.
MILEOUMN	=	Respondent's indicated average number of miles per day spent snowmobiling on developed trails located outside of Minnesota.
MPG	=	Respondent's indicated miles-per-gallon figure.

Total Out-Of-State Gasoline Consumption Estimates

There are roughly the same number of registered snowmobiles in Minnesota as there are registered snowmobiles in the four surrounding states. The Minnesota DNR estimates that there is, at the minimum, no net loss of snowmobile use from Minnesota to the surrounding states when compared to the incoming use of Minnesota snowmobiling resources by non-Minnesotans. Therefore, the 1996/1997 season's minimum gasoline consumption by non-Minnesota snowmobiles within Minnesota is 3,017,262 gallons.

1996/1997 Total Recreational Gasoline Consumption by Snowmobiles Within Minnesota

In 1992, a variety of methods were used to determine total gasoline consumption by snowmobiles within Minnesota (Vlaming, Anderson, and Flekke; 1992). Only one of those methods proved be a concise and accurate method of estimating consumption for current or past use seasons (equation 5):

Equation 5: Total Consumption Within Minnesota Method

$$\frac{\text{(TMILES-(MILEOUMN*DAYSOUMN)}}{\text{MPG}}$$

TMILES	=	Respondent's indicated total miles put on the snowmobile during the 1996/1997 snowmobile use season.
DAYSOUMN	=	Respondent's indicated number of days spent snowmobiling on developed trails located outside of Minnesota.
MILEOUMN	=	Respondent's indicated average number of miles per day spent snowmobiling on developed trails located outside of Minnesota.
MPG	=	Respondent's indicated miles-per-gallon figure.

Using equation 5, the average amount of gasoline consumed per registered snowmobile in 1996/1997 is 58.9 gallons. When we multiple this figure by the number of registered snowmobiles (276,813) and then add it to the estimate of out-of-state gasoline consumption (3,017,262 gallons), this method's estimate of gasoline consumption by registered and out-of-state snowmobiles within Minnesota for the 1996/1997 season is 19,321,548 gallons. However, this figure does not include consumption of gasoline by nonregistered snowmobiles, nor does it exclude consumption by snowmobiles for nonrecreational purposes. To remedy these shortcomings, additional steps were taken:

Step 1: The number of nonregistered snowmobiles in the state is unknown--estimates range from 5-35 percent of the total number of registered vehicles. There is no data to support or refute the hypothesis that registered and nonregistered snowmobile recreational use levels are similar. Therefore, a minimum range for total consumption was identified using registered snowmobiles only, and a maximum range was identified using the maximum estimate of nonregistered snowmobiles combined with registered snowmobiles--assuming use levels are identical between both registered and nonregistered vehicles.

Step 2: The estimate derived from equation 5 incorporates all types of consumption, ranging from trail use to agricultural purposes. The difference between this estimate (58.9 gallons) and the estimate of gasoline consumed by snowmobiles using developed trails (47.5 gallons) equals 11.4 gallons which represents nontrail consumption per snowmobile in Minnesota. To adjust this new figure so it does not include nonrecreational consumption, we examined responses to the 1996/1997 survey with regard to the total number of days the snowmobile was used, the total number of days the snowmobile was used for recreation within Minnesota, the total number of days the snowmobile was used on developed trails within Minnesota, and the total number of days the snowmobile was used on developed trails located outside of Minnesota. Using this information, a recreation coefficient was calculated on a case-by-case basis for the 1996/1997 survey (equation 6). The results were then averaged, producing a recreation coefficient of (.791). This coefficient represents the recreational percentage of nontrail gasoline consumed per snowmobile. The recreation coefficient was multiplied by the total nontrail consumption figure to identify recreational nontrail gasoline consumption per snowmobile (11.4 * .791 = 9.0 gallons per snowmobile).

Equation 6: Recreation Coefficient Equation for Off-Trail Use

1. Nontrail recreation days within Minnesota = total MN recreation days - days on MN trails
2. Total days in Minnesota spent off trail = (total days - days on trails outside of MN) - days on MN trails
3. Recreation coefficient = $\frac{\text{nontrail recreation days within Minnesota}}{\text{total days in Minnesota spent off trail}}$

Using the adjustments described above, the estimate of total recreational gasoline consumption by snowmobiles within Minnesota during the 1996/1997 snowmobiling use season was re-calculated (table 2). Table 2 indicates that the amount of gasoline consumed by all snowmobiles within Minnesota, excluding nonrecreational use, ranged from 18,657,196 gallons to 24,131,199 gallons, depending on the number of nonregistered snowmobiles within Minnesota.

Table 2. Actual total recreational gasoline consumption by all snowmobiles within Minnesota for the 1996/1997 snowmobile use season.

	Number of Snowmobiles	x	Gasoline Consumption On Developed Trails (gallons per snowmobile)*	+	Non-Trail Recreation Gasoline Consumption (gallons per snowmobile)	+	Estimate of Out-Of-State Gasoline Consumption (gallons)	=	Total 1996/1997 Gasoline Consumption (gallons)
Total Registered	276,813	x	(47.5	+	9.0)	+	3,017,262	=	18,657,196
Total Registered + Maximum Non-Registered	276,813 + 96,885	x	(47.5	+	9.0)	+	3,017,262	=	24,131,199

* Based upon the 1996/1997 Minnesota Snowmobile Use Survey

Comparison of Actual 1996/1997 Total Recreational Gasoline Consumption and Projected 1996/1997 Total Recreational Gasoline Consumption

The figures in table 2 are based upon actual data derived from the study's survey returns. By substituting the 47.5 gallons of gasoline consumed per snowmobile on developed trails with the updated Winter Algorithm's (equation 3) estimate of gallons per snowmobile based on the late January snow depth, we can examine the degree of variance of the Winter Algorithm as a predictive formula. Given that the January 25th snow depth in the Grand Marais area for the 1996/1997 use season was 32 inches, the updated Winter Algorithm estimates that the total amount of gasoline consumed per snowmobile on Minnesota developed trails is 43.8 gallons (a prediction error of 8.4 percent). Table 3 substitutes this figure for the actual gasoline consumed per snowmobile on Minnesota developed trails to produce estimated 1996/1997 total recreational consumption.

Table 3. Estimated total recreational gasoline consumption by all snowmobiles within Minnesota for the 1996/1997 snowmobile use season.

	Number of Snowmobiles	x	Gasoline Consumption On Developed Trails (gallons per snowmobile)*	+	Non-Trail Recreation Gasoline Consumption (gallons per snowmobile)	+	Estimate of Out-Of-State Gasoline Consumption (gallons)	=	Total 1996/1997 Gasoline Consumption (gallons)
Total Registered	276,813	x	(43.8	+	9.0)	+	3,017,262	=	17,632,988
Total Registered + Maximum Non-Registered	276,813 + 96,885	x	(43.8	+	9.0)	+	3,017,262	=	22,748,516

*Estimate derived from the updated Winter Algorithm (equation 3), based on a January 25, 1997 snow depth of 32 inches in the Grand Marais, Minnesota area.

The estimated total gasoline consumption figures in table 3 represent a difference of 1,024,208 and 1,382,683 gallons when compared to the actual minimum and maximum figures for that season, respectively. These amounts represent an underestimation error of approximately 6 percent. When using the Winter Algorithm, error is expected to exist for any given season and will reflect an overestimation or underestimation of total consumption for any given season. Over multiple seasons, the differences between the estimated and actual total gasoline consumption figures will negate each other, so that overestimates equal underestimates. This provides an accurate average total consumption estimate when using the Winter Algorithm.

1997/1998 Projected Total Recreational Gasoline Consumption by Snowmobiles Within Minnesota

To project total recreational gasoline consumption for the current season, the procedure for determining the estimated 1996/1997 winter total recreational gasoline consumption was followed, substituting the 1996/1997 late January snow depth figure with the 1997/1998 late January snow depth figure.

For the 1997/1998 use season, the Minnesota State Climatology Office indicates that the January 25th snow depth in the Grand Marais area was 16 inches. Based on this snow depth figure, the updated Winter Algorithm estimates that total recreational developed trail consumption within Minnesota is 29.5 gallons per snowmobile. Table 4 provides the estimates of total recreational gasoline consumption by snowmobiles within Minnesota for the 1997/1998 use season.

Table 4. Estimated total recreational gasoline consumption by all snowmobiles within Minnesota for the 1997/1998 snowmobile use season.

	Number of Snowmobiles	x	Gasoline Consumption On Developed Trails (gallons per snowmobile)*	+	Non-Trail Recreation Gasoline Consumption (gallons per snowmobile)	+	Estimate of Out-Of-State Gasoline Consumption (gallons)	=	Total 1996/1997 Gasoline Consumption (gallons)
Total Registered	276,813	x	(29.5	+	9.0)	+	3,017,262	=	13,674,563
Total Registered + Maximum Non-Registered	276,813 + 96,885	x	(29.5	+	9.0)	+	3,017,262	=	17,404,635

*Estimate derived from the updated Winter Algorithm (equation 3), based on a January 25, 1998 snow depth of 16 inches in the Grand Marais, Minnesota area.

Estimating Total Recreational Gasoline Consumption by Snowmobiles Within Minnesota for Future Use Seasons

The Winter Algorithm provides the means to project average gasoline consumption by all snowmobiles within Minnesota using developed trails (excluding nonrecreational consumption), based on the average late January snow depth in the Grand Marais, MN area. Records held by the Minnesota State Climatology Office indicate that over the past 30 years the average January 25th snow depth for the Grand Marais area is 18.7 inches. Using this figure, the updated Winter Algorithm computes average gasoline consumption per snowmobile on developed trails within Minnesota to be 31.9 gallons.

To further project gasoline consumption for an average winter, four assumptions must be made:

1. The number of registered snowmobiles remains constant at 276,813.

2. The maximum percentage of nonregistered snowmobiles is 35 percent of the total number of registered snowmobiles.

3. Nontrail recreational consumption levels are the same as the current 1996/1997 rate of 9.0 gallons per vehicle.

4. The estimated out-of-state consumption figure remains at the 1996/1997 use season level of 3,017,262 gallons.

Using the average winter trail consumption figure (31.9 gallons per snowmobile) provided by the updated Winter Algorithm and each of the assumed figures above, table 5 projects the average winter total recreational gasoline consumption by all snowmobiles within Minnesota.

For the average season:

The *minimum* total recreational gasoline consumption by all snowmobiles within Minnesota is 14,338,913 gallons.

The *maximum* total recreational gasoline consumption by all snowmobiles within Minnesota is 18,301,510 gallons.

Table 5. Estimated average winter total recreational gasoline consumption by all snowmobiles within Minnesota.

	Number of Snowmobiles	x	Gasoline Consumption On Developed Trails (gallons per snowmobile)*	+	Non-Trail Recreation Gasoline Consumption (gallons per snowmobile)	+	Estimate of Out-Of-State Gasoline Consumption (gallons)	=	Total 1996/1997 Gasoline Consumption (gallons)
Total Registered	276,813	x	(31.9	+	9.0)	+	3,017,262	=	14,338,913
Total Registered + Maximum Non-Registered	276,813 + 96,885	x	(31.9	+	9.0)	+	3,017,262	=	18,301,510

*Estimate derived from the updated Winter Algorithm (equation 3), based on an average January 25th snow depth of 18.7 inches in the Grand Marais, Minnesota area.

CONCLUSIONS

As previously mentioned, the Winter Algorithm is based on an association between late January snow depths in the Grand Marais, Minnesota area and the amount of gasoline consumed per snowmobile on developed Minnesota trails. The updated Winter Algorithm (equation 3) was developed using data from seven snowmobile use seasons. The validity and accuracy of the Winter Algorithm is dependent upon the continued collection of snowmobile seasonal use data. For each new season of data, the Winter Algorithm should be updated. It is suggested that data from ten seasons will provide a long-term equation for predicting gasoline consumption by snowmobiles within Minnesota.

The average winter total recreational gasoline consumption figures are derived, in part, from four primary assumptions. It is likely that the total number of registered snowmobiles will increase, as has been the trend for the past several years. Additional research could provide an accurate estimate of the number of nonregistered snowmobiles within the state and the use levels of those snowmobiles. Continued collection of information will yield insight into the use levels of nontrail recreational and nonrecreational snowmobiling. Out-of-state gasoline consumption can be adequately determined only through surveys of snowmobilers from the surrounding four state area as well as Canada. With the reduction of assumptions comes increased accuracy and confidence in estimating future gasoline consumption by all snowmobiles within Minnesota.

REFERENCES

Regnier, C. 1988. *Present Attitudes and Long Term Behavior of Minnesota Snowmobilers.* St. Paul, MN: Minnesota Department of Natural Resources.

Vlaming, J. C., D. H. Anderson, and G. Flekke. 1992. *Gasoline Consumption by Snowmobiles Within Minnesota.* Final Report submitted to: Minnesota Department of Natural Resources, Trails and Waterways Unit. St. Paul, MN: University of Minnesota, Department of Forest Resources.

APPENDIX A
Letter Accompanying Initial Mailing of Survey Card

October 21, 1997

Dear Registered Snowmobile Owner:

The University of Minnesota is conducting a snowmobile use study in cooperation with the Minnesota Department of Administration and Department of Natural Resources (DNR). As you may already know, the DNR spends over two million dollars per year to develop, maintain, and administer snowmobile trails.

Enclosed you will find a survey. The snowmobile you own, which is identified on your survey, has been selected in a random sample of Minnesota's registered snowmobiles for this study. The survey asks several question about the use of this machine during the 1996-1997 winter snowmobile season (last winter). Please complete the survey and return it by mail as soon as possible. The survey is postage paid and return addressed.

Your participation is very important and it should take no more than 5 minutes to complete the survey. Because your responses will represent the use patterns of other snowmobiles, it is important that you complete the questions as accurately as possible. Remember, you are to answer the questions **only** for the use of the snowmobile identified on the sticker on the front of the enclosed survey. Of course, this survey is *voluntary* and *confidentiality will be maintained.*

The results of this study will be made available to all interested parties. You may receive a summary of results by writing "Copy of Results Requested" on the front of the survey.

Thank you for your help!

Sincerely,

Michael S. Lewis
Research Fellow
(612) 624-1746

Dorothy H. Anderson, Ph.D.
Associate Professor
(612) 624-2721

APPENDIX B
Survey Card

Survey of Registered Snowmobile Use

These survey questions pertain only to the use of the ***snowmobile identified on the sticker*** on the front of this postcard. Please answer the following questions with regard to that snowmobile only. DO NOT give answers about snowmobiling you did on other machines.

1. During the winter of 1996-1997:
   -How many **total miles** did you put on the snowmobile identified on the sticker?_____ total miles
   -How many **total days** was this snowmobile used?_____total days
   -On how many **days** was this snowmobile used for **recreation** in Minnesota?_____days
   -On how many **days** was this snowmobile used for **agricultural** or **farming purposes**?_____days

2. During the winter of 1996-1997, on how many **days** was this snowmobile used on developed (maintained), signed snowmobile trails **WITHIN MINNESOTA**?_____days What was the average number of **miles** snowmobiled *per day* on those trails?_____miles

3. During the winter of 1996-1997, on how many **days** was this snowmobile used on developed (maintained), signed snowmobile trails **OUTSIDE OF MINNESOTA**?_____days What was the average number of **miles** snowmobiled *per day* for those trips outside of Minnesota?_____miles

4. What was the average number of **miles-per-gallon (MPG)** for the snowmobile identified on the sticker during the 1996-1997 winter?_____MPG

5. During the winter of 1996-1997, how many **total miles** did you put on **AUTOMOBILE(s)** (e.g., cars and trucks) owned by you to haul this snowmobile to developed (maintained), signed snowmobile trailheads in Minnesota?_____total miles What was the average number of **miles-per-gallon (MPG)** for these automobile(s)?_____MPG

Thank you! Please drop the completed survey in the mail.

APPENDIX C
First Follow-Up Mailing--Postcard Reminder

University of Minnesota, Department of Forest Resources
1530 N. Cleveland Avenue, 115 Green Hall
St. Paul, Minnesota 55108

Dear Registered Snowmobile Owner:

A couple of weeks ago you received a survey from the University of Minnesota asking about the use of a snowmobile owned by you during the 1996-1997 winter snowmobile season (last winter). If you have completed this survey and returned it, ***thank you*** for your cooperation!

If you have not returned the survey, please do so at your earliest convenience. Your time and effort to fill out the survey is crucial to the success of this project.

If you have misplaced the survey, please write to me at the address above or call (612) 624-1746. We will send you another one.

Thank you for your help!

Sincerely,

Michael S. Lewis
Research Fellow

Dorothy H. Anderson, Ph.D.
Associate Professor

APPENDIX D
Second Follow-Up Mailing--Letter

November 18, 1997

Dear Registered Snowmobile Owner:

Approximately 4 weeks ago you received a survey from the University of Minnesota asking about the use of a snowmobile owned by you during the 1996-1997 winter snowmobiling season (last winter).

So far we have not received your completed survey. Because we've contacted a small number of snowmobilers for this study, we need to receive as many completed surveys as possible. Your participation is extremely important. In the event that you did not receive the first survey or no longer have it, another survey is enclosed. Please complete and mail this survey at your earliest convenience. It will not take more than 5 minutes of your time.

The results of this study will be made available to all interested parties. You may receive a summary of results by writing "Copy of Results Requested" on the front of the survey.

If you have any questions about this study, please feel free to contact me at the address shown on the letterhead or by telephone.

Thank you! We genuinely appreciate your help!

Sincerely,

Michael S. Lewis
Research Fellow
(612) 624-1746

Dorothy H. Anderson, Ph.D.
Associate Professor
(612) 624-2721

APPENDIX E
1996/1997 Minnesota Snowmobile Use Survey Results

Description of Snowmobile Variables Obtained by Survey

The following are the basic snowmobile variables (including a variable label) gathered as part of the 1996/1997 Minnesota Snowmobile Use Survey and a description of each variable.

Snowmobile Variable	Label
1. Total miles the snowmobile was used in 1996/1997	TMILES
2. Total days snowmobile was used in 1996/1997	TDAYS
3. Total days snowmobile was used for recreation in Minnesota in 1996/1997	DAYSREC
4. Total days snowmobile was used for agricultural or farming purposed in 1996/1997	DAYSFARM
5. Total days snowmobile was used on developed trails in Minnesota in 1996/1997	DAYSWIMN
6. Average number of miles traveled per day on developed trails in Minnesota in 1996/1997	MILEWIMN
7. Total days snowmobile was used on developed trails outside of Minnesota in 1996/1997	DAYSOUMN
8. Average number of miles traveled per day on developed trails outside of Minnesota in 1996/1997	MILEOUMN
9. Estimated miles-per-gallon (MPG) for the snowmobile	MPG

Rejection of Outlying Data Points

The following describes the accepted data ranges for each basic study snowmobile variable and the reason for selecting this range.

Snowmobile Variable	Range	Reason
TMILES	<5000	Data larger than this was considered too large. Five thousand miles implies an average daily use of 33 miles.
TDAYS	<151	Allows for 5 months of use.
DAYSREC	<151	Allows for 5 months of use.
DAYSWIMN	<151	Allows for 5 months of use.
MILEWIMN	<251	Allows up to 250 miles traveled each day.
DAYSOUMN	<151	Allows for 5 months of use.
MILEOUMN	<251	Allows up to 250 miles traveled each day.
MPG	>2, <31	Per manufacturer data.

TMILES. Response to: "During the winter of 1996/1997, how many **total miles** did you put on the snowmobile identified on the sticker?" (1996/1997 Minnesota Snowmobile Use Survey)

Miles	N	Percent	Cum Percent
0 (not used)	92	9.5	9.5
1-50	112	11.5	20.0
51-250	132	13.6	34.6
251-450	111	11.4	46.0
451-650	120	12.3	58.3
651-850	82	8.4	66.8
851-1050	83	8.5	75.3
1051-1250	49	5.0	80.3
>1250	191	19.7	100.0
Totals	**972**	**100.0**	–

Mean = 732.70 miles
Median = 500.00

TDAYS. Response to: "During the winter of 1996/1997, how many **total days** was this snowmobile used?" (1996/1997 Minnesota Snowmobile Use Survey)

Days	N	Percent	Cum Percent
0 (not used)	92	9.5	9.5
1-7	175	18.1	27.7
8-14	166	17.2	44.9
15-21	196	20.3	65.2
22-28	63	6.5	71.7
29-35	112	11.6	83.3
36-42	36	3.7	87.0
43-49	21	2.2	89.2
50-56	20	2.1	91.3
57-63	16	1.7	93.0
64-70	8	.8	93.8
71-77	8	.8	94.6
78-84	10	1.0	95.6
85-91	12	1.2	96.9
92-98	2	.2	97.1
99-105	9	.9	98.0
>105	19	2.0	100.0
Totals	**965**	**100.0**	--

Mean = 22.92
Median = 15.00

DAYSREC. Response to: "During the winter of 1996/1997, on how many **days** was this snowmobile used for **recreation** in Minnesota?" (1996/1997 Minnesota Snowmobile Use Survey)

Days	N	Percent	Cum Percent
0	114	11.8	11.8
1-7	199	20.7	32.5
8-14	169	17.5	50.1
15-21	193	20.0	70.1
22-28	59	6.1	76.2
29-35	96	10.0	86.2
36-42	33	3.4	89.6
43-49	16	1.7	91.3
50-56	16	1.7	92.9
57-63	12	1.2	94.2
64-70	11	1.1	95.3
71-77	8	.8	96.2
78-84	9	.9	97.1
85-91	6	.6	97.7
92-98	3	.3	98.0
99-105	5	.5	98.5
>105	14	1.5	100.0
Totals	**963**	**100.0**	–

Mean = 20.02
Median = 14.00

DAYSFARM. Response to: "During the winter of 1996/1997, on how many **days** was this snowmobile used for **agricultural** or **farming purposes**?" (1996/1997 Minnesota Snowmobile Use Survey)

Days	N	Percent	Cum Percent
0	874	89.5	89.5
1-7	61	6.3	95.8
8-14	15	1.5	97.3
15-21	10	1.0	98.4
22-28	2	.2	98.6
29-35	2	.2	98.8
36-42	4	.4	99.2
43-49	1	.1	99.3
50-56	1	.1	99.4
57-63	1	.1	99.5
>63	5	.5	100.0
Totals	**976**	**100.0**	–

Mean = 1.48
Median = 0.00

DAYSWIMN. Response to: "During the winter of 1996/1997, on how many **days** was this snowmobile used on developed (maintained), signed snowmobile trails **WITHIN MINNESOTA**?" (1996/1997 Minnesota Snowmobile Use Survey)

Days	N	Percent	Cum Percent
0	218	22.8	22.8
1-7	245	25.6	48.4
8-14	153	16.0	64.4
15-21	162	16.9	81.3
22-28	46	4.8	86.1
29-35	60	6.3	92.4
36-42	18	1.9	94.3
43-49	10	1.0	95.3
50-56	10	1.0	96.3
57-63	8	.8	97.2
64-70	8	.8	98.0
71-77	1	.1	98.1
78-84	2	.2	98.3
85-91	5	.5	98.9
92-98	2	.2	99.1
99-105	3	.3	99.4
>105	6	.6	100.0
Totals	**957**	**100.0**	--

Mean = 13.62
Median = 8.00

MILEWIMN. Respondents' estimates of the average number of miles snowmobiled per day on developed (maintained), signed snowmobile trails within Minnesota. (1996/1997 Minnesota Snowmobile Use Survey)

Miles	N	Percent	Cum Percent
1-10	82	11.6	11.6
11-20	110	15.6	27.2
21-30	94	13.3	40.5
31-40	82	11.6	52.1
41-50	110	15.6	67.7
51-60	49	6.9	74.6
61-70	31	4.4	79.0
71-80	47	6.7	85.7
81-90	13	1.8	87.5
91-100	62	8.8	96.3
>100	26	3.7	100.0
Totals	**706**	**100.0**	--

Mean = 46.84
Median = 40.00

DAYSOUMN. Response to: "During the winter of 1996/1997, on how many **days** was this snowmobile used on developed (maintained), signed snowmobile trail **OUTSIDE OF MINNESOTA**?" (1996/1997 Minnesota Snowmobile Use Survey)

Days	N	Percent	Cum Percent
0	773	79.7	79.7
1-7	143	14.7	94.4
8-14	28	2.9	97.3
15-21	16	1.6	99.0
22-28	4	.4	99.4
29-35	5	.5	99.9
36-42	0	0	99.9
>42	1	.1	100.0
Totals	**970**	**100.0**	–

Mean = 1.41
Median = 0.00

MILEOUMN. Respondents' estimates of the average number of miles snowmobiled per day on developed (maintained), signed snowmobile trails located outside of Minnesota. (1996/1997 Minnesota Snowmobile Use Survey)

Miles	N	Percent	Cum Percent
1-10	5	2.7	2.7
11-20	8	4.3	7.0
21-30	11	5.9	13.0
31-40	6	3.2	16.2
41-50	29	15.7	31.9
51-60	6	3.2	35.1
61-70	10	5.4	40.5
71-80	20	10.8	51.4
81-90	8	4.3	55.7
91-100	40	21.6	77.3
>100	42	22.7	100.0
Totals	**185**	**100.0**	–

Mean = 82.92
Median = 80.00

MPG. Response to: "What was the average number of **miles-per-gallon (MPG)** for the snowmobile identified on the sticker during the 1996/1997 winter?" (1996/1997 Minnesota Snowmobile Use Survey)

MPG	N	Percent	Cum Percent
3	4	.6	.6
4	3	.5	1.1
5	6	.9	2.1
6	9	1.4	3.5
7	9	1.4	4.9
8	33	5.2	10.1
9	18	2.8	12.9
10	163	25.7	38.6
11	40	6.3	45.0
12	94	14.8	59.8
13	35	5.5	65.3
14	29	4.6	69.9
15	76	12.0	81.9
16	14	2.2	84.1
17	10	1.6	85.6
18	14	2.2	87.9
20	43	6.8	94.6
21	2	.3	95.0
22	6	.9	95.9
23	3	.5	96.4
25	11	1.7	98.1
26	2	.3	98.4
30	10	1.6	100.0
Totals	**634**	**100.0**	–

Mean = 12.89
Median = 12.00

REQUEST. Respondents requesting results of the 1996/1997 Minnesota Snowmobile Use Survey.

Response	N	Percent	Cum Percent
No	882	90.3	90.0
Yes	95	9.7	100.0
Totals	**977**	**100.0**	–