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SUSITNA HYDROELECTRIC PROJECT

PHASE II PROGRESS REPORT

BIG GAME STUDIES

Volume III MOOSE - UPSTREAM

Warren B. Ballard

Jackson S. Whitman

Nancy G. Tankersley

Lawrence D. Aumiller

Pauline Hessing

ALASKA DEPARTMENT OF FISH AND GAME

Submitted to the Alaska Power Authority

April 1983

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PREFACE

In early 1980, the Alaska Department of Fish and Game contracted with the Alaska Power Authority to collect information useful in assessing the impacts of the proposed Susitna Hydroelectric Project on moose, caribou, wolf, wolverine, black bear, brown bear and Dall sheep.

The studies were broken into phases which conformed to the anticipated licensing schedule. Phase I studies, January 1, 1980 to June 30, 1982, were intended to provide information needed to support a FERC license application. This included general studies of wildlife populations to determine how each species used the area and identify potential impact mechanisms. Phase II studies continued to provide additional information during the anticipated 2 to 3 year period between application and final FERC approval of the license. Belukha whales were added to the species being studied. During Phase II, we are narrowing the focus of our studies to evaluate specific impact mechanisms, quantify impacts and evaluate mitigation measures.

This is the first annual report of ongoing Phase II studies. In some cases, objectives of Phase I were continued to provide a more complete data base. Therefore, this report is not intended as a complete assessment of the impacts of the Susitna Hydroelectric Project on the selected wildlife species.

The information and conclusions contained in these reports are incomplete and preliminary in nature and subject to change with further study. Therefore, information contained in these reports is not to be quoted or used in any publication without the written permission of the authors.

The reports are organized into the following 9 volumes:

Volume I.	Big Game Summary Report
Volume II.	Moose - Downstream
Volume III.	Moose - Upstream
Volume IV.	Caribou
Volume V.	Wolf
Volume VI.	Black Bear and Brown Bear
Volume VII.	Wolverine
Volume VIII.	Dall Sheep
Volume IX.	Belukha Whale

SUMMARY

Preliminary analyses of movements of 10 adult cow moose radio-collared in a proposed experimental burn area near the Alphabet Hill revealed the presence of 3 subpopulations occupying the area--2 wintering and 1 resident. From an intensive aerial census of the proposed burn and adjacent area during March 1982, an estimated 279 moose occupied the 47,000 acres.

In fall 1982, 22 adult radio-collared moose within the Susitna Hydroelectric Study area were recaptured and recollared in an effort to continue movement and habitat use studies during Phase II. Home range sizes and movements of moose during the reporting period were presented. During 1982, 20 radio-collared moose crossed the Susitna River in the vicinity of the impoundments a minimum of 42 occasions. Forty-nine percent of the crossings were initiated during the month of January, February, May and September.

Based upon locations of radio-collared moose which utilize the impoundment, boundaries of impact zones were delineated. Zones were classified as primary, secondary, and tertiary. The primary zone included radio-collared moose which would be directly

impacted by the project, while the secondary zone was comprised of moose which overlapped home ranges of moose occupying the primary zone. Population estimates ranged from approximately 1,900 to 2,600 moose which could be directly impacted by the project. Moose occupied the impoundment areas more during the months of March-May than other time periods. Two hundred and ninety moose were estimated to inhabit the Watana impoundment area from an aerial census on 25 March 1982.

Habitat use of radio-collared moose was assessed by overlapping moose locations on preliminary vegetation maps. In relation to availability, moose preferred woodland black spruce, open black spruce, closed mixed forest, and woodland white spruce types. Lakes, rock, sedge-grass tundra, sedge-shrub tundra and mat-cushion tundra were not preferred.

For the Watana impoundment area on a year-round basis, elevations ranging from 2001-2200 and 2401-3000 ft. were used more by radio-collared moose while elevations ranging from 1201-1400 and in excess of 3200 ft. were used significantly less, in relation to availability. During winter and spring, elevations ranging from 1601-2000 and 2201-2800 ft. were used more than expected. Use of slopes and aspects were not random.

During the reporting period a moose population dynamics model was developed and tested in an effort to predict population trends under preproject conditions. Components of the preliminary model are presented and discussed. Eventually the model will be used to test hypotheses concerning the impacts of Susitna Hydroelectric development on moose.

A summary of project impacts on moose and ways they may affect basic population parameters are presented.

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INTRODUCTION

Moose in the vicinity of a proposed hydroelectric project on the mainstem of the Susitna River have been under study for a number of years (Taylor and Ballard 1979). However, studies concerning the impacts of this project on moose did not begin in earnest until 1980. Moose (*Alces alces*) are one of the more important wildlife species which could be seriously impacted by hydroelectric development. Phase I moose studies (Ballard et al. 1981; 1982) were directed at determining how moose use the area in and around the two proposed impoundments, determining the approximate number of moose using the area, and identifying potential impact mechanisms.

Phase II moose studies were initiated in January 1982. These studies were designed to provide refinement of the information gathered during Phase I studies. The principal objectives of Phase II studies are as follows:

(1) To delineate a zone of impact of the Susitna Hydroelectric Project on moose.

(2) To determine the number of moose using the zone of impact and habitat which will be altered by construction of the Susitna Hydroelectric Project during winter and early spring.

(3) To determine changes in moose use of an area before and after a prescribed burn.

(4) To evaluate moose use of potential mitigation lands.

(5) To develop a habitat-based assessment of the current value of lands that will be lost or altered to moose.

This report updates some of the findings presented in the Final Phase I report (Ballard et al. 1982) with additional data collected from mid-August 1981 to early June 1982. Because the information contained in this report treats only portions of continuing studies, it should not be used in scientific technical publications without the written approval of the investigators.

STUDY AREA

Study area boundaries are within Game Management Unit 13 (GMU 13) and contain the middle and upper Susitna basins. More exact boundaries were previously described (Ballard et al. 1982).

SECTION I. PROPOSED EXPERIMENTAL BURN

Introduction

Controlled burning has been frequently mentioned as a potential tool which could be used by game managers to increase the numbers of moose on lands adjacent to or distant from the project area in an attempt to mitigate losses associated with Susitna Hydroelectric development. Although most biologists would concur that fire management can be used to retard or set back plant succession to maintain optimum moose habitat, information is needed to formulate a prescription which would provide the quickest and greatest benefits for moose. The magnitude and degree to which a moose population will respond to fire management is poorly understood.

Late in Phase I studies, the Bureau of Land Management in cooperation with the Alaska Department of Fish and Game, proposed and began planning an experimental burn to improve moose habitat. The proposed controlled burn area (47,000 acres) is located just south of the Alphabet Hills (Fig. 1). Although the proposed burn area had been identified as important moose winter range, baseline data concerning type and intensity of use, population size, and vegetation composition was lacking. Although the proposed burn will undoubtedly eventually improve moose winter range, the

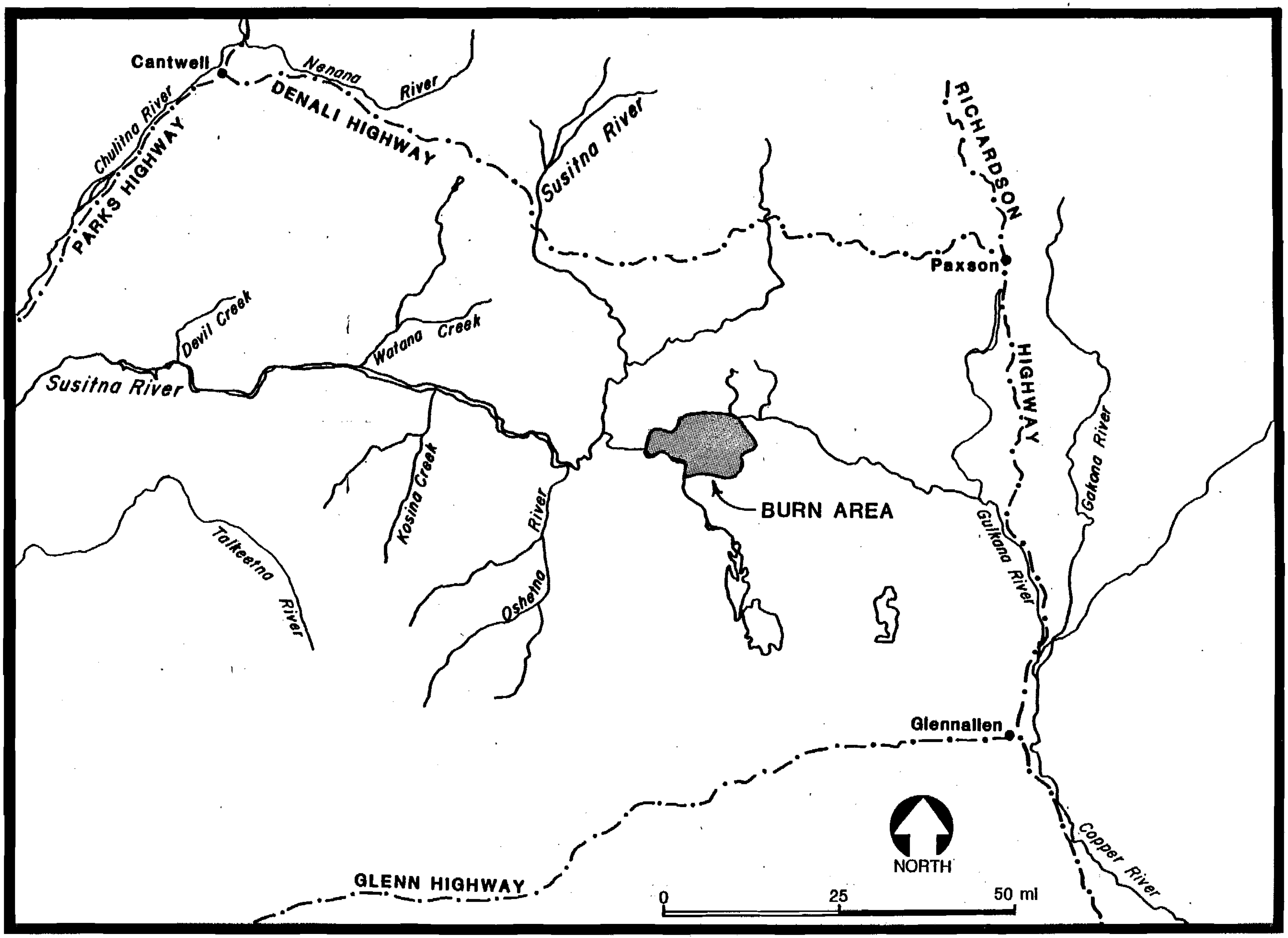


Figure 1. Boundaries of proposed control burn area in Game Management Unit 13 of southcentral Alaska.

timing of the burn will occur late enough in the year so that no regrowth of vegetation will occur. Therefore in the short term (1 winter) the burn has the potential to be detrimental to moose because winter range may be temporarily destroyed.

Methods

To provide a basis for assessing the utility and efficiency of controlled burning as a mitigation measure, an attempt was made to begin acquiring baseline information in 1982 concerning numbers of moose using the area, season of use, movement patterns, and winter moose density.

During April and July 1982 a total of 10 adult cow moose were captured and radio-collared within the proposed burn area. Statistics associated with the tagging programs are presented in Table 1. Moose immobilized during summer generally required 13 mg etorphine hydrochloride (M-99) in combination with 300 mg xylazine hydrochloride (Rompun). As anticipated, these doses were higher than those normally used to immobilize moose during fall and spring (10 cc etorphine). Higher drug doses during summer and fall are usually necessary because moose are generally in better physical condition, than after the winter-spring period of nutritional stress.

Table 1. Statistics associated with capture and radio-collaring of 10 adult cow moose in April and July 1982 within the proposed controlled burn area.

New Accession Number	Old Collar Number	Sex	Date of Capture	Location	Radio Collar #	Visual Collar Color	Metal Ear Tag L. R.	Age Yrs. (Mos.)	With Calf and No.	Total Length (cm)	Hind Foot (cm)	Head Length (cm)	Heart Girth (cm)	Condition	Drug Dosage	Placement & Induction Time (min)
120712	8037	F	7/19/82	Big bend Maclaren	9543	White	ear tags missing	--	C (1)	--	--	--	--	6	9 cc M-99, 1 cc Rompun 3 cc M-99 9 cc M-99, 1 cc Rompun	left leg (49) left rump left rump
120761	--	F	4/08/82	Burn area	9540	White	16995	4 (10)	No	282	84	--	83	5	--	--
120762	--	F	4/08/82	Burn area	9538	White	16948/15928	4 (10)	No	298	83	--	193	5		
120763	--	F	4/08/82	Burn area	9541	White		4 (10)	No	282	83	70	193	5		
120764	--	F	4/08/82	Burn area	9544	White	16854	at least 4 (10)	No	305	70	--	168	6		
120765	--	F	4/08/82	Burn area	9539	White	16338/16934	14 (10)	No	288	--	79	208	6		
120774	--	F	7/19/82	Burn W. of Kelly Lake	11864	White			No	--	--	--	--	8	10 cc M-99, Rompun 3 cc M-99	1 cc left side (18)
120775	--	F	7/20/82	Burn W. of Kelly Lake	11867	White	15992/15986	--	C (1)	282	80	79	198	8	9 cc M-99, Rompun 3 cc M-99	1 cc left hip left hip
120776	--	F	7/20/82	Burn S. of Kelly Lake	11865	White	15997/15990	--	No	267	76	70	173	7	9 cc M-99, Rompun 3 cc M-99	1 cc left hip left hip (14)
120777	--	F	7/20/82	Burn area	11866	White	15987/15989	--	No	274	81	75	190	9	--	(11)

On 24 and 25 March 1982 the proposed burn was divided into 9 units and censused using methods described by Gasaway et al. (1982) in an effort to determine winter moose density prior to burning.

Results

Although no data were available for this report, preliminary movement analyses from 10 radio-collared moose suggest that 3 separate populations utilize the proposed burn area; (1) one population winters in the area and spends summer and early fall north of the Alphabet Hills and the Denali Highway; (2) another subpopulation also winters in the area but migrates to the Oshetna River area where they remain through spring, summer, and fall; and (3) The area is also inhabited by a year-round resident population.

During the census, a total of 167 moose in 139 mi^2 were counted (Table 2). These were observed from fixed-wing aircraft at an intensity of 5.2 min./mi^2. Based upon an intensive resurvey of 1 area which was randomly selected, we estimated that approximately 40% of the moose present had not been counted. Therefore, the corrected March preburn moose population estimate was 279 moose for a density of 2.0 moose/mi^2. Distribution of observed moose were also recorded and are on file at the Glennallen ADF&G office.

Table 2. Results of moose census in GMU-13 proposed burn area, 24 and 25 March 1982.

Sample Unit	Area (mi^2)	Time (min)	Min/ mi^2	Observed No. Moose	Observed Moose/mi^2	Total estimated number moose 1/ No. Moose	Total estimated number moose 1/ Moose/mi^2
91	16.8	89	5.3	7	0.4	12	0.7
92	14.2	77	5.4	21	1.5	35	2.5
93	10.6	68	6.4	16	1.5	27	2.5
94	18.9	76	4.0	3	0.2	5	0.3
95	14.4	68	4.7	5	0.4	8	0.6
79	15.4	83	5.4	51	3.3	85	5.5
80	14.5	80	5.5	26	1.8	43	3.0
81	13.1	62	4.7	10	0.8	17	1.3
82	20.8	112	5.4	28	1.4	47	2.3
Total	138.7	715	46.8	167	11.3	279	18.7
Mean $\bar{x}$			5.2		1.3		2.0

1/ Sightability index generated by randomly selecting southeast quarter of unit surveying at 12 min/mi^2. An additional 2 moose were observed and thus approximately 40% of moose were not observed at survey intensity of 5.2 min/mi^2. Estimated number of moose = 3 observed x sightability index (1.67).

A prescription for the burn was prepared and the burn was scheduled to occur in August 1982. However, because of weather conditions not conducive to burning, the experiment was rescheduled for 1983.

SECTION II. HOME RANGE, DISTRIBUTION AND MOVEMENTS OF MOOSE

Radio-collaring Moose

Twenty-two adult moose originally captured in 1980 for Phase I studies were recollared in October 1982 to insure continued radio contact for Phase II studies. Moose captured in fall 1982 required an average of 18.5 cc etorphine hydrochloride (M-99) and 360 mg xylazine hydrochloride (Rompun) for successful immobilization (Table 3). Induction time ranged from 7 to 61 minutes, averaging 26.1 minutes. Drug dosages reported herein are the largest ever used on Unit 13 moose. We suspect that the larger doses were necessary because the moose were in excellent physical condition for this time of year. Between mid-August 1981 and early June 1982, 62 radio-collared moose were located on 727 occasions. Including recently captured animals, radio-collared moose were located an average of 1.3 occasions/month.

Table 3. Statistics associated with recapturing radio-collared moose in the Susitna Hydroelectric Project Study Area of southcentral Alaska during October 1982.

New Accession Number	Old Collar Number	Sex	Date Capture	Location	Radio Collar #	Visual Collar Color	Metal Ear Tag L. R.	Age Yrs.	Age (Mos.)	With Calf and No.	Total Length (cm)	Hind Foot (cm)	Condition	Drug Dosage	Placement & Induction Time (min)
120617	6406	F	10/12/82	Tsusena Creek	12425	White	15877/15876	--	--	No			8	20 cc M-99	(21)
120622	6407	F	10/12/82	Clark Creek	12424	White	None	13	(4)	No			8	20 cc M-99 3 cc M-99, 1 cc Rompun	(47)
120623	5527	F	10/09/82	Middle Brushkana Creek	12430	Y-50	16252/16253	9	(4)	C (1)	--	--	9	--	
120624	6393	F	10/14/82	Upper Watana Creek	12422	White	16922/16923	11	(4)	--	--	--	7	10 cc M-99 5 cc M-99, 3 cc Rompun	Rt. shoulder (19)
120629	6434	F	10/12/82	---	12415	White	16907/16906	4	(4)	--	--	--	--	10 cc M-99 3 cc M-99, 2 cc Rompun	(36)
120630	6438	F	10/12/82	Tsusena Creek	12423	White	16108/16109	7	(4)	--	--	--	--	20 cc M-99 3 cc M-99, 1 cc Rompun 3 cc M-99, 1 cc Rompun	Rump (50)
120634	6436	F	10/12/82	Stephan Lake	12428	White	16912/16913	13	(4)	--	--	--	8	10 cc M-99 3 cc M-99, 2 cc Rompun 3 cc M-99, 2 cc Rompun	(61)
120635	6433	F	10/12/82	Stephan Lake	12438	White	16162/16161	--	--	--	--	--	8	10 cc M-99 3 cc M-99, 2 cc Rompun 3 cc M-99, 1 cc Rompun	Left rump (44) Rt. back Rt. rear
120636	6448	F	10/15/82	Kosina Creek	12420	White	16165/16166	5	(4)	--	--	--	--	10 cc M-99 5 cc Rompun, 3 cc Rompun	Left shoulder (13)
120637	6437	F	10/16/82	Tsitsi Lake	12427	White	16170/16169	--	--	--	--	--	7	15 cc M-99, 3 cc Rompun	(13)
120639	6444	F	10/15/82	Tsitsi Lake	12435	White	16891/16892	5	(4)	No	--	--	8	15 cc M-99, 3 cc Rompun 5 cc M-99, 3 cc Rompun	(41)

Table 3. (cont'd)

New Accession Number	Old Collar Number	Sex	Date Capture	Location	Radio Collar #	Visual Collar Color	Metal Ear Tag L. R.	Age Yrs.	Age (Mos.)	With Calf and No.	Total Length (cm)	Hind Foot (cm)	Condition	Drug Dosage	Placement & Induction Time (min)
120640	6440	F	10/15/82	Kosina Creek	12412	White	16160/16159	6	(4)	--	--	--	7	10 cc M-99	(17)
120642	6445	M	10/12/82	Fog Creek	12432	White	15915/16903	5	(4)	--	297	82	7	10 cc M-99 3 cc M-99, 2 cc Rompun	left flank (7) left flank
120643	6447	F	10/12/82	Fog Lakes	12431	White	16918/16919	--	--	No	--	--	8	10 cc M-99 3 cc M-99, 2 cc Rompun	left hind leg (7) mid rump
120644	6452	F	10/12/82	Fog Creek	12429	White	15947/15946	--	--	No			--	10 cc M-99 2 cc Rompun	left rump (22)
120645	6451	F	10/14/82	Upper Butte	12418	White	15945/15944	11	(4)	No	--	--	7.5	10 cc M-99 5 cc M-99, 3 cc Rompun	right shoulder (17)
120648	6462	F	10/15/82	Coal Creek	12416	White	15940/15941	5	(4)	No			--	15 cc M-99 3 cc Rompun 5 cc M-99, 3 cc Rompun	left shoulder (13) neck
120649	6463	F	10/14/82	Clarence Lake	12433	White	16172/16171	--	--	No		5		10 cc M-99 5 cc M-99, 3 cc Rompun	left rump (13) left shoulder
120650	6467	F	10/15/82	Coal Creek	12414	White	15827/15826	5	(4)	C (1)	--	--	--	10 cc M-99 5 cc M-99, 3 cc Rompun	left shoulder (13)
120652	6464	F	10/14/82	Clarence Creek	12417	White	16152/16151	14	(4)	C (1)	--	--	7	10 cc M-99 5 cc M-99, 3 cc Rompun	left leg (14) left flank
120653	6450	F	10/14/82	Clarence Creek	12421	White	16105/16104	14	(4)	No	--	--	9	10 cc M-99 3 cc M-99, 1 cc Rompun 5 cc M-99, 3 cc Rompun	right rump (30) right rump
120654	6400	F	10/14/82	Clarence Creek	12419	White	16842/16841	10	(4)	No	--	--	8	10 cc M-99 5 cc M-99, 3 cc Rompun 5 cc M-99, 3 cc Rompun	left rump () left side left shoulder

Home Range Size

Appendix A summarizes seasonal and total home range sizes of radio-collared moose studied in the Nelchina and upper Susitna River Basins from October 1976 through early June 1982. No additional subpopulations or new movement corridors were detected from data collected between mid-August 1981 to early June 1982. Considerable variation in size was noted for both seasonal and total home range sizes. Some of the variation may be attributed to an insufficient number of locations.

Comparison of total home range size with numbers of locations for both calf and adult moose suggested considerable variation between individuals. Although weak correlations may exist, individual examination of the larger individual home range suggests two explanations. Larger range sizes (’700 km^2) for some calves were due to their dispersal away from the cow's home range. Therefore, subtraction of the area occupied while with the cow will reduce the size of the area and make them comparable with non-dispersing calf home ranges. However, for adults the larger (’1,100 km^2) home ranges were primarily the result of movements during the rut (Sept.-Nov.) and/or movements in April away from wintering areas (see Appendix A moose #'s 623, 635, 639, 664, 668, 696, 707, 708, and 722 for examples in Ballard et al. 1982). During these periods, except during migration, moose appear to move farther and more frequently than during other seasons. An additional reason for the large size of some home ranges was that the method used included high, mountainous areas (≥4,000 ft. elevation) which are rarely used.

Appendix B compares the annual home range sizes for individual moose for which more than one year's data exist. Although most moose obviously utilize the same core area, the specific size of the area may vary considerably each year. Reasons for these annual differences may be numerous but we offer the following as the most likely explanations: Some migrating moose do not move each year depending upon weather conditions; some areas are only used during critical periods (for example, see one-time movement of moose 664 during severe winter 1978-79); our rate of monitoring radio- collared moose was not always sufficient to detect occupation of areas utilized for short periods of time; some unknown annual proportion of the moose population colonizes new areas and subsequently occupies different home ranges (for example, see permanent movement of moose 725 to area east of the Copper River).

River Crossings

During 1982, 20 radio-collared moose crossed the Susitna River in the area of the proposed impoundments on 42 occasions bringing the total number of documented crossings since April 1980 to 82

(Table 4). During January, February, May, and September 49% of the river crossings were initiated (Fig. 2). There did not appear to be any consistent season for individual moose to cross the river but this was probably the result of relatively infrequent monitoring. Undoubtedly the frequency of river crossings by moose is much greater than what our data suggest.

Zone of Impact

Radio-collared moose which either seasonally or on a year-round basis occupy areas to be directly altered by operation and maintenance of both the Watana and Devil Canyon Impoundments were used to delineate an area where moose would be directly impacted. Home range polygons were determined for each moose which utilizes either the impoundment or its facilities, and the outermost borders of all polygons were used to delineate the border of the primary impact zone (Fig. 3). Home range polygons were computed by connecting outermost point locations (Mohr 1947) and only for those moose which had an excess of 4 location points. Similarly, secondary and tertiary zones of impact were determined by using the outer edges of moose home range polygons which overlap moose which will be directly impacted. The latter two zones were delineated on the assumption that moose displaced from the primary zone will compete with moose occupying the secondary and tertiary zones.

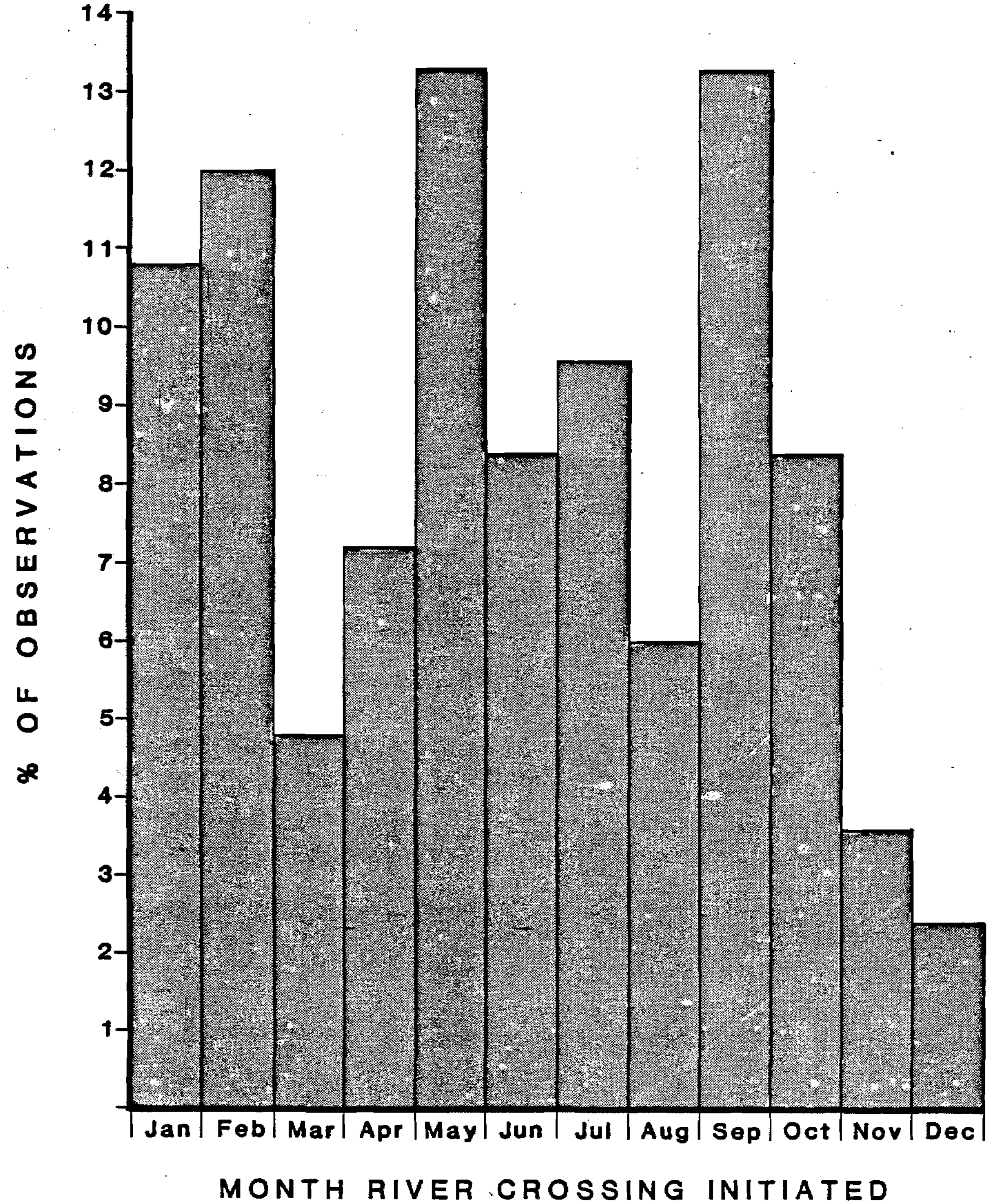


Figure 2. Timing of initiation of moose crossing of the Susitna River above Devil Canyon, Alaska from April 1980 through December 1982.

Table 4. Susitna River crossings, and calf production and mortality of 75 radio-collared moose studied from 11 April 1980 through December 1982 in the upper Susitna River Basin of southcentral Alaska. Superscripts with the same number indicate cow-calf groups.

Moose #	Sex-Age	Year	# Times Located	# Occasions Crossed Susitna River	Dates of River Crossings	Date First Observed With Calves	# Calves Observed	Dates When Calves Last Observed	# Calves Lost	# Calves Surviving	Misc. Notes
120617	F-A	1980	20	0	--	0	0	--	--	--	
		1981	14	0	--	5/29	2	5/29	1	1	
		1982	16	0	--	0	0	--	--	--	
120618	F-A	1980	13	0	--	0	0	--	--	--	Dead 7/1/81.
		1981	3	0	--	5/29	1	5/29	1	0	Bear predation.
120619	F-A	1980	16	1	5/13-6/4	0	0	--	--	--	
		1981	14	5	5/10-6/1 6/1-7/1 10/2-10/27 10/27-11/18 11/18-12/9	6/1	1	7/1	1	0	
		1982	14	2	5/12-5/24 9/27-10/30	5/24	1	5/24	1	0	
120620	F-A	1980	2	--	--	--	--	--	--	--	Dead 4/22/80
120621	F-A	1980	1	--	--	--	--	--	--	--	Lost collar
120622	F-A	1980	18	0	--	0	0	--	--	--	
		1981	13	0	--	0	0	--	--	--	
		1982	15	0	--	6/8	1	6/8	1	0	
120623	F-A	1980	10	0	--	0	0	--	--	--	
		1981	4	0	--	10/?	1	--	0	1	
		1982	9	2	1/4-2/2 2/2-4/16	7/10	1	10/30	1	0	
120624	F-A	1980	14	0	--	5/25	1	6/26	1	0	
		1981	11	4	9/16-10/5 10/5-10/28 10/28-11/17	5/29	1	--	--	0	
		1982	13	2	1/5-2/2 2/2-2/24	--	0	--	--	--	
120625	F-A	1980	6	0	--	0	0	--	--	--	Dead 6/26/80.

Table 4. (cont'd)

Moose #	Sex-Age	Year	# Times Located	# Occasions Crossed Susitna River	Dates of River Crossings	Date First Observed With Calves	# Calves Observed	Dates When Calves Last Observed	# Calves Lost	# Calves Surviving	Misc. Notes
120626	M-A	1980	13	0	--	--	--	--	--	--	Killed '81 hunting season.
		1981	8	2	7/22-8/17 8/17-9/10	--	--	--	--	--	
120627	M-A	1980	12	3	4/22-5/14 6/26-7/10 7/28-8/1	--	--	--	--	--	Killed '81 hunting season.
		1981	--	--	--	--	--	--	--	--	
120628	F-A	1980	16	0	--	5/22	2	5/22	2	0	
		1981	13	1	11/18-12/14	0	0	--	--	--	
		1982	14	0	--	0	0	--	--	--	
120629	F-A	1980	15	0	--	5/31	2	5/31	2	0	
		1981	13	0	--	0	0	--	--	--	
		1982	12	0	--	6/8	2	6/8	2	0	
120630 [1]	F-A	1980	13	0	--	6/10	2	6/10	1	1	
		1981	16	0	--	0	0	--	--	--	
		1982	14	0	--	0	0	--	--	--	
120631	F-A	1980	14	0	--	0	0	--	--	--	Lost collar 10/81
		1981	11	0	--	0	0	--	--	--	
120632	F-A	1980	12	0	--	--	--	--	--	--	Lost collar 7/14-8/12/80
120633	F-A	1980	3	0	--	--	--	--	--	--	Lost collar 4/22-5/13/80
120634	F-A	1980	15	0	--	5/31	1	5/31	1	0	
		1981	12	0	--	5/29	2	5/29	1	1	
		1982	17	0	--	0	0	--	--	--	
120635	F-A	1980	16	1	4/22-5/31 9/17-10/2	5/31	2	5/31	2	0	
		1981	14	2	9/9-9/27	5/29	2	5/29	2	0	
		1982	14	2	2/11-2/24 2/24-3/26	0	0	--	--	--	

Table 4. (cont'd)

Moose #	Sex-Age	Year	# Times Located	# Occasions Crossed Susitna River	Dates of River Crossings	Date First Observed With Calves	# Calves Observed	Dates When Calves Last Observed	# Calves Lost	# Calves Surviving	Misc. Notes
120636	F-A	1980	14	0	--	--	0	--	--	--	
		1981	12	0	--	5/26	1	5/26	1	0	
		1982	13	0	--	0	0	--	--	--	
120637 2/	F-A	1980	16	0	--	5/31	2	6/26	1	1	
		1981	13	0	--	0	0	--	--	--	
		1982	13	0	--	8/18	1	8/18	1		
120638	F-A	1980	13	0	--	0	0	--	--	--	
		1981	7	0	--	<1/1	1	7/1	1	0	Both cow and calf killed by bear.
120639	F-A	1980	18	0	--	7/14	1	7/14	1	0	
		1981	10	0	--	0	0	--	--	--	
		1982	15	0	--	0	0	--	--	--	
120640 1/	F-C	1980	13	0	--	6/2	1	--	0	1	
		1981	13	0	--	<7/1	1	--	0	1	
		1982	13	0	--	0	0	--	--	--	
120641 4/	F-A	1980	17	0	--	5/31	2	6/26	1	1	Dead 5/82
		1981	15	0	--	6/1	1	6/1	1	0	
		1982	7	0	--	0	0	--	--	--	
120642	M-A	1980	14	0	--	0	0	--	--	--	
		1981	12	0	--	0	0	--	--	--	
		1982	16	0	--	0	0	--	--	--	
120643	F-A	1980	18	0	--	0	0	--	--	--	
		1981	11	0	--	5/29	1	5/29	1	0	
		1982	15	0	--	0	0	--	--	--	
120644	F-A	1980	14	0	--	6/2	2	6/2	2	0	
		1981	13	0	--	0	0	--	--	--	
		1982	18	0	--	0	0	--	--	--	
120645	F-A	1980	14	0	--	5/25	2	6/6	2	0	
		1981	13	0	--	5/22	1	5/22	1	0	
		1982		0	--	0	0	--	--	--	
120646	F-A	1980	3	0	--	--	--	--	--	--	Dead 5/30 from collaring or wolf predation.

Table 4. (cont'd)

Moose #	Sex-Age	Year	# Times Located	# Occasions Crossed Susitna River	Dates of River Crossings	Date First Observed With Calves	# Calves Observed	Dates When Calves Last Observed	# Calves Lost	# Calves Surviving	Misc. Notes
120647	F-A	1980	18	2	5/25-5/27 5/27-5/31	0	0	--	--	--	
		1981	14	2	7/22-8/4 8/4-8/9	5/26	2	5/26	1	1	
		1982	4	1	2/1-2/24	--	--	--	--	--	Dead 2/82, apparent winter kill.
120648	F-A	1980	14	0	--	6/27	1	1	0	1	
		1981	14	0	--	5/26	1	5/26	1	0	
		1982	13	0	--	7/28	1		1	0	
120649	F-A	1980	14	0	--	5/25	1	5/25	1	1	
		1981	15	0	--	0	0	--	--	--	
		1982	13	0	--	0	0	--	--	--	
120650	F-A	1980	16	0	--	5/27	1	--	--	1	
		1981	16	0	--	0	0	--	--	--	
		1982	13	0	--	6/10	1	--	0	1	
120651	F-A	1980	13	0	--	0	0	--	--		Dead 1/9/81.
		1981	1	0	--	--	--	--	--	--	Wolf Predation.
120652	F-A	1980	16	0	--	6/2	2	6/2	2	0	
		1981	14	0	--	0	0	--	--	--	
		1982	12	0	--	6/10	2	6/10	1	1	
120653	F-A	1980	14	0	--	5/27	2	5/27	2	0	
		1981	14	0	--	0	0	--	--	--	
		1982	16	3	3/13-4/13 6/10-7/27 8/13-10/8	0	0	--	--	--	
120654	F-A	1980	14	0	--	0	0	--	--	--	
		1981	12	0	--	0	0	--	--	--	
		1982	14	1	2/1-2/24	0	0	--	--	--	
120655	F-A	1980	14	0	--	0	0	--	--	--	
		1981	12	2	9/8-9/16 9/16-10/28	0	0	--	--	--	
		1982	8	2	12/7-1/5 1/5-2/1	0	0	--	--	--	Dead 6/82.
120656	F-A	1980	16	0	--	6/27	2	6/27	1	1	
		1981	2	0	--	0	0	--	--	--	
		1982									

Table 4. (cont'd)

Moose #	Sex-Age	Year	# Times Located	# Occasions Crossed Susitna River	Dates of River Crossings	Date First Observed With Calves	# Calves Observed	Dates When Calves Last Observed	# Calves Lost	# Calves Surviving	Misc. Notes
120662	F-A	1980	10	0	--	0	0	--	--	--	
		1981	11	0	--	7/28-9/9	1	--	0	1	
		1982	12	0	--	0	0	--	--	--	
120663		1980	10	0	--	0	0	--	--	--	
		1981	12	0	--	6/27-7/28	1	--	0	1	
		1982	10	1	1/11-2/24	5/1	1	--	0	1	
120664	F-A	1980	11	0	--	0	0	--	--	--	
		1981	1	0	--	0	0	--	--	--	
		1982									
120666	F-A	1981	10	0	--	0	0	--	--	--	
		1982	6	0	--	0	0	--	--	--	
120667	M-A	1981	12	0	--	--	--	--	--	--	
		1982	6	0	--	--	--	--	--	--	
120668 [6]	F-A	1981	13	0	--	--	--	--	1	0	
		1982	12	0	--	6/8	1	--	0	1	
120669 [6]	F-C	1981	12	0	--	--	--	--	--	--	
120670C	F-C	1981	14	0	--	--	--	--	--	--	Lost radio contact 5/22.
120671 [7]	F-A	1981	11	0	--	--	--	--	--	--	
		1982	10	0	11	7/28	1	0	0	1	
120672 [7]	M-C	1981	11	0	--	--	--	--	--	--	
		1982	15	0	--	--	--	--	--	--	
120673 [8]	F-A	1981	3	0	--	--	--	--	--	--	Lost collar.
120674 [8]	M-C	1981	12	0	--	--	--	--	--	--	
		1982	11	2	1/5-2/2 2/2-2/24 5/6-6/8	--	--	--	--	--	

Table 4. (cont'd)

Moose #	Sex-Age	Year	# Times Located	# Occasions Crossed Susitna River	Dates of River Crossings	Date First Observed With Calves	# Calves Observed	Dates When Calves Last Observed	# Calves Lost	# Calves Surviving	Misc. Notes
120675 9/	M-C	1981	13	0	--	--	--	--	--	--	
		1982	11	1	--	--	--	--	--	--	
120676 1/	M-C	1981	13	2	9/16-10/1 10/1-10/27	--	--	--	--	--	
		1982	12	2	2/24-3/13 4/15-5/1	0	0	--	--	--	
120677 2/	M-C	1981	13	2	8/4-9/10 9/10-10/1	--	--	--	--	--	
		1982	12	0	--	--	--	--	--	--	
120678 3/	F-C	1981	13	0	--	--	--	--	--	--	
		1982	12	0	--	0	0	--	--	--	
120679 4/	F-C	1981	14	0	--	--	--	--	--	--	
		1982	2	0	--	--	--	--	--	--	Dead 2/82. Apparent winter kill.
120680 10/	F-Y	1981	11	0	--	--	--	--	--	--	
		1982	12	0	--	0	0	--	--	--	
120681 11/	F-C	1981	5	0	--	--	--	--	--	--	
		1982									
120682	M-A	1981	6	0	--	--	--	--	--	--	
		1982									
120683 12/	F-A	1981	13	2	4/15-5/26 5/26-6/24	6/24	1	--	--	1	
		1982	11	0	--	6/8	1	6/8	1	0	

Table 4. (cont'd)

Moose #	Sex-Age	Year	# Times Located	# Occasions Crossed Susitna River	Dates of River Crossings	Date First Observed With Calves	# Calves Observed	Dates When Calves Last Observed	# Calves Lost	# Calves Surviving	Misc. Notes
120684	[13/]F-A	1981	13	0	--	--	--	--	--	--	
		1982	11	5	1/4-2/1	6/8	1	7/28	1	0	
					6/8-7/28						
					7/28-10/30						
					10/30-11/16						
					11/16-12/4						
120685	[14/]F-C	1981	10	0	--	--	--	--	--	--	
		1982	13	3	5/10-5/28	0	0	--	--	--	
					5/28-6/1						
					6/1-7/27						
120686	[15/]F-C	1981	12	2	7/22-9/9	--	--	--	--	--	
					9/21-10/1						
		1982	13	0	--	7/27	1	7/27	1	0	
120687	[16/]	1981	11	0	--	5/26	1	--	0	1	
		1982	9	0	--	0	0	--	--	--	
120688	F-A	1981	12	0	--	--	--	--	--	--	
		1982	8	0	--	0	0	--	--	--	
120689	[16/]F-C	1981	11	0	--	--	--	--	--	--	
		1982	10	0	--	0	0	--	--	--	
120690	[13/]M-C	1981	11	0	--	--	--	--	--	--	
		1982	10	0	--	--	--	--	--	--	
120691	[15/]F-A	1981	12	0	--	--	--	--	--	--	
		1982	11	2	1/4-2/1	--	--	--	--	--	
					2/1-2/24						
120692	[14/]F-C	1981	11	0	--	6/24	1	--	0	1	
		1982									

Table 4. (cont'd)

Moose #	Sex-Age	Year	# Times Located	# Occasions Crossed Susitna River	Dates of River Crossings	Date First Observed With Calves	# Calves Observed	Dates When Calves Last Observed	# Calves Lost	# Calves Surviving	Misc. Notes
120693	12/ F-C	1981	12	3	4/15-5/26 5/26-6/24 10/1-10/27	--	--	--	--	--	
		1982	10	3	12/81-1/82 2/24-3/23 3/23-5/5	0	0	--	--	--	
120694	10/ F-A	1981	13	0	--	--	--	--	--	1	
		1982	14	0	--	6/8	1	6/8	1	0	
120695	17/ F-A	1981	9	3	7/18-7/28 7/28-9/9 9/17-10/2	--	--	--	--	1	
		1982	13	2	6/8-8/10 8/18-10/26	0	0	--	--	--	
120696	17/ M-C	1981	9	1	7/18-7/22	--	--	--	--	--	
		1982	10	2	3/13-5/12 5/24-6/8	0	0	--	--	--	
120697	F-A	1981	11	0	--	--	--	--	--	--	
		1982	11	4	1/5-2/24 2/24-3/23 4/14-5/5 6/8-7/28	0	0	--	--	--	

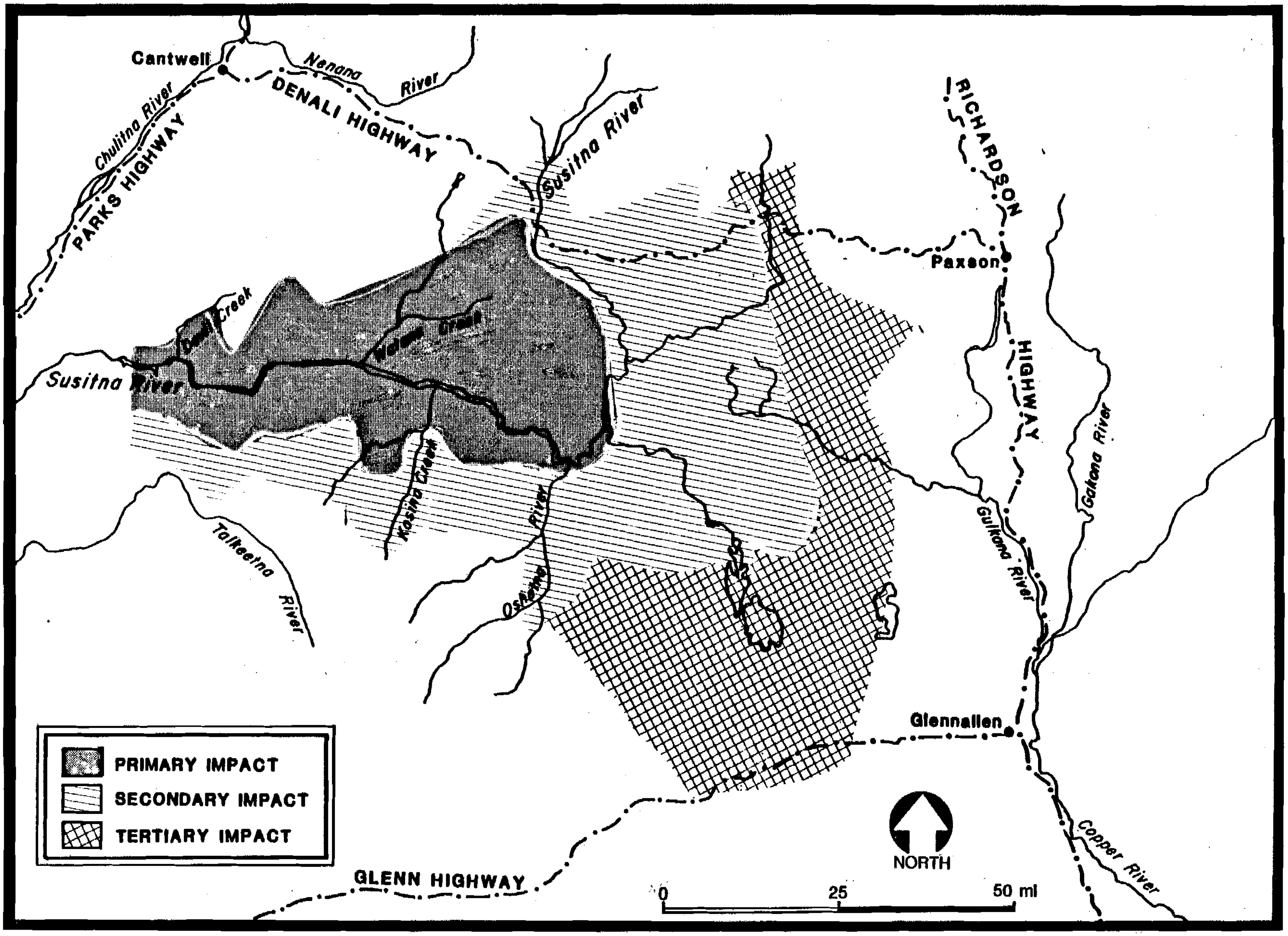


Figure 3. Boundaries of primary, secondary and tertiary zones of impact for the Susitna Hydroelectric Project based upon movements of radio-collared moose from 1976–1982 in Game Management Unit 13 of southcentral Alaska.

Numbers of moose occurring within the primary impact zone were estimated by 3 methods (Table 5). The first method was similar to the preliminary analysis provided by Ballard et al. (1982). The proportion of radio-collared moose occurring within the impoundment zone was compared to the total number of radio-collared moose within the 1980 census boundary and was then extrapolated to the total population estimate. Although such an estimate (1,913 moose) could potentially be biased because of capture location, over half of the radio-collared moose included in the method were captured for other studies, and thus were located away from the project area. Therefore any biases should be minimized. Method 2 applied the average moose density estimate derived from censusing moose count areas 7 and 14 during fall 1980 (see Ballard *et al.* 1982) to the amount of moose habitat contained within the primary zone. Method 3 utilized the actual count area boundaries used for the census. Each count area had been stratified into one of 4 moose densities (none, low, medium, and high) and its area had been determined. The moose density estimates for each stratum were then applied to the amount of each type occurring within the primary zone. Densities and associated square miles of fall habitat for moose which come in contact with the Watana impoundment were estimated as follows: High density at 3.7 moose/mi^2 = 203 mi^2, moderate density at 1.8 moose/mi^2 = 315 mi^2, and low density at 1.1 moose/mi^2 = 445 mi^2.

Table 5. Area of moose habitat (less than 4,000 ft. elevation) and moose population estimates for 3 moose impact zones associated with development of the Susitna Hydroelectric Project.

	Mi^2	Mi^2 of Nonmoose Nabitat	Mi^2 of Moose Habitat	#'s Radio Collared Moose	Moose Population Estimates Method 1	Method 2	Method 3
Primary Zone	1,378	124	1,254	68	1,913	2,633	2,265
Secondary Zone	1,750	261	1,489	50		3,765	
Tertiary Zone	2,258	161	2,097	53		4,742	

According to this assessment approximately 1,800 moose would be directly impacted by the Watana impoundment and its associated development. Similarly, densities and square miles of fall 1980 habitat for the Devil Canyon impoundment were classified as follows: 12 mi^2 at high density, 146 mi^2 at moderate density and 137 mi^2 at low density. Using these estimates, 450 moose would be directly affected by the Devil Canyon development.

Winter Use of Watana Impoundment

Methods

Winter locations of moose found within the impact zone (Fig. 4) were used to delineate the approximate boundaries of an area which should be intensively censused during severe winter conditions in future years.

Because moose appeared to concentrate in the Watana impoundment area during March 1982, an attempt was made to census the Watana impoundment area out to 1/4 mile from the 2,200 ft. high pool level. The census was conducted on 25 March 1982. Conditions for the census were poor due to complete but old snow cover, overcast light conditions, and moderate air turbulence. No census was conducted in the Devil Canyon area.

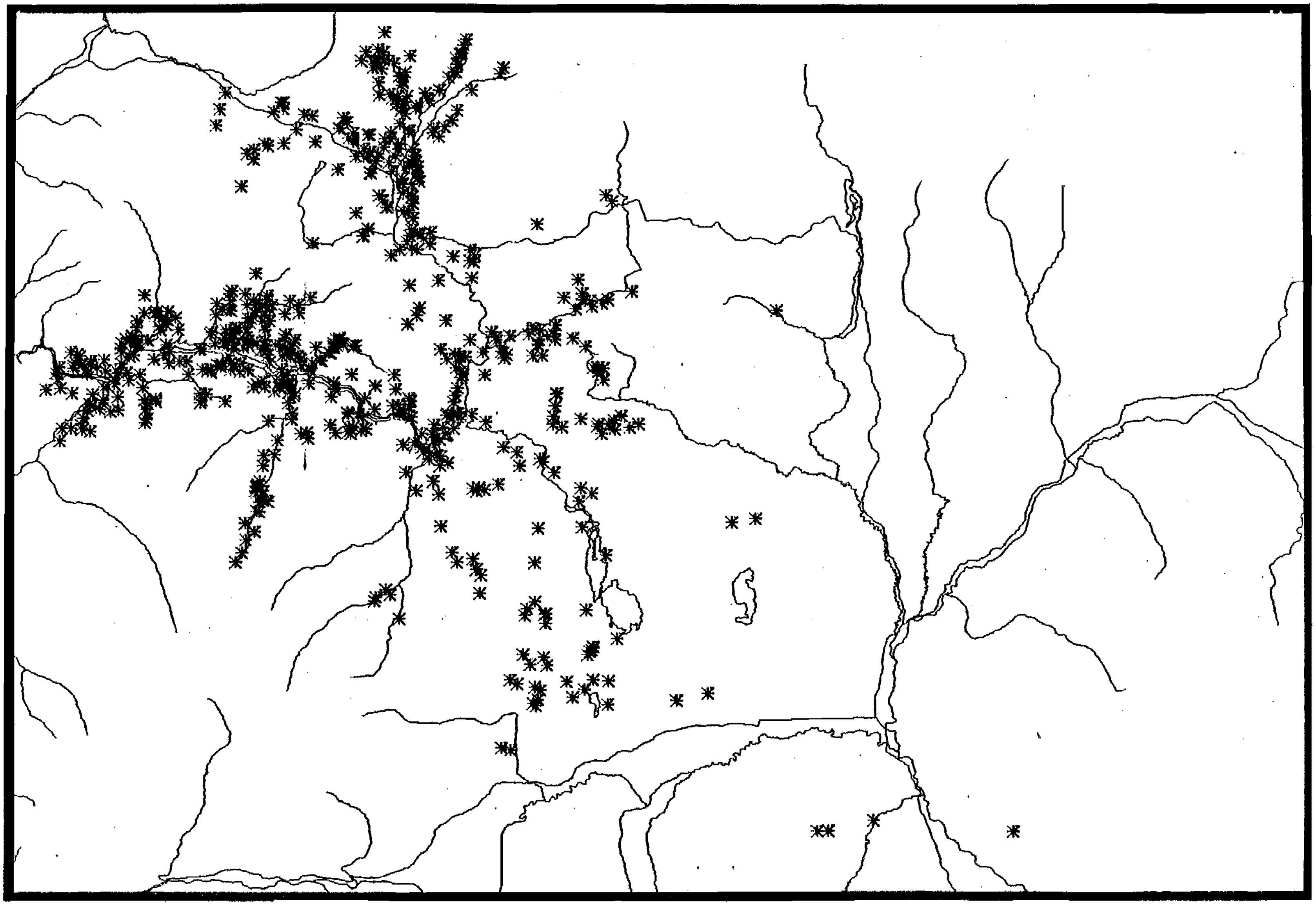


Figure 4. Distribution of winter (January, February and March) observations of radio-collared moose from 1977 through 1982 in the Nelchina and upper Susitna River Basins of southcentral Alaska.

Results

A total of 4.4 hours were spent surveying 96.8 mi^2 of habitat (river water area excluded) during which 174 moose were observed (Table 6). Because of the relatively low sampling intensity (2.73 min/mi^2) and poor surveying conditions, certainly not all moose present were observed. We utilized the observability correction factor obtained from censusing the proposed burn area to provide a minimum estimate of the moose not observed. This resulted in a minimum population estimate of 290 moose (3 moose/mi^2) utilizing the impoundment area on 25 March 1982. This latter estimate was 7 times greater than the number of moose estimated to occupy the area in March 1981. (Ballard et al. 1982).

Recruitment

Although no attempt was made to measure productivity of radio-collared cow moose during 1982, productivity appeared comparable to earlier studies (Ballard et al. 1981, 1982). However, mortality (approximately 71%) of calves continued at a relatively high level (Table 4) and was similar to earlier years where most losses were attributable to predation by brown bears (Ballard et al. 1980; 1981; 1982).

Table 6. Distribution of moose in 4 areas of the proposed Watana impoundment on the Susitna River, Alaska observed during an aerial census on 25 March 1982.

Area	# of Moose			
	Adults	Calves	Unknown	Total Moose
Upstream end to Goose Creek	26	9	--	35
Goose Creek to Jay Creek	55	17	6	78
Jay Creek to Watana Creek	28	5	6	39
Watana Creek to downstream end	13	5	4	22
Totals	122	36	16	174

SECTION III. LAND USE

Vegetation/Habitat Selection

Methods

Use of 19 habitat types around the proposed Devil Canyon and Watana impoundments was determined by overlaying locations of radio-collared moose onto portions of the 1:63,360 scale vegetation maps provided by Palmer Agricultural Experimental Station (Subtask 7.12, 1982). This included only moose occupying the primary impact zone (Fig. 3). Habitat types were identified according to Viereck and Dyrness's (1980) level II classification.

Two methods were used for determining habitat use: (1) Only moose locations within the borders of a specific type were tallied and locations on ecotone areas (borders of mapped vegetation types) were excluded; and (2) locations on ecotone areas (borders) were added to the specific types which were used. Because availability of these habitat types had been calculated in the Subtask 7.12 1982 report for a greater area than just near the impoundments (Gold Creek to the Maclaren River) we had to determine habitat availability for this smaller area of concern.

Availability of each habitat type was determined by overlaying a grid (mesh = .01 mi^2) on the vegetation maps and randomly selecting grid points. The habitat type or types within each selected grid intersect was tallied. All moose locations within the mapped areas were included.

Results

Based on a preliminary assessment, the following habitat types were preferred in relation to their availability by moose both year-round and in spring: woodland black spruce, open black spruce, closed mixed forest and woodland white spruce (Table 7). Willow habitat types were preferred when ecotones were included but were not selected out of proportion to their availability when ecotones were excluded. During spring, willow habitat types were used proportionally less than their availability. Also, low shrub habitat types were used year-round in excess of their availability when ecotone areas were excluded. Lakes, rock, sedge-grass tundra, sedge-shrub tundra, and mat-cushion tundra were generally used less than expected based upon their availability. Generally, the remaining vegetation types not listed above were used in proportion to their abundance. Because corrected updated vegetation maps are currently in preparation and only moose locations obtained from April 1980 to September 1981 were included, all conclusions based upon this analysis are preliminary.

Table 7. Availability of 19 habitat types and moose utilization of them in the Susitna River Study Area from April 1980 through September 1981.

		All locations				Spring Locations	
		Ecotones excluded		Ecotones included		Ecotones included	
Habitat Type	% Available	% Use	X²	% Use	X²	% Use	X²
Low shrub	21.0	25.9	4.2*	23.6	2.0	24.5	1.4
Mat-cushion tundra	12.5	0.7	52.5*	2.3	65.1*	3.0	18.2*
Birch	11.1	9.9	0.5	11.9	0.3	10.7	2.9
Woodland black spruce	9.7	19.8	31.1*	17.5	28.6*	15.0	6.2*
Open black spruce	6.1	13.8	27.4*	12.6	28.5*	12.0	11.1*
Open tall shrub	5.7	3.3	4.1*	3.8	3.8	4.7	0.4
Sedgegrass tundra	5.4	1.5	12.0*	1.7	18.5	2.6	3.5
Closed mixed forest	5.0	8.1	5.9*	8.9	12.9*	12.0	17.4*
Woodland white spruce	4.3	9.0	14.7*	7.9	12.8*	7.3	4.1*
Sedge shrub tundra	3.9	0.2	15.6*	0.3	26.2*	--	--
Open mixed forest	3.6	2.6	0.9	2.2	3.4	2.1	1.3
Open white spruce	2.3	2.2	0.03	2.6	0.1	1.7	0.4
Closed tall shrub	2.2	1.1	2.2	1.3	2.4	2.6	0.1
Rock	2.0	0	9.2*	0	15.9*		-
Lake	1.8	0.4	4.3*	0.3	9.7*	--	--
Willow	1.1	0.7	0.7	2.2	4.0*	0.9	11.4*
Closed birch forest	0.9	0.4	0.9	0.4	1.9	0.9	0.3
Open birch forest	0.8	0.2	1.6	0.4	1.2	--	--
Wet sedge grass tundra	0.6	0	2.8	0.4	0.5	--	--
Totals	100.0	99.8	190.7*	100.3	237.8*	100.0	64.0*
N	1450 grid points	455 moose locations		784 moose locations		233 moose locations	

* Use significantly different (P<0.05) than expected, based on habitat availability.

Use of Various Elevations, Slopes and Aspects

Methods

The availability of various elevations, slopes, and aspects to moose within the primary impact zone was assessed by recording these variables at the intersection of section lines on 1:63,360 scale topographic maps (U.S.G.S.). Moose usage was determined from radio locations plotted on topographic maps. Moose locations in the impact zone and the availability data were divided into those associated with each impoundment area. Elevations were determined by extrapolating between contour lines to the nearest 50 ft. interval. To assess the importance of the area to be inundated and also lands immediately adjacent to the impoundments which are most likely to be altered from such things as project facilities, changes in microclimate, changes in plant phenology, we determined the proportion of moose locations within the primary impact zone occurring at or below 2,300 ft. Slopes were classified into 3 categories: flat = 0° to 10° with contour line intervals exceeding 0.19 inch, gentle = 11° to 30° with contour line intervals ranging from 0.03 to 0.19 inch, and moderate = ≥30° with contour line intervals less than 0.03 inches. Aspect was classified as flat, or 1 of 8 compass directions, from the direction of a line perpendicular to the contour lines through the moose location point.

Results

There was considerable variation in the monthly and annual elevations occupied by radio-collared moose in the primary impact zone (Table 8). Generally, moose in the project area move to higher elevations in October, presumably to breed, and then depending on snow conditions, begin moving downward reaching the lowest elevations occupied during the year from January through May (Fig. 5). Moose appear to be driven to lower elevations in winter by heavy snowfall; however, we suspect that in average or mild winters, temperature inversions and high winds make foraging and traveling easier at higher elevations. Consequently, moose may occupy relatively high areas in winter and spring depending on snow depths, temperatures, and other factors. Moose occupy lower elevations in late spring and early summer during calving. This may be related to earlier snow melt, earlier growth of spring forage, and perhaps increased cover requirements during calving.

The monthly importance of elevations at or below 2,300 ft. to moose within the primary impact zone was quite variable between years except during winter and spring months. Use during at least 1 month each winter and spring exceeded 30% of the locations (Table 9). As expected, use of the impoundment zone by moose was lowest during the months of October through December. Overall, 21.4% of all moose locations collected from October 1976 through May 1982 were at or less than 2,300 ft. elevation.

Table 8. Average monthly elevations for 74 radio-collared moose studied intermittently from October 1976 through May 1982 in the primary impact zone of the Susitna project.

	1976-77			1977-78			1978-79			1979-80			1980-81			1981-82		
Month	$\bar{x}$	Range	# (Moose)	$\bar{x}$	Range	# (Moose)	$\bar{x}$	Range	# (Moose)	$\bar{x}$	Range	# (Moose)	$\bar{x}$	Range	# (Moose)	$\bar{x}$	Range	# (Moose)
June				2548	1800-3800	(12)	2575	1300 3900	(12)	2800	--	(1)	2454	1600 3650	(32)	2710	1725 3800	(29)
July				2930	2200-4000	(14)	2455	1600 3600	(11)				2514	2000 4200	(13)	2590	1500 3400	(48)
Aug.				2856	2100 3900	(14)	2856	2200 4000	(13)				2592	1800 3300	(31)	2435	1900 3050	(24)
Sept.				--	--	--	2631	2200 3400	(12)	2800	--	(1)	2620	1800 3300	(30)	2566	1450 4100	(49)
Oct.	3333	3000-3600	(6)	2786	2000 3200	(14)	3024	2100 3900	(11)	3700	--	(1)	2850	1800 3700	(29)	2797	1450 4550	(49)
Nov.	2700	2400-3200	(5)	2821	1900 3600	(11)	2658	1450 3600	(10)	2350	1900 2800	(1)	2902	2100 3600	(29)	2725	1950 3850	(47)
Dec.	2708	2400-3500	(6)	--	--	--	2620	1600 3600	(10)				3044	2800 3750	(16)	2731	1975 4100	(43)
Jan.	2233	2000-3400	(6)	2525	2300 2800	(4)	2575	1900 3600	(8)				2689	1800 3400	(15)	2515	1650 4300	(42)
Feb.	2578	2300-2800	(5)	2770	1800 3600	(10)	2667	2600 2800	(3)				2512	1400 3500	(25)	2485	1400 3600	(44)
March	2850	2200-3600	(14)	2550	2200-2900	(4)	2713	2200-3400	(8)				2396	1700-3300	(48)	2461	1600-3500	(43)
April	2476	1800-3600	(15)	2490	1900-3800	(10)	2543	2100-3200	(7)	2327	1500-3300	(30)	2583	1500-3500	(36)	2503	1375 4100	(42)
May	2452	1400-3800	(13)	2471	1900-2800	(13)	--	--	--	2387	1400-3400	(28)	2565	1400-3400	(46)	2480	1975-3500	(43)

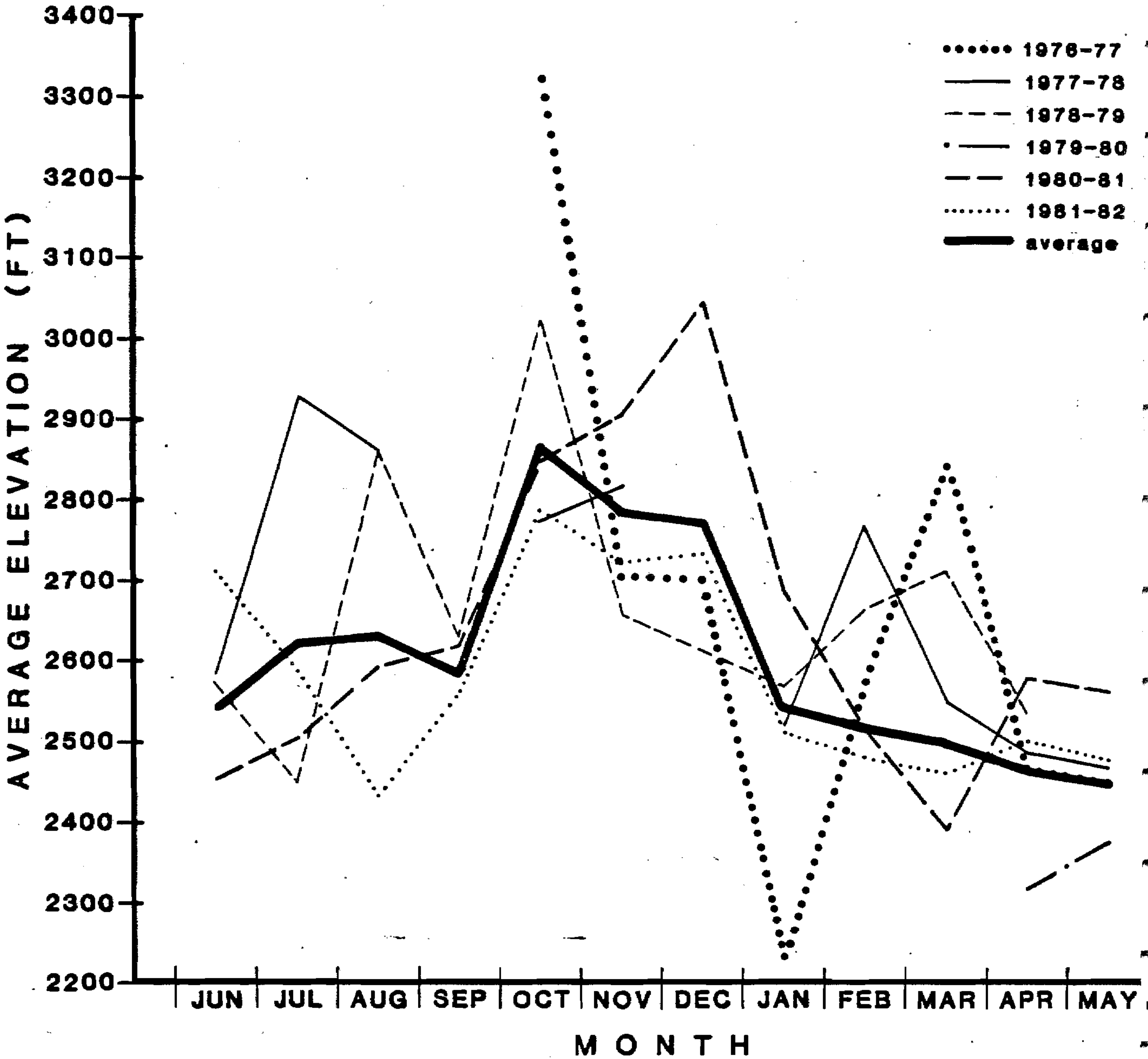


Figure 5. Mean monthly elevations occupied by 74 radio-collared moose from October 1976 through May 1982 in the primary impact zone of the Susitna project.

Table 9. Radio-collared moose locations occurring at or below 2300 ft. elevation in relation to total number of locations by month and year for moose occupying in the Susitna Hydroelectric Project primary impact zone from 1976 through May 1982.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	Totals
1976-77													
N	--	--	--	--	0 (6)	0 (7)	0 (12)	1 (6)	0 (9)	1 (24)	9 (21)	11 (23)	22 (108)
%	--	--	--	--	0	0	0	16.7	0	4.2	42.9	47.8	20.4
1977-78													
N	6 (57)	1 (20)	1 (16)	--	1 (14)	1 (14)	--	0 (4)	2 (10)	2 (6)	5 (10)	4 (21)	23 (172)
%	10.5	5.0	6.3	--	7.1	7.1	--	0	20.0	33.3	50.0	19.0	13.4
1978-79													
N	8 (44)	4 (11)	6 (18)	2 (20)	1 (17)	1 (13)	3 (10)	2 (8)	0 (3)	1 (8)	3 (7)	--	31 (159)
%	18.2	36.4	33.3	10.0	5.9	7.7	30.0	25.0	0	12.5	42.9	--	19.5
1979-80													
N	0 (1)	--	--	0 (1)	0 (1)	1 (2)	--	--	--	--	24 (49)	28 (66)	53 (120)
%	0	--	--	0	0	50.0	--	--	--	--	49.0	42.4	44.2
1980-81													
N	20 (71)	7 (18)	8 (60)	10 (46)	9 (82)	3 (42)	0 (16)	3 (22)	3 (25)	30 (87)	6 (38)	9 (50)	108 (557)
%	28.2	38.9	13.3	21.7	11.0	7.1	0	13.6	12.0	34.5	15.8	18.0	19.4
1981-82													
N	5 (29)	18 (70)	5 (24)	19 (95)	6 (89)	8 (53)	8 (44)	12 (44)	22 (73)	18 (46)	8 (47)	16 (58)	145 (672)
%	17.2	25.7	20.8	20.0	6.7	15.1	18.2	27.3	30.1	39.1	17.0	27.6	21.6
Totals													
N	39 (202)	30 (119)	20 (118)	31 (162)	17 (209)	14 (131)	11 (82)	18 (84)	27 (120)	52 (171)	55 (172)	68 (218)	382 (1788)
%	19.3	25.2	16.9	19.1	8.1	10.7	13.4	21.4	22.5	30.4	32.0	31.2	21.4

Watana Impoundment

Elevations ranging from 2,001-2,200 and 2,401-3,000 ft. within the primary impact zone of the Watana impoundment were used more than expected (P‘0.05) based upon availability, while elevations from 1,201-1,400 ft. and in excess of 3,204 ft. were used less (P‘0.05) than expected (Fig. 6). Elevations ranging from 1,401-2,000, 2,201-2,400, and 3,001-3,200 ft. were used in proportion to their availability (P’0.05). During winter and spring, elevations ranging from 1,601-2,000, and 2,201-2,800 ft. were used more than expected (P‘0.05), reflecting the downward movement of moose during these seasons (Fig. 7). Elevations in excess of 3,001 ft. were used less than expected (P‘0.05) during winter and spring seasons.

Similarly, slope usage by moose was not random (P‘0.05), $X^2 = 24.5$). Flat slopes were used less than expected (P‘0.05) while moderate slopes were used more than expected (P‘0.05), both year-round and from January to May (Fig. 8). Gentle slopes were used in proportion to their availability (P‘0.05).

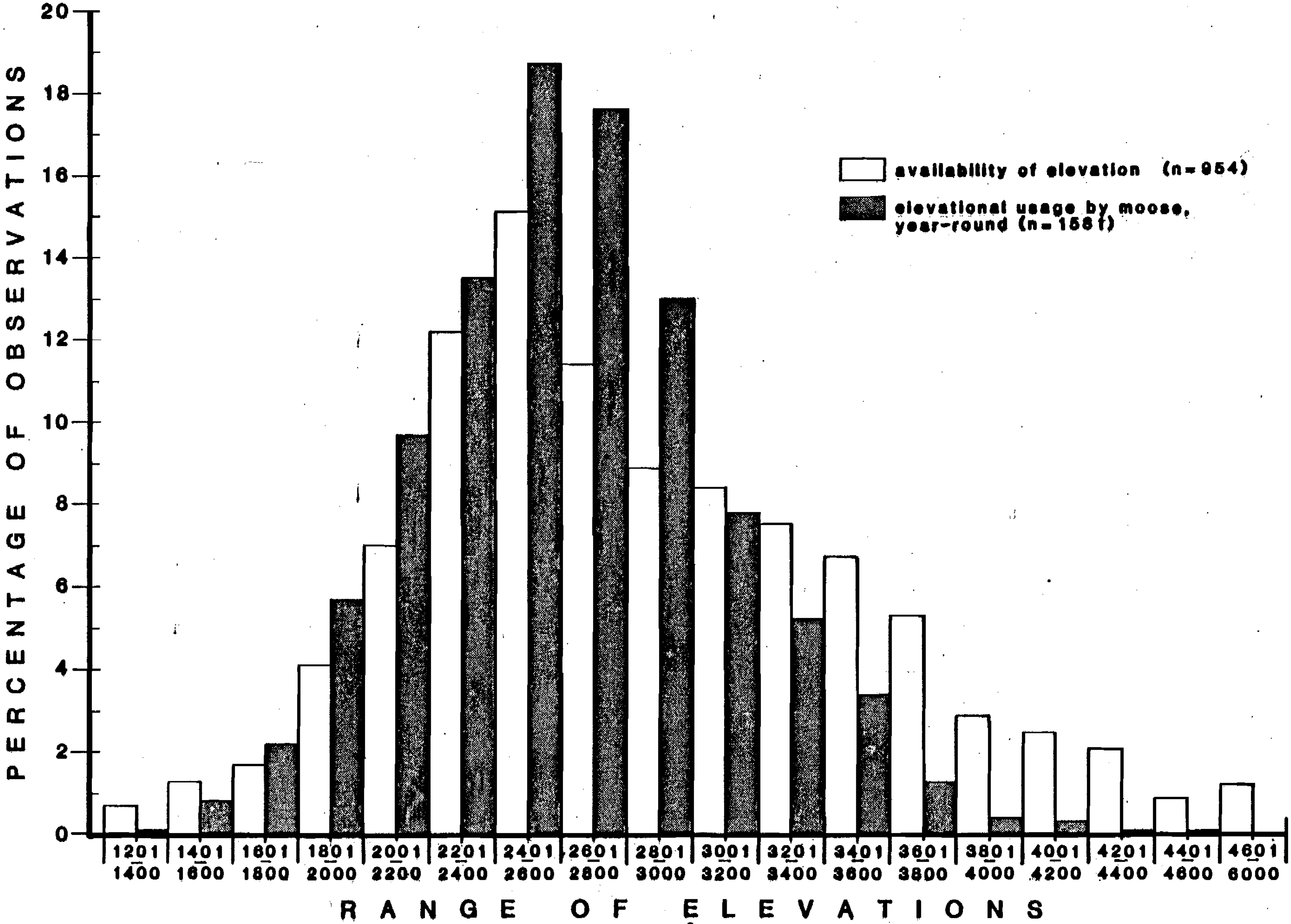


Figure 6. Year-round elevational usage by radio-collared moose in relation to availability in the primary impact zone of the proposed Watana impoundment, 1976-1982.

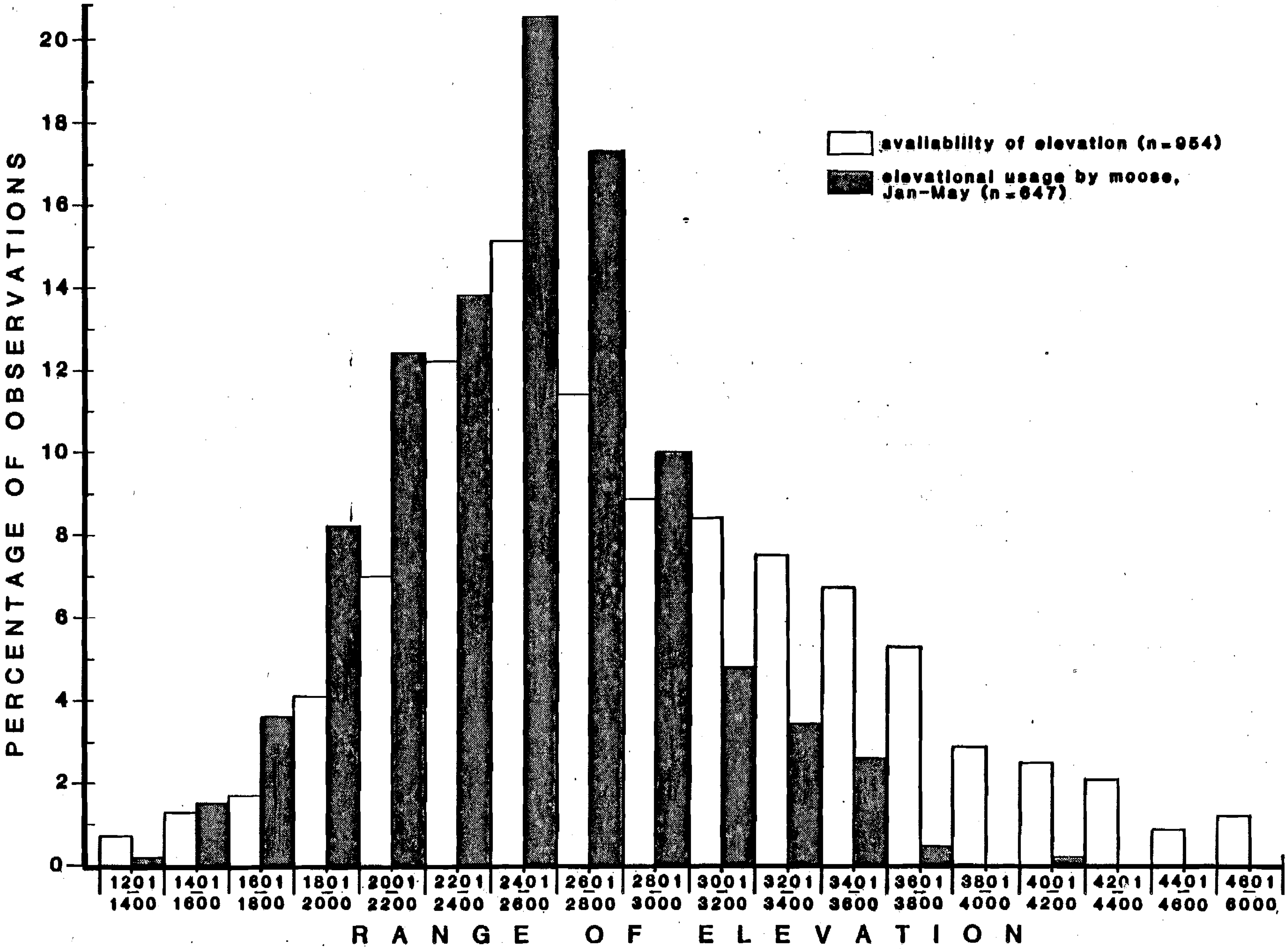


Figure 7. Use of various elevations by radio-collared moose in relation to availability during January-May in the primary impact zone along the Susitna River near Watana Creek, Alaska from 1976-1982.

South slopes were used more than expected ($X^2 = 21.65$, $P<0.05$) while flat slopes were used less than expected ($X^2 = 22.9$, $P<0.05$) (Fig. 9). All other aspect categories were used in proportion to their availability ($P>0.05$). A similar situation also existed during winter and spring months ($X^2 = 63.97$, $P<0.005$) except that southwest slopes were used more than expected ($P<0.05$, $X^2 = 4.05$).

Devil Canyon

Elevations ranging from 1,601 to 2,400 ft. were used relatively more by moose both year-round and during January to May ($P<0.05$), while those in excess of 2,800 ft were used either significantly less than expected ($P<0.05$) or in proportion to their occurrence (Figs. 10 and 11). However, area with elevations to be inundated by the Devil Canyon impoundment were used in proportion to their availability ($P>0.05$).

Moose occupying the Devil Canyon area used both south and southwest facing slopes more than expected ($P<0.05$) based upon availability (Fig. 12). North facing slopes were used less than expected ($P<0.05$), while all other slope categories were used in proportion to their occurrence.

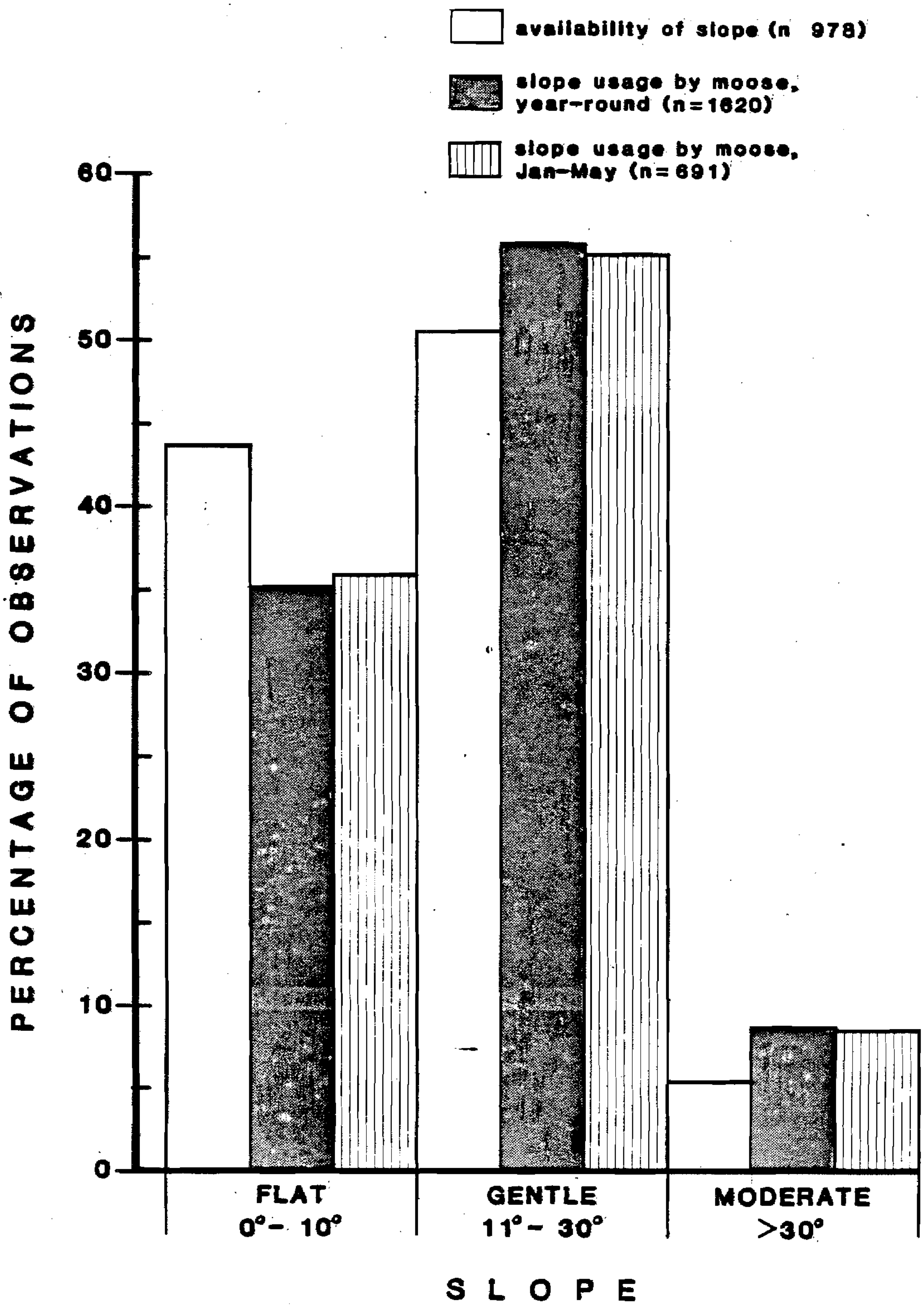


Figure 8. Use of three slope classifications by radio-collared moose in relation to availability in the primary impact zone along the Susitna River near Watana Creek, Alaska from 1976-1982.

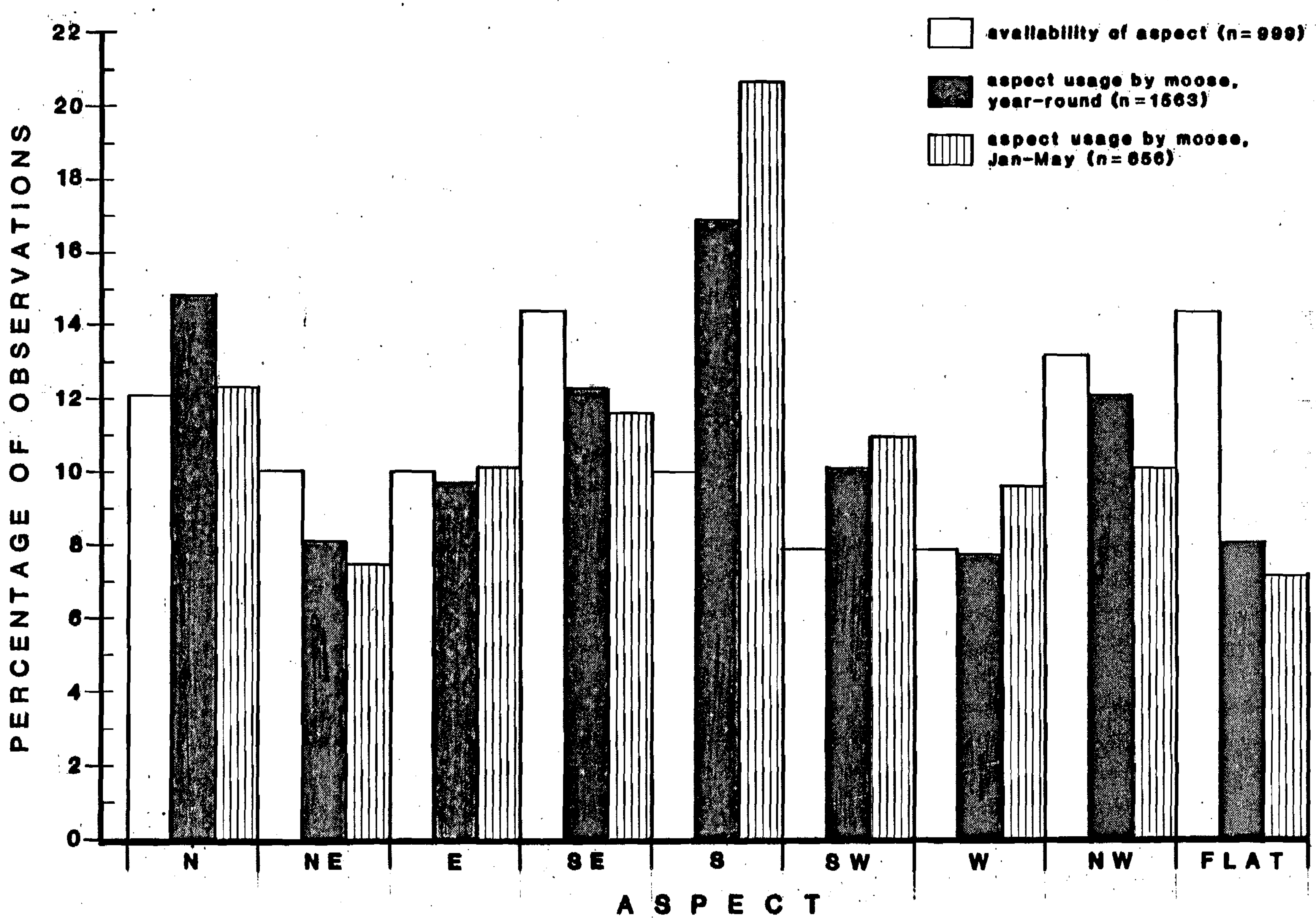


Figure 9. Year-round and seasonal use of slope aspects by radio-collared moose in relation to availability in the primary impact zone along the Susitna River near Watana Creek, Alaska from 1976-1982.

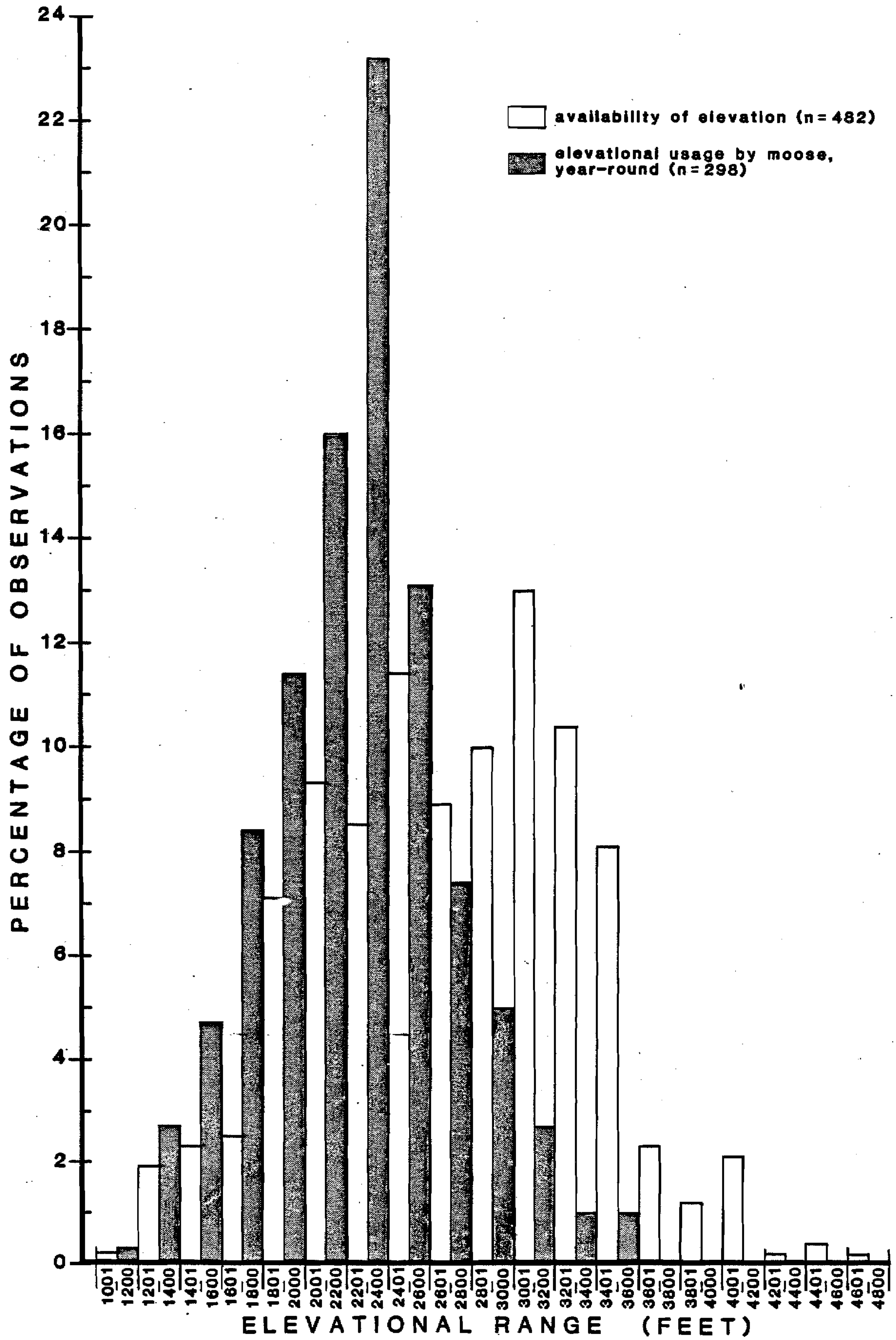


Figure 10. Year-round use of various elevations by radio-collared moose in relation to availability in the primary impact zone along the Susitna River near Devil Canyon, Alaska from 1976-1982.

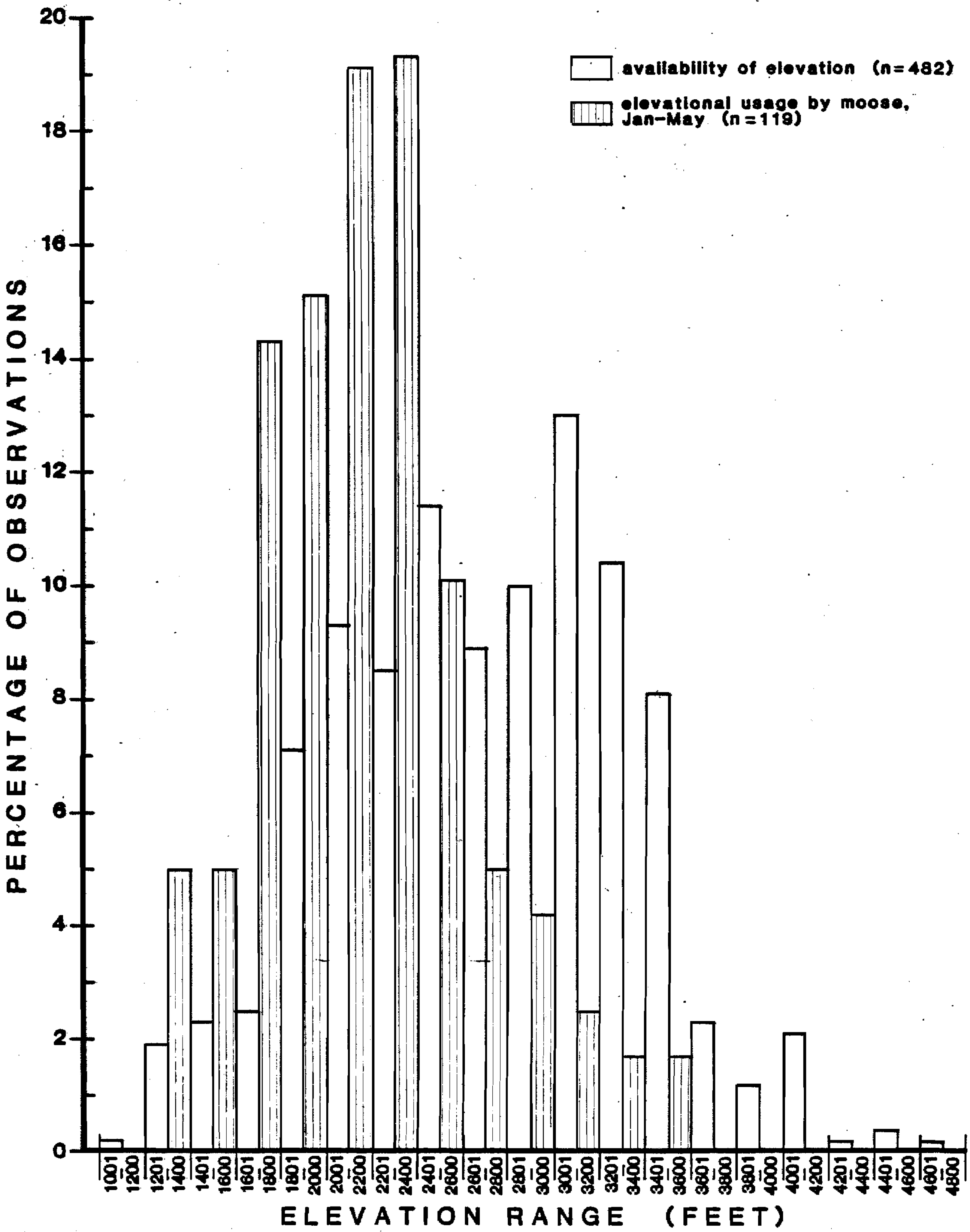


Figure 11. Use of various elevations by radio-collared moose from January-May in relation to availability in the primary impact zone along the Susitna River near Devil Canyon, Alaska from 1976-1982.

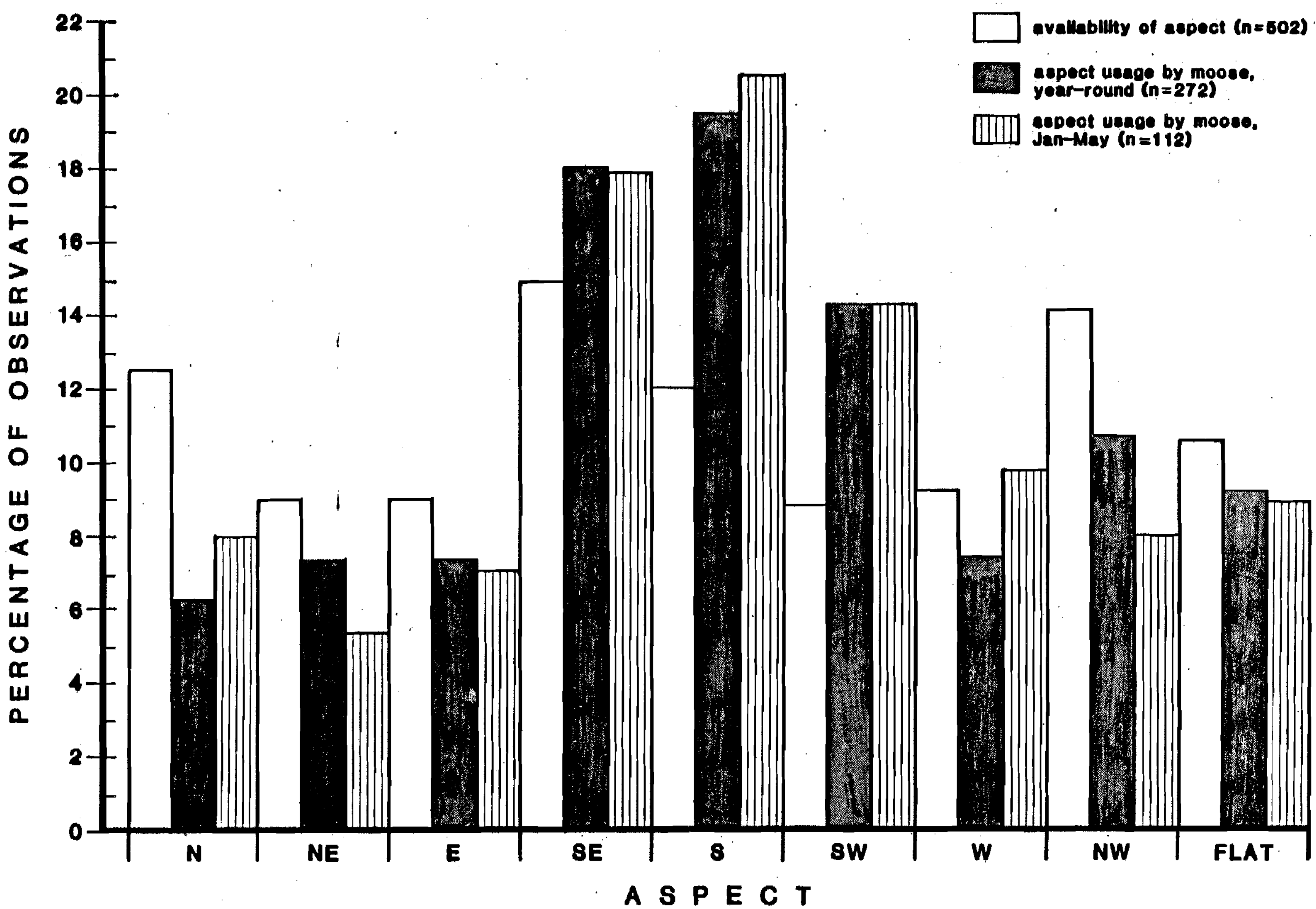


Figure 12. Use of nine aspects by radio-collared moose from 1976-1982 in relation to availability in the primary impact zone along the Susitna River near Devil Canyon, Alaska.

Both year-round and during January to May flat slopes (Fig. 13) were used less than expected (P‘0.05) while moderate slopes were used more than expected (P’0.05). During January to May gentle slopes were used in proportion to their occurrence (P‘0.05), but year-round they were used more than expected (P‘0.05).

SECTION IV. MOOSE POPULATION MODELING

Introduction

In an attempt to identify additional mechanisms of project impact and to quantify impacts previously identified by Ballard *et al.* (1982), a multidisciplinary model is currently being developed for moose. This segment of the report presents our progress in developing a satisfactory moose population model for pre-project conditions. Because longer, more intense moose population studies to assess the impacts of predation on moose were previously conducted in an adjacent portion of GMU 13 (Ballard *et al.* 1981 a,b), that area was used as the basis for this particular model. Boundaries of the area were previously described by Ballard *et al.* (1981a). Briefly, the boundaries are the Alaska Range on the north, Brushkana and Deadman Creeks on the west, Susitna River on the south and the Maclaren River on the east. Although this area extends beyond the impact zones, we believe that the biological characteristics of the area are representative of the project area. Also, an attempt was made to

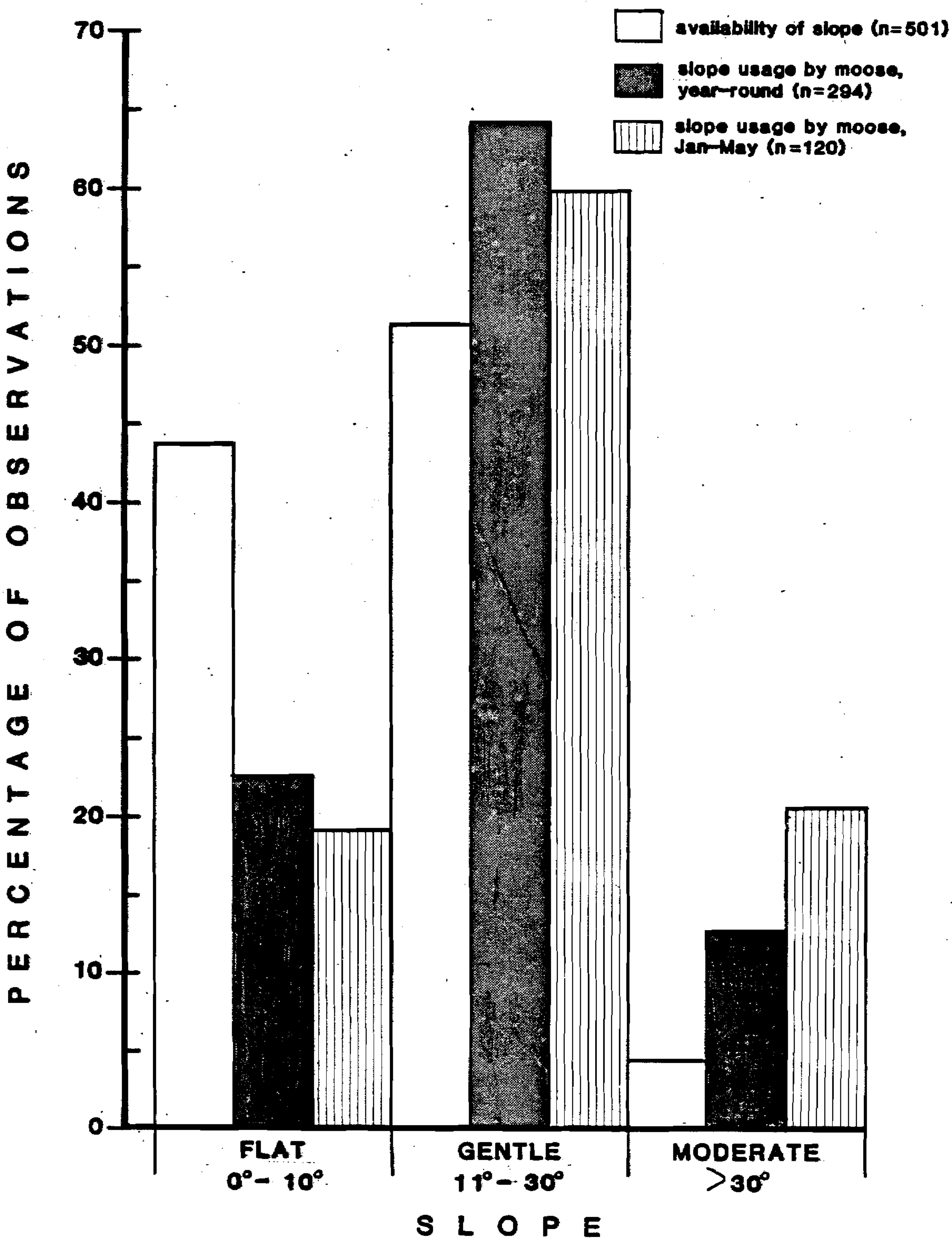


Figure 13. Use of three slope classifications by radio-collared moose in relation to their availability in the primary impact zone along the Susitna River, Alaska near Devil Canyon from 1976-1982.

model the entire GMU 13 moose population as well, in an effort to provide a comparison to the Susitna model and allow assessment of the percentage of the GMU 13 moose population to be impacted by the project. Both models will be published elsewhere (Ballard et al. In Prep.).

These population models start with an estimate of population size, and sex and age structure, and proceed through an annual cycle of reproduction and mortality factors which for these models are termed "events" (Fig. 14). Population estimates are calculated for each year at calving and subsequently the population declines as mortality factors act on the population.

Population Estimates

Population Size

The starting 1975 population size estimate (X) for each model was derived from the following formula:

$$X = \frac{(A)\ (B)}{C}$$

Where A is the number of moose observed/hour during the 1975 autumn composition counts; B is the 1980 area population estimate for either the study area or GMU 13; and C is the number of moose observed/hour during the 1980 autumn composition counts which

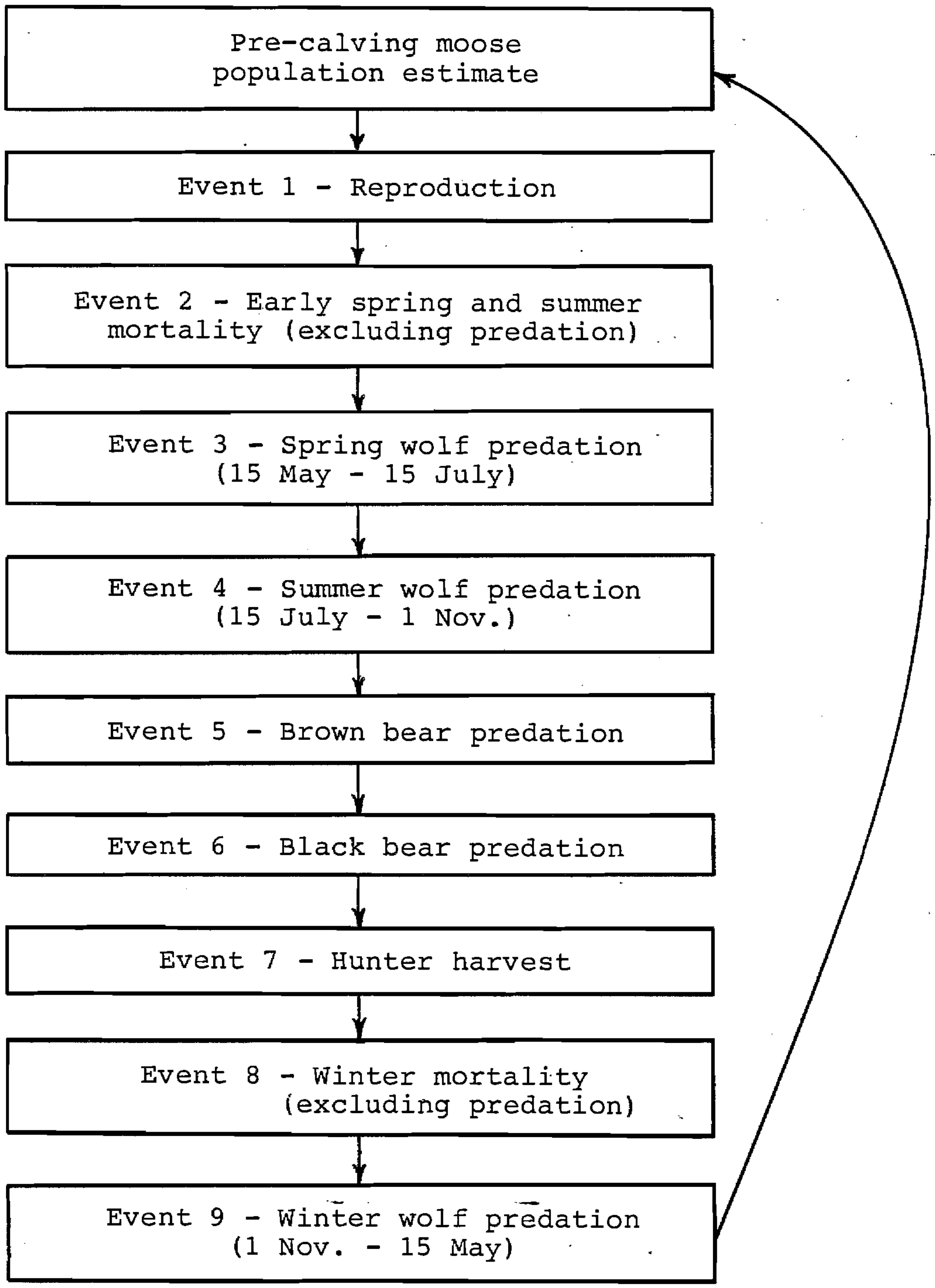


Fig. 14. Timing and sequence of factors used in the models to determine the annual population dynamics of moose in the Susitna River Study Area and the entire GMU 13 in southcentral Alaska.

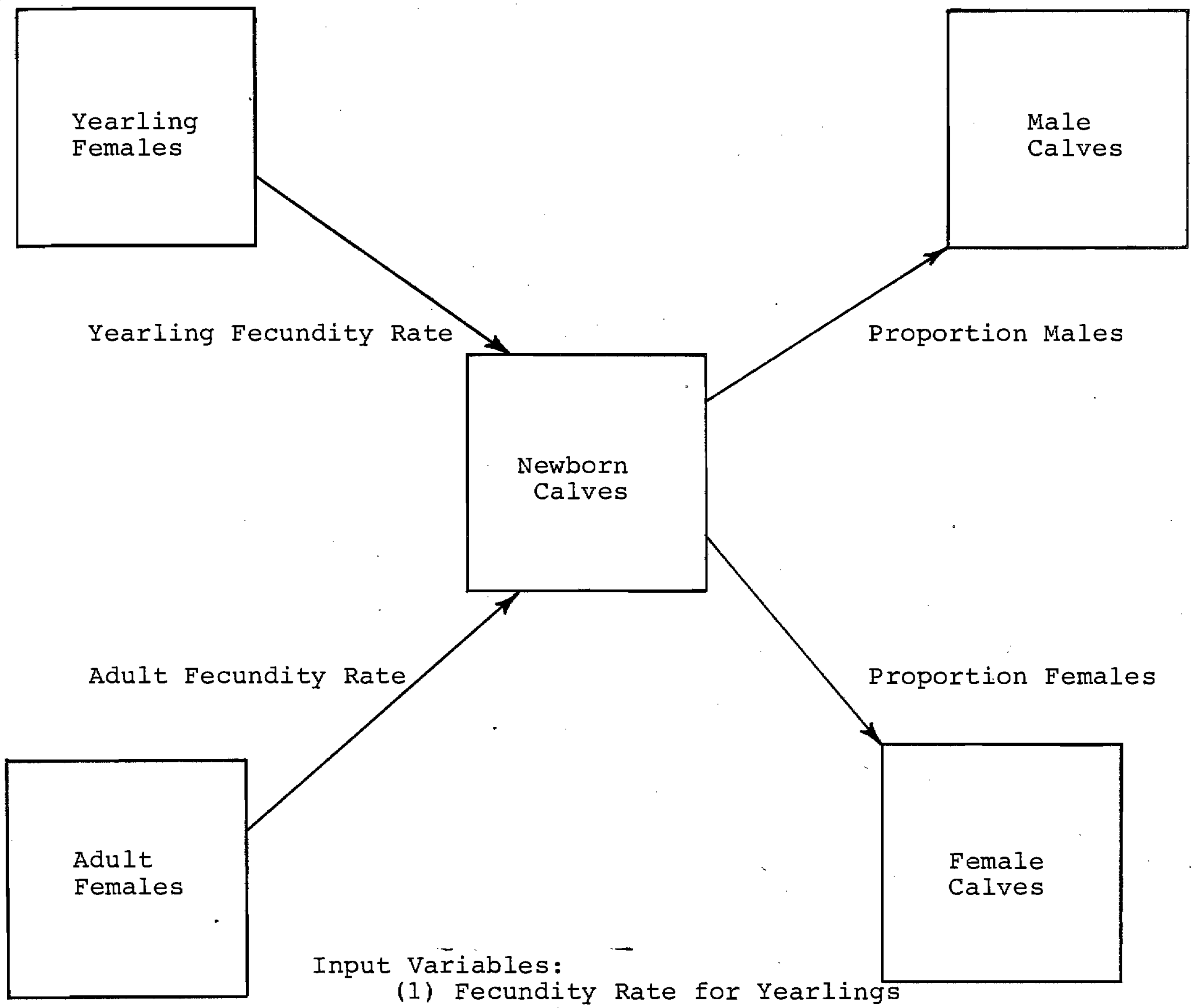
were conducted immediately before the census. We assumed that the numbers of moose observed/hour during fall composition counts reflected annual changes in moose density. Variable B was estimated from a census during November 1980. Approximately 8,142 km^2 of GMU 13, which included all of the 7,262 km^2 wolf removal area, were stratified and censused to determine the number of moose, using quadrat sampling techniques described by Gasaway (1978) and Gasaway et al. (1979). Moose density estimates derived during the census in 1980 were used as the basis for grossly estimating numbers of moose within the Susitna Study Area and within GMU 13 from 1975-1981. The actual moose population estimate in fall 1980 was used as a check for the population size generated by the project model. It was assumed that for the model to be valid, the fall 1980 population estimate derived from the model should closely coincide with the census estimate.

A different approach was used for the GMU 13 model. Those portions of GMU 13 not censused in 1980 were stratified into 4 density categories (none, low, moderate, and high). The stratification was based upon a combination of distribution and numbers of moose observed during composition counts conducted from 1975-1981, and the knowledge of 5 biologists with experience in this area (more than 24 man-years). Density estimates for the 4 categories derived from sampling were then applied to the non-sampled area to arrive at a GMU 13 population estimate of 23,000 moose for fall 1980. The GMU 13 model was modified so that the fall 1980 population size generated by the model would conform with the estimate derived from censusing and stratification.

Event 1 - Reproduction and Sex and Age Structure

The sex ratio of calves at birth was assumed to be 50:50 while the sex ratio of yearlings and adults was determined by the previous year's estimate of reproduction and mortality. In the case of year 1 (1975) the sex ratio was determined by the fall moose composition count and back calculated to correspond with population size at calving (Fig. 15). All age classifications were directly extrapolated from the count data except for the percent of calves in the herd. This was adjusted upward by 5% because calves are often located away from large groups of moose and are usually underestimated in composition counts (Ballard et al. 1982 a,b and Gasaway pers. comm.). Also, because preliminary runs revealed that in both models, populations declined to extinction, initial estimates of numbers of yearlings were doubled. Estimates of yearlings based upon composition counts were drastically underestimated, probably because they were incorrected aged as adults.

Pregnancy rates of cow moose were determined from rectal palpation of captured animals in 1976, 1977, and 1980 (VanBallenberghe 1978; Ballard and Taylor 1980; and Ballard et al. 1982).



Input Variables:
(1) Fecundity Rate for Yearlings
(2) Fecundity Rate for Adults
(3) Sex Ratio at Birth

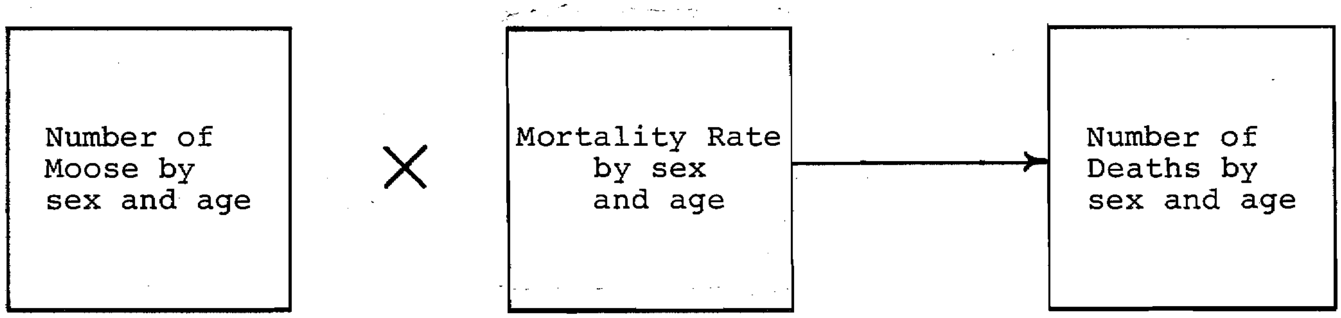
Fig. 15. Schematic diagram of Event 1 (reproduction) for the moose model.

Although some minor variations in rates was noted, we assumed that 88% of the sexually mature cows (≥2 yr age) were pregnant each year.

Estimates of moose productivity were determined during calf collaring programs from 1977-79 (Ballard et al. 1980; 1981) and were estimated at 135 calves/100 pregnant cows or 1.19 calves/adult cow. Productivity of 2-year-olds was estimated at 0.29 calves/cow (from Blood 1974). For the models, we assumed that productivity remained constant each year (which was probably not the case). In fact, in that portion of the Susitna River Study Area where brown bears were transplanted, there was a significant ($P<0.01$) negative relationship between the preceding winter's snow depth and the following fall's calf:cow ratio (Ballard et al. 1980), suggesting that some fluctuations in productivity occur due to winter severity. However, because of large variations in snow depth between drainages, and because calf survival has been significantly increased by predator reduction programs following severe winters, we were unable to modify productivity estimates based on available data.

Event 2 - Early Spring and Summer Mortality (Excluding Predation)

Following birth, both calf and adult mortality estimates (Fig. 16) were subtracted from the population. Immediately after birth, 6% of the calves were assumed to die from natural factors



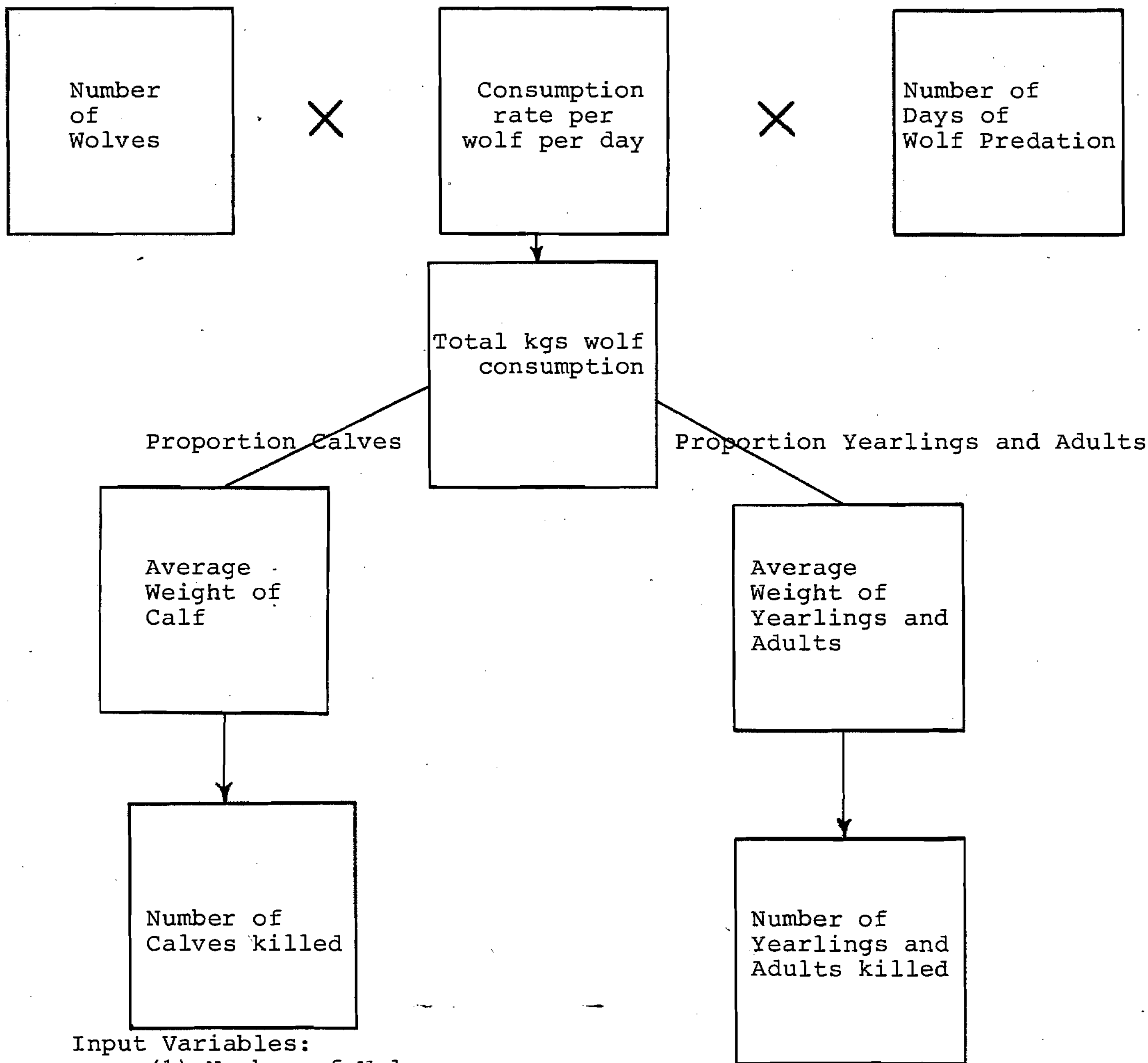
Input Variables:
(1) Mortality Rate for each sex and age group

Fig. 16. Schematic diagram of Events 2 and 8 (early spring and winter mortality) for the moose model.

other than wolf and bear predation such as stillbirth, drownings, and other accidents (from Ballard <u>et</u> <u>al</u>. 1981).

Events 3, 4, 9 - Wolf Predation

Estimates of annual moose mortality due to wolf predation for each model were divided into 3 time periods to correspond with pup production, human exploitation and natural mortality, and changes in diet composition (Fig. 17). The time periods were as follows: #1) 15 May-15 July (Event 3); #2) 15 July-1 November (Event 4); and #3) 1 November-15 May (Event 9). Period #1 encompasses the wolf denning period and represents the annual low in the wolf population. Because pups are quite small and totally dependent on the alpha female for nourishment during this time period, no food consumption was allocated for them. Period #2 encompassed the post-denning period and represents the highest level of the wolf population (adults plus pups prior to hunting and trapping season) during the year. For this latter time period we assumed that pups had similar food requirements as adults. Period #3 encompassed both the populations's highest level during the year (prior to hunting and trapping season) but also the lowest level (post hunting and trapping season). Consequently, we used the mid-point between the two population estimates to provide an average number of wolves for the winter. Wolf population levels were derived from Table 30 from Ballard <u>et</u> <u>al</u>. In Prep. for the Susitna River Study Area while the GMU 13 estimates were derived from Tables 22 and 30 (<u>op</u>. <u>cit</u>.)



Input Variables:

(1) Number of Wolves
(2) Consumption Rate of Wolves
(3) Number of Days of Wolf Predation
(4) Proportion of Wolf Kill Consisting of Calves
(5) Proportion of Wolf Kill Consisting of Yearlings and Adults
(6) Average Weight of Calves
(7) Average Weight of Yearlings and Adults

Fig. 17. Schematic diagram of Events 3, 4 and 9 (wolf predation) for the moose model.

Estimates of percent biomass of moose consumed by wolves for Period 1 were based entirely on scat analyses according to methods described by Floyd et al. (1978). The analyses indicated that 91% of the biomass of prey consumed by wolves from 15 May-15 July was comprised of ungulates, with calf and adult moose comprising 35% and 47%, respectively, of the total biomass consumed. Estimates of percent biomass of calf and adult moose consumed by wolves during Periods 2 (15 July-1 November) and 3 (1 November-15 May) were determined from kills observed while monitoring radio-marked packs. The estimates for the study were divided into 2 time periods to correspond with the increased importance of caribou as wolf prey from 1979-1981. From 1975-1978 we estimated that from 15 July-1 November (Period 2) calf and adult moose comprised 12% and 78%, respectively, of the prey biomass, while from 1 November-15 May (Period 3) calf and adult moose comprised 18% and 73%, respectively, of the biomass. During Period 2 from 1979-1981, percent biomass of adult moose declined to 73%, while the percent of calf moose remained constant. Percent biomass declined to 17% and 68% calf and adult moose, respectively, during Period 3 from 1979-1981.

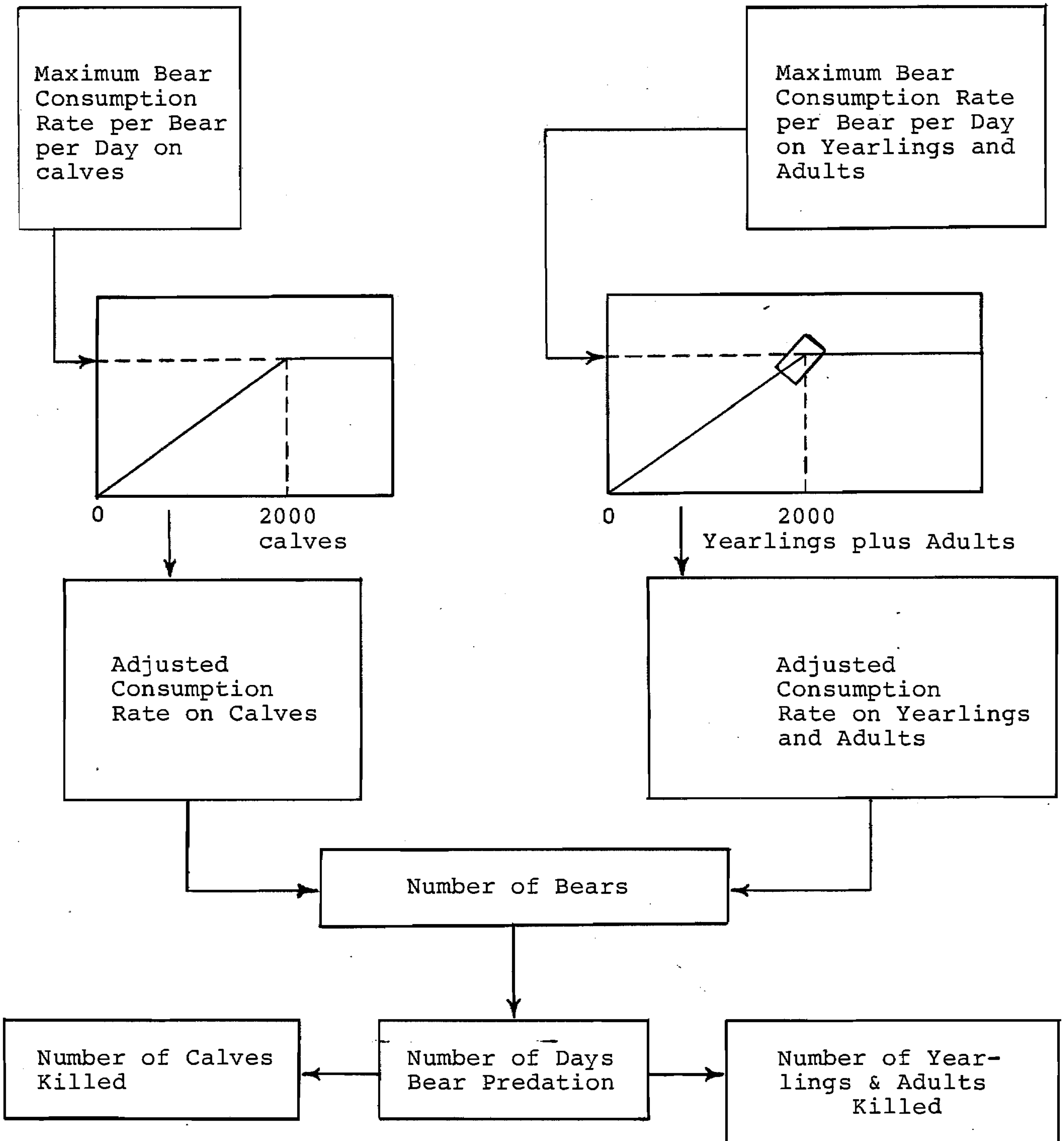
The estimated biomass of calf and adult moose killed by wolves during each time period per year was extrapolated from wolf population estimates for each period multiplied by the numbers of days in each period multiplied by the estimates of wolf daily consumption rates. For all 3 time periods, it was assumed that wolves consumed 7.1 kgs prey/wolf/day (Table 20 _op_. _cit_.). Estimates of percent biomass by prey species were then multiplied to derive estimated biomass. For each time period, the number of moose killed was estimated by dividing the average weight of each age class for each period derived from literature and field studies into the estimated biomass. The wolf daily consumption rate used is relatively high in relation to that reported in the literature and thus we consider the estimates of number of moose killed per year to be inflated.

Event 5 - Brown Bear Predation

Predation rates of brown bear on both adult and calf moose were derived from observations of kills during daily relocation flights of 23 adult radio-collared bears (Ballard _et_ _al_. 1981 and Table 35 from Ballard _et_ _al_. In Prep.). The relocation flights were done between 15 May-15 July, the period of most brown bear predation on moose (Ballard _et_ _al_. 1981). Kill rates of adult moose were calculated by assuming that all adult moose killed by the 23 radioed bears between 15 May to 15 July were observed (N=28), and after this time no adult moose were killed. Observed rates of calf moose killed were 1 calf/9.4 days/adult bear. These kill rates were extrapolated to the adult bear population estimates for the Susitna Study Area and GMU 13 (derived from

Miller and Ballard 1982). No information was available on annual bear population fluctuations so for these models we assumed a stable population from 1975-1981 (Fig. 18).

Preliminary runs of the model indicated that kill rates of calf moose were too high. It seems more likely that estimates of bear kill rates on calf moose would be underestimated even from daily relocation flights because many bears remained on calf kills less than 24 hours (Ballard, unpub. data). Therefore, we modified the estimates of calf kill rate by assuming that the magnitude of bear predation was partially dependent on the density of moose calves. For the study area model, it was assumed that bears preyed upon 50% of the estimated number of calves produced for 1977 and 1978. This was based upon estimates derived from moose composition counts (0.14 calves/ bear/day for 60 days and 0.02 adults/bear/day, for 60 days). At higher levels of calf production than the 1977 and 1978 levels, we assumed that the numbers preyed upon remained constant. At lower levels of calf production, we assumed that a linear relationship existed between percent calves taken by bears and calves produced. During 1979 only, we reduced brown bear predation on calves to 0.10 calves/ bear/day to correspond with removal of 47 transplanted bears from the Susitna Study Area for a 2-month period in late spring and early summer (Miller and Ballard 1983).



Input Variables:
(1) Maximum Consumption Rate on Calves
(2) Maximum Consumption Rate on Yearlings and Adults
(3) Number of Bears
(4) Number of Days of Bear Consumption

Fig. 18. Schematic diagram of Events 5 and 6 (brown bear and black bear predation) for the moose model.

Preliminary runs of the project model suggested that our estimates of bear predation on adults were also too high. The original kill estimates meant that an excess of 20% annual adult moose mortality occurred from brown bear predation alone. Such estimates, compared with all of the other mortality factors were obviously greatly exaggerated. Because many bears remain with adult moose kills for 5-6 days, periodic relocation of bears could tend to overestimate kill rates, similar to overestimation of wolf kill rates (Fuller and Keith 1980). However, most of our data were collected during contiguous daily flights and because individual carcasses and bears could usually be identified, the rates should not have been greatly exaggerated. Possibly the 23 adult radio-collared bears had kill rates greater than the rest of the bear population, but we have no evidence to support this idea. Predation estimates on adult moose were modified in a similar way to those for calf moose except that we assumed that at the 1977 and 1978 moose population estimates brown bears were responsible for 7% adult mortality.

Preliminary runs of the GMU 13 model suggested that the estimates of bear predation derived for the Susitna area were also too high for the entire unit. This was not unexpected since we originally applied bear density estimates obtained for the Susitna area (Miller and Ballard 1982b) to the entire unit. Undoubtedly variations in both brown bear density and predation on calves occur within the unit. Consequently, both the number of bears and predation rates were subjectively adjusted downwards to 708 adult bears preying on calf and adult moose at a rate of 0.10 calves/bear/day and 0.01 adult moose/bear/day during 15 May-15 July.

Event 6 - Black Bear Predation

Although black bears (*Ursus americanus*) occur in GMU 13 and they have been observed preying on moose (Ballard and Miller, unpub. data), they were rare and were considered an insignificant source of mortality within the Susitna River Study Area. However, because black bears were quite numerous in other portions of GMU 13, they were incorporated into the GMU 13 model (Fig. 18).

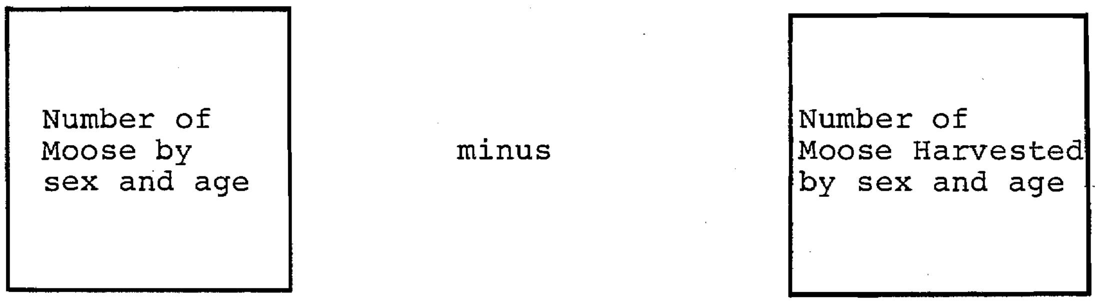
Based on existing density estimates and observed rates of predation from one portion of the unit, we originally estimated that 1,650 black bears occur in the Unit and that they were preying on calf and adult moose at a rate of 0.021 and 0.012/bear/day, respectively. Similar to brown bear predation rates, preliminary runs suggested that perhaps both the population estimates and the predation rates for black bear were too high. Consequently, they were subjectively reduced to a population of 1,000 black bears preying on moose at 0.003 calves/bear/day and 0.001 adults/bear/day for 60 days following birth.

Event 7 - Hunter Harvest

Annual hunting mortality, which during this study affected bulls only, was determined for each year of study from "mandatory harvest reports" (Fig. 19). Harvest reports from successful and unsuccessful moose hunters are required by law in GMU 13, however, this is not enforced and compliance is less than 100%. To encourage moose hunters to report results of their hunt, reminder letters are sent to all those who took a harvest ticket but did not report their hunt results. Because no reminder letters were sent in 1980, the harvest for that year was determined by extrapolating from return and non-return reports in previous years to reports returned in 1980.

Antler measurements on harvest reports since 1978 provided a basis for grossly estimating the number of yearlings killed, although some measurements were undoubtedly false. Antler measurements of ≤30 inches were considered to be yearlings or younger. Beginning in 1980, only bulls with antler spreads of 36 inches or at least 3 brow tines were legal for harvest. For the 1978 and 1979 hunting seasons 55.4% of the measured moose had antlers of 30" or less, therefore we assumed that annually from 1975-1979 half of the harvest was comprised of yearling bulls.

The annual hunting mortality rate for adult bulls was estimated at 25% based on radio-collar data (N = 28).



Input Variables:

(1) Number of Moose Harvested by sex and age

Fig. 19. Schematic diagram of Event 7 (hunting mortality) for the moose model.

Event 8 - Winter Mortality(Excluding Predation)

Estimates of winter mortality in the model (Fig. 16) were subtracted from the estimated number of moose present each November following hunter harvest. The magnitude of winter mortality (usually by starvation) was initially estimated from radio-collared moose by methods described by Hayne (1978) and Gasaway et al. (In Press). Winter mortality was calculated as follows (from Gasaway et al. In Press):

$$\text{Percent mortality} = \frac{a}{b}$$

where a = number of winter mortalities of radio-collared moose

b = estimated number of collared animal months

b estimated as follows: $\frac{(c)(d)}{e}$

Where: c = mean # months collars transmitting (excluding dead moose)

d = total # radio-collared moose (including dead moose)

e = time interval for annual mortality.

Winter mortality data was available from 1977-1981 for calf moose and from 1979-1982 for yearling moose (Table 10).

Table 10. Mortality rates due to winter starvation of radio-collared calf and yearling moose in the Nelchina and Susitna River Basins, 1977-1982.

	Calves				Yearlings	
	1977-78 1/ 1979-80 1/ 1980-81		1978-79 2/		1979-80 1/ 1980-81 1981-82	
Sex	F	M	F	M	F	M
# mortalities	1	1	3	8	1	2 3/
$\bar{x}$ mos. collars transmitting (excluding mortalities)	5.0	5.6	2.6	2.7	9.9	10.5
Total # radio-collared moose (including mortalities)	25	26	41	26	50	37
Time interval (# mos.)	7	7	5	5	12	12
% mortality	5.6	4.8	14.1	57.1	2.4	6.2

1/ Mild winters
2/ Severe winters
3/ Both mortalities from hunting

For modeling, it was assumed that during mild winters (1975-76 through 1977-78 and 1979-1980) calf mortality was 6%. Winter 1978-79 was considered relatively severe (Eide and Ballard 1982) with high rates of calf mortality during late winter (Table 10). These higher rates for males and female calves were used for 1978-89 in the models. For yearling females, we utilized the calculated rate of 2.4%; and for yearling bulls we utilized the calculated mortality rate of 6% (Table 10). Even though the yearling bull mortality rate was attributable to hunting, which theoretically would have been illegal, it was used because bulls usually suffer proportionately larger natural mortality than females and we suspected the calculated rate was low.

Annual winter mortality rates for adult cows varied from 0 to 5.6% during 1976-1982 (Table 11). Overall the winter mortality rate was estimated at 3.6% and this was used for each year of the study. Apparently the winter of 1978-79 was severe enough to cause significant increases in calf mortality but not for adults.

It was assumed that during mild winters adult bulls suffered rates of winter mortality identical to that of cows (3.6%). During severe winters, we assumed that adult bulls would suffer higher rates of mortality than cows, so the 1978-79 winter mortality was subjectively estimated at 7.2%.

Table 11. Mortality rates of adult (>2 yr.) radio-collared cow moose due to winter starvation and unidentified mortality in the Nelchina and Susitna River Basins of southcentral Alaska from 1976-1982.

Year	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	Total
# Mortalities	0	1	1	1	2	4	9
$\bar{x}$ mos. collars transmitting (excluding mortalities)	5.5	11.5	10.6	6.0	10.0	10.4	24.1
Total # radio-collared moose (including mortalities)	36	42	45	52	80	82	126
Time Interval (# mos.)	12	12	12	12	12	12	12
% Mortality	0	2.5	2.5	3.9	3.0	5.6	3.6

Project Population Model Analyses

Population Size Estimates

Between 1975 and 1981, estimates derived from fall composition counts and the model suggest that the area's moose population increased (Fig. 20). The model indicates that the fall moose population increased by 24%, while population estimates based on the composition counts indicated a much larger increase of 101%. Projected population estimates beyond May 1981 (Fig. 20) assume that all mortality factors remain identical to those of 1980-81.

Each year's independent moose population estimate based upon composition counts were compared to those generated by the model (Fig. 21). From this comparison, it becomes quite evident that the annual population estimates based on composition counts were not accurate. Using both the 1975 and 1976 data with documented levels of productivity and mortality, the population eventually becomes extinct. Based upon the 1980 census estimate and the composition of the population at that time, no winter mortality could have occurred for the moose population to have increased up to the 1981 or 1982 estimates based on the composition counts. Because this is highly unlikely, it suggests that the number of moose observed/hour in composition counts is probably not an accurate index of change in annual moose density. Also, it suggests that the relationship between moose observed per hour in

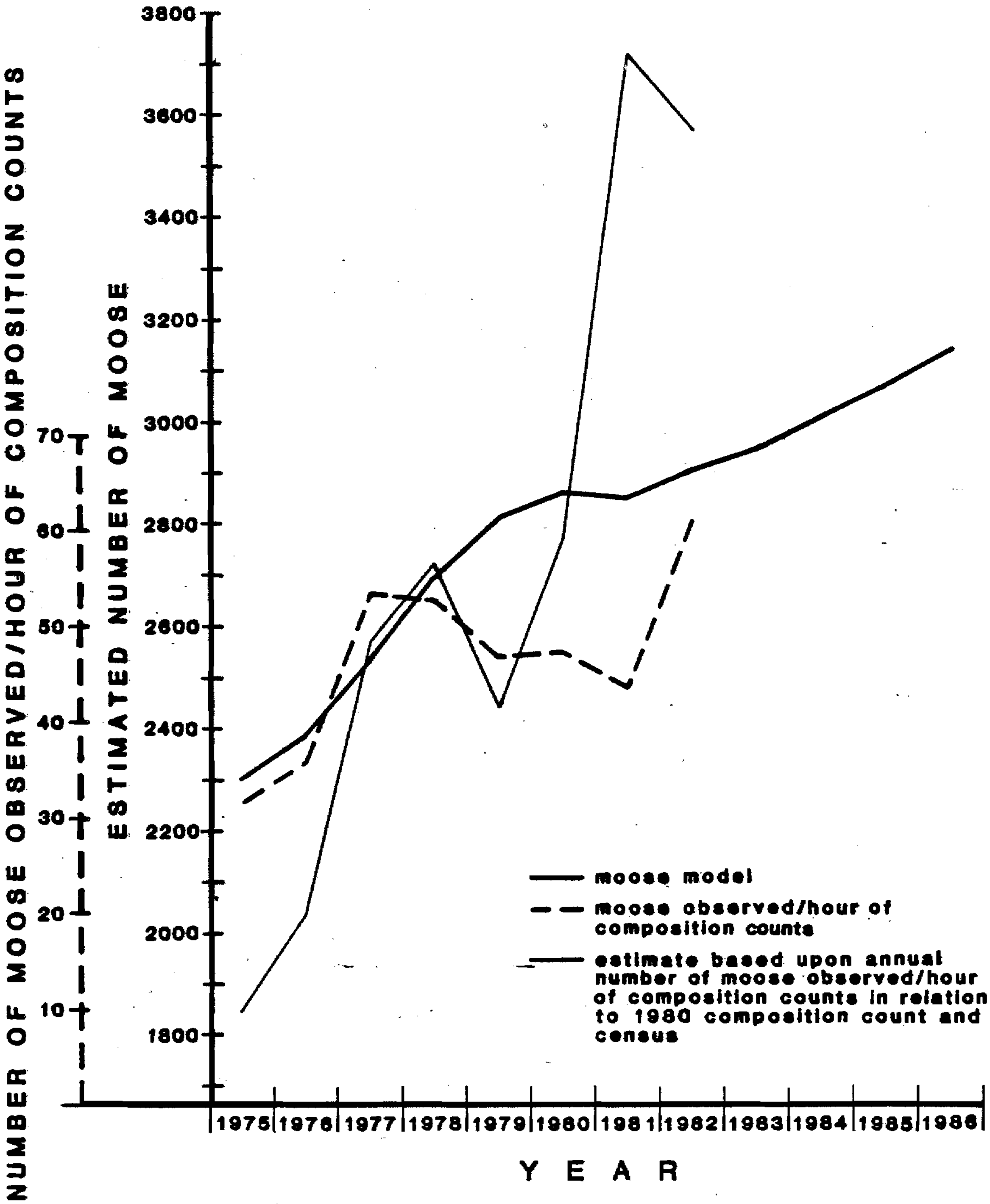


Figure 20. November moose population estimates as derived from modeling versus composition counts for the Susitna River Study Area of southcentral Alaska, 1975–1986.

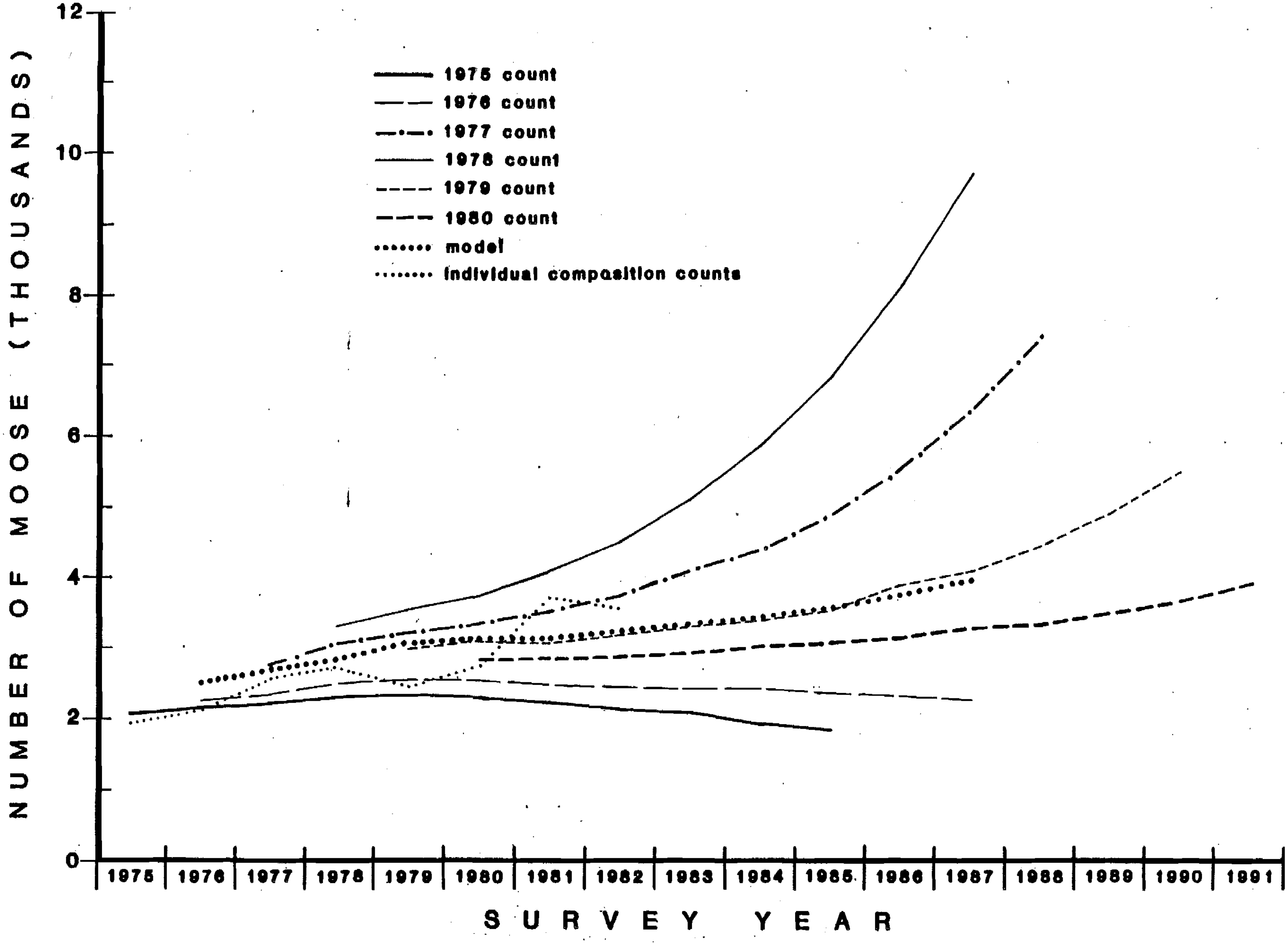


Figure 21. Fall moose population trends derived from modeling using annual composition count data for initial population size for the Susitna River Study Area, 1975-1991.

composition counts versus population estimates obtained from censusing may be quite variable from year to year. All other population estimates suggested an increasing population trend although the rates of increase were quite different.

Sex and Age Structure

Comparison of several sex-age parameters between the model and composition counts suggests that at least three sex-age classifications are underestimated during composition counts. Calf:cow ratios as estimated from the model were higher than those obtained from composition counts (Fig. 22). Even though composition count ratios were adjusted upward based upon observed differences between composition surveys and census data, the model suggests that the discrepancy between these 2 counts may be larger than existing data suggest (Gasaway et al. 1982; Ballard et al. 1982). The discrepancy occurs because cow:calf pairs are often segregated from larger groups of moose and have a lower probability of being observed with either survey method.

Also, the model suggests that both survey estimates tend to underestimate the proportions of yearling bulls (Fig. 23) and cows present in the population. This could occur for at least 3 reasons: (1) counts are often made following hunting mortality, so that usually an unknown proportion of yearling bulls has been removed and remains unaccounted for; (2) an unknown proportion of

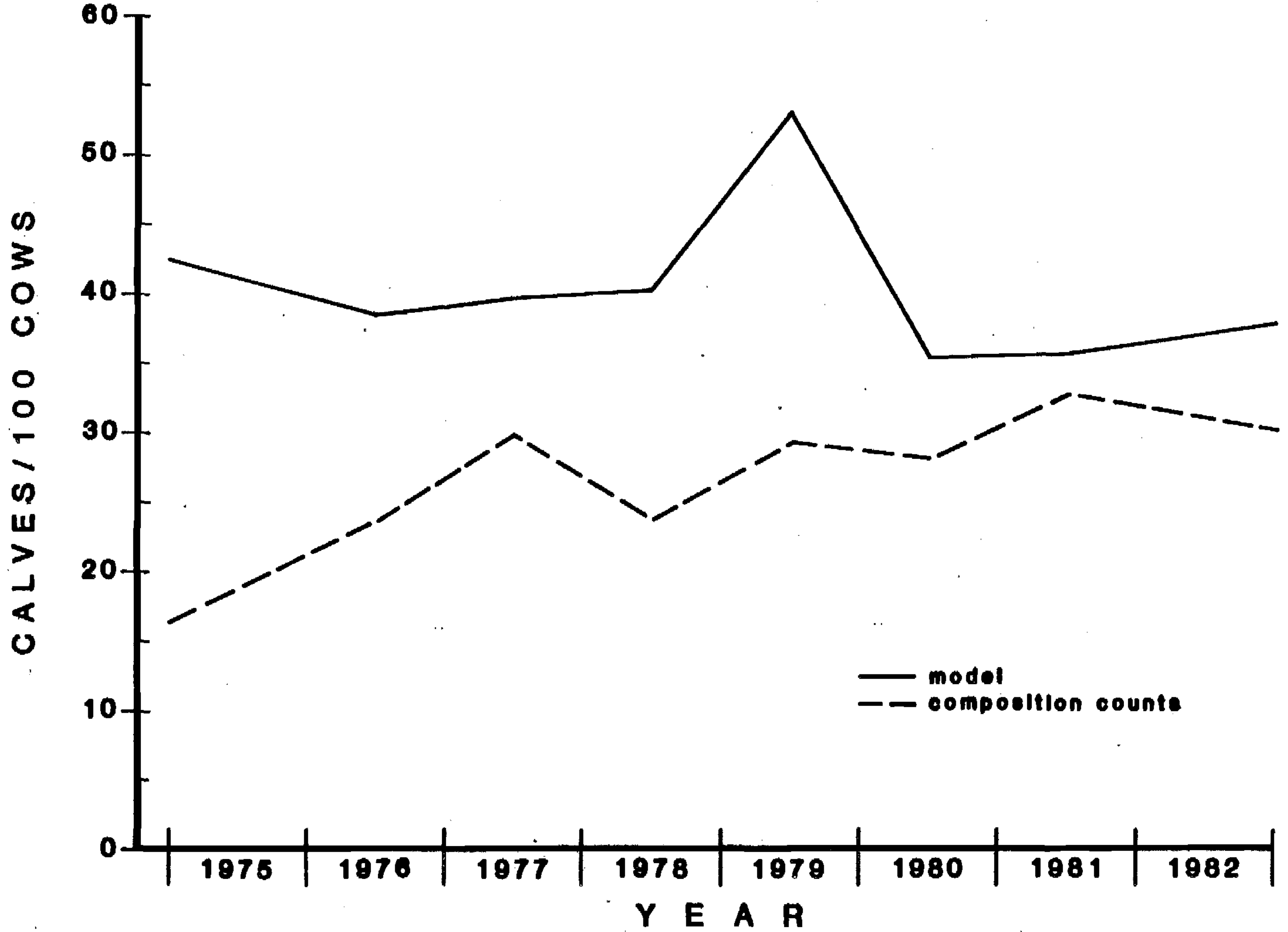


Figure 22. Estimated moose calf:cow ratios derived from modeling versus calf:cow ratios obtained from annual composition counts in the Susitna River Study Area, 1975-1982.

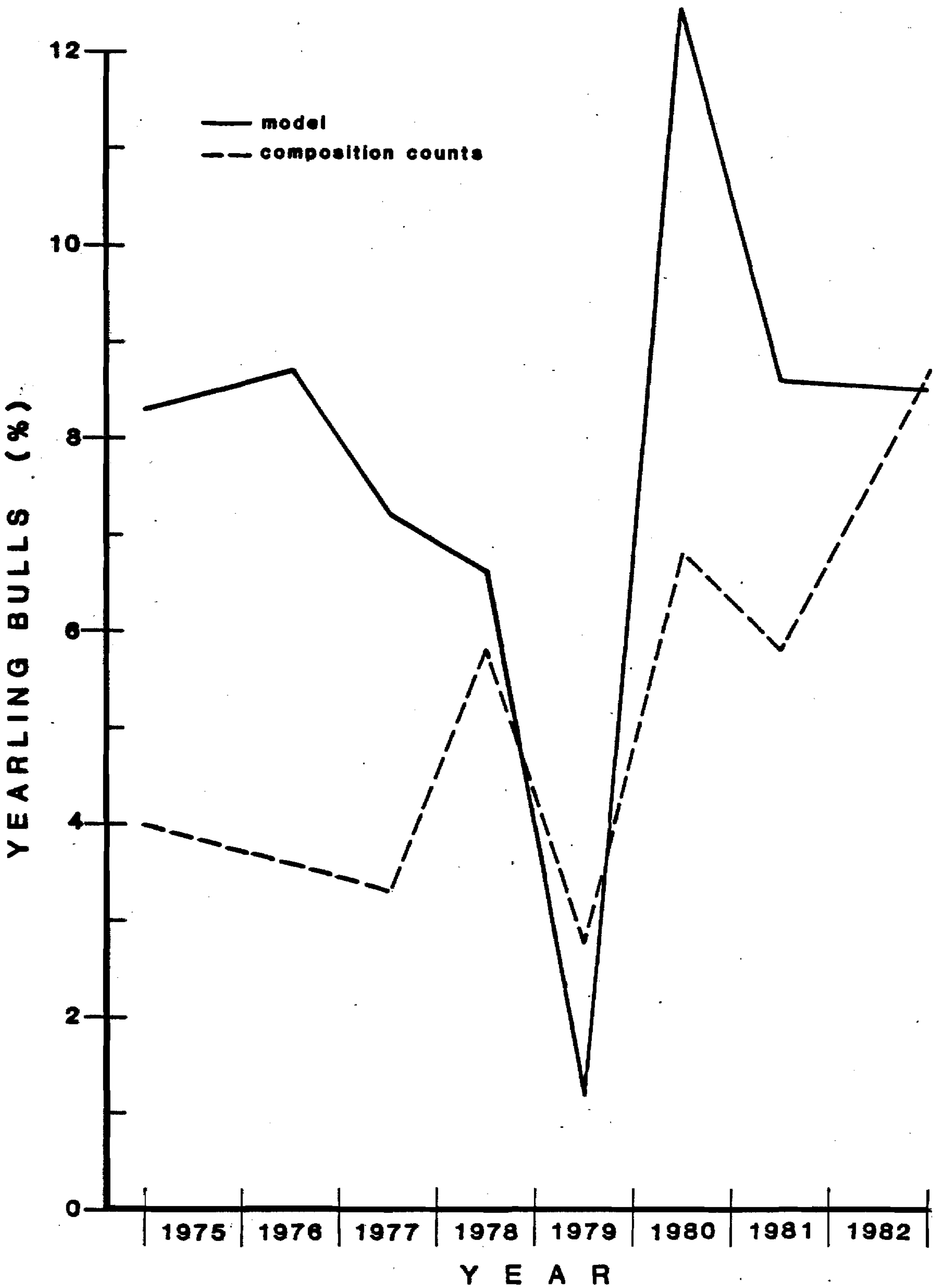


Figure 23. Percent yearling bulls in moose populations each fall as determined from modeling versus composition counts for the Susitna River Study Area, 1975-1982.

the yearling bulls cannot be identified from fixed-wing aircraft because antlers are comprised of either buttons or short spikes, and (3) during the 1975 and 1976 composition surveys the criteria utilized for estimating ages of yearling bulls were not accurate according to antler configuration data (Gasaway, pers. comm.). Because the proportion of yearling females is based upon the estimates of yearling males, this sex-age class would also be underestimated.

Calf Mortality

Predation by brown bears was the single most important calf mortality factor during the study period. Because of the manner in which brown bear mortality was calculated, the numbers of calves killed by bears each year varied (Fig. 24) but the actual percentage of calves killed remained constant each year except in 1979 when bears were temporarily transplanted from the area.

Calf mortality attributable to wolf predation declined from 9.1% in 1975 tO 4.1% in 1978 (Table 12). This suggests that during the years that wolves were experimentally killed (1976-78) calf survival increased slightly. Following termination of wolf control and repopulation of the area by wolves, calf mortality attributable to wolf predation increased and slightly exceeded precontrol levels by 1981. During the same period, starvation

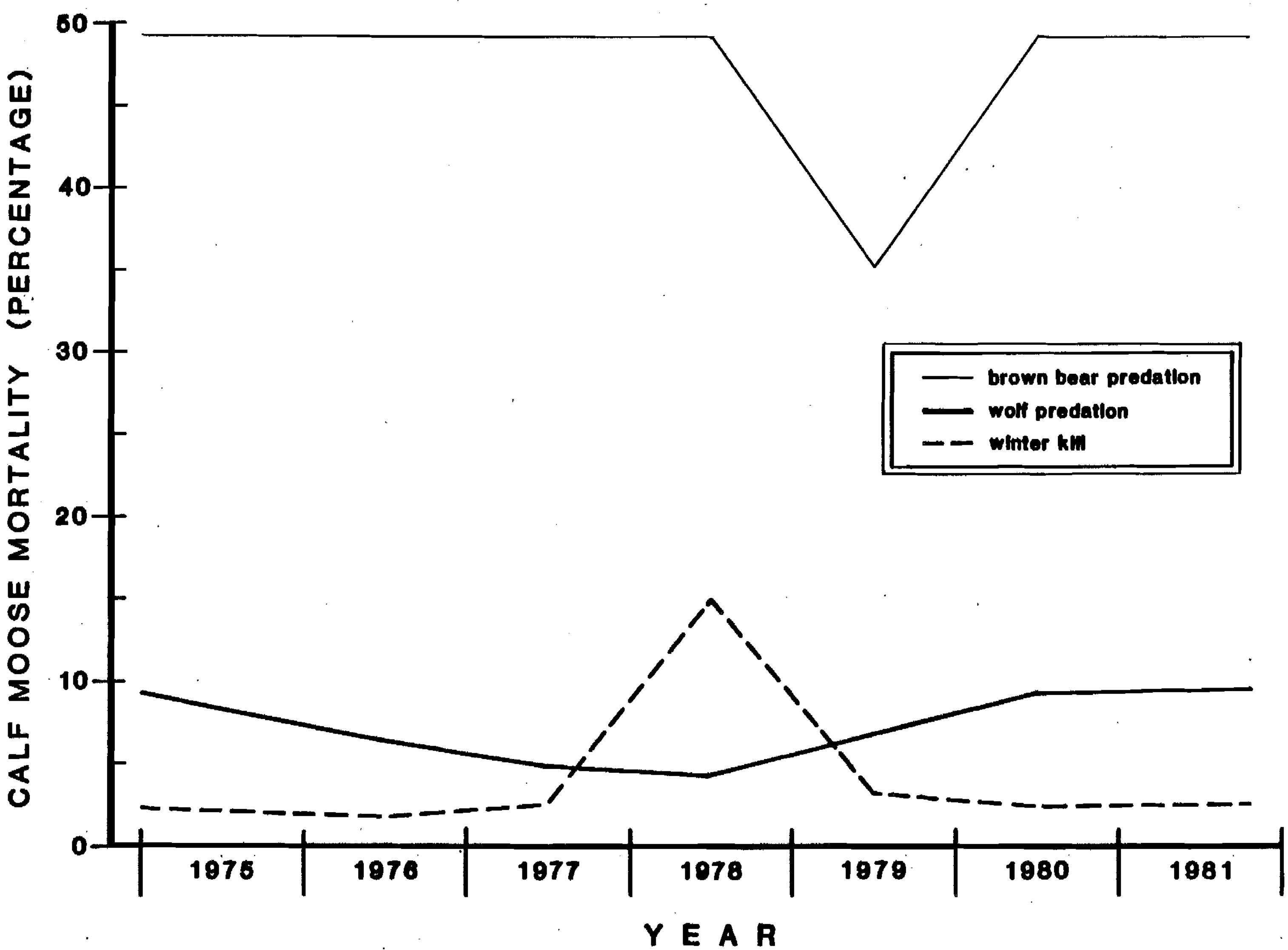


Figure 24. Annual rates of calf moose mortality due to predation and winter kill as determined from modeling the Susitna River Study Area moose population, 1975-1981.

Table 12. Estimates of spring moose population size, and causes and magnitude of mortality by sex and age class as determined from modeling the Susitna River Study Area moose population from 1975-76 to 1981-82.

Year	1975-76						
Age Class	Calves		Yrlgs.		Adults		Total
Sex	M	F	M	F	M	F	Both
Spring Population Est.	811	811	274	274	93	1365	3628
Mortality							
Early Spring and Summer	48	48	0	0	0	0	96
Spring Wolf Predation	36	36	2	2	1	8	85
Summer Wolf Predation	18	18	9	9	3	46	103
Brown Bear Predation	399	399	19	19	7	96	939
Hunting	0	0	51	0	52	0	103
Winter Wolf Predation	20	20	10	10	4	52	116
Winter Kill	18	18	11	5	1	43	60
Subtotal	539	539	102	45	68	245	1502
% of Population	66.5	66.5	37.2	16.4	73.1	17.9	41.4

Year	1976-77						
Age Class	Calves		Yrlgs.		Adults		Total
Sex	M	F	M	F	M	F	Both
Spring Population Est.	699	699	272	272	197	1349	3488
Mortality							
Early Spring and Summer	41	41	0	0	0	0	82
Spring Wolf Predation	21	21	1	1	1	4	49
Summer Wolf Predation	10	10	5	5	4	24	58
Brown Bear Predation	343	343	18	18	13	91	826
Hunting	0	0	41	0	42	0	83
Winter Wolf Predation	13	13	6	6	4	31	73
Winter Kill	17	17	2	5	4	44	89
Subtotal	445	445	67	35	68	194	1254
% of Population	63.7	63.7	24.6	12.9	34.5	14.4	36.0

Year	1977-78						
Age Class	Calves		Yrlgs.		Adults		Total
Sex	M	F	M	F	M	F	Both
Spring Population Est.	721	721	254	254	318	1392	3660
Mortality							
Early Spring and Summer	43	43	0	0	0	0	86
Spring Wolf Predation	17	17	1	1	1	4	41
Summer Wolf Predation	7	7	3	3	4	18	42
Brown Bear Predation	354	354	16	16	20	88	848
Hunting	0	0	52	0	52	0	104
Winter Wolf Predation	10	10	4	4	5	24	57
Winter Kill	18	18	10	5	8	46	105
Subtotal	449	449	86	29	90	180	1283
% of Population	62.3	62.3	33.9	11.4	28.3	12.9	35.1

Year	1978-79						
Age Class	Calves		Yrlgs.		Adults		Total
Sex	M	F	M	F	M	F	Both
Spring Population Est.	753	753	272	272	396	1437	3883
Mortality							
Early Spring and Summer	45	45	0	0	0	0	90
Spring Wolf Predation	15	15	1	1	1	3	36
Summer Wolf Predation	6	6	3	3	4	14	36
Brown Bear Predation	370	370	16	16	23	85	880
Hunting	0	0	74	0	74	0	148
Winter Wolf Predation	10	10	4	4	6	23	57
Winter Kill	181	44	17	16	21	48	317
Subtotal	627	490	115	30	129	173	1564
% of Population	83.3	65.1	42.3	11.0	32.6	12.0	40.3

Table 12. (cont'd)

Year	1979-80						
Age Class	Calves		Yrlgs.		Adults		Total
Sex	M	F	M	F	M	F	Both
Spring Population Est.	787	787	126	263	424	1506	3893
Mortality							
Early Spring and Summer	47	47	0	0	0	0	94
Spring Wolf Predation	21	21	0	1	1	4	48
Summer Wolf Predation	14	14	3	6	9	33	79
Brown Bear Predation	276	276	8	16	26	91	693
Hunting	0	0	82	0	82	0	164
Winter Wolf Predation	18	18	4	8	12	44	104
Winter Kill	25	25	1	5	11	49	116
Subtotal	401	401	98	36	141	221	1298
% of Population	51.0	51.0	77.8	13.7	33.3	14.7	33.3

Year	1980-81						
Age Class	Calves		Yrlgs.		Adults		Total
Sex	M	F	M	F	M	F	Both
Spring Population Est.	796	796	386	386	311	1512	4187
Mortality							
Early Spring and Summer	47	47	0	0	0	0	94
Spring Wolf Predation	32	32	2	2	1	6	75
Summer Wolf Predation	18	18	9	9	8	37	99
Brown Bear Predation	391	391	21	21	17	82	923
Hunting	0	0	0	0	134	0	134
Winter Wolf Predation	23	23	13	13	10	50	132
Winter Kill	18	18	21	8	5	49	119
Subtotal	529	529	66	53	175	224	1576
% of Population	66.5	66.5	17.1	13.7	56.3	14.8	37.6

Year	1981-82						
Age Class	Calves		Yrlgs.		Adults		Total
Sex	M	F	M	F	M	F	Both
Spring Population Est.	814	814	267	267	456	1621	4239
Mortality							
Early Spring and Summer	48	48	0	0	0	0	96
Spring Wolf Predation	40	40	1	1	2	8	92
Summer Wolf Predation	18	18	7	7	11	40	101
Brown Bear Predation	400	400	14	14	25	87	940
Hunting	0	0	0	0	153	0	153
Winter Wolf Predation	20	20	8	8	13	46	115
Winter Kill	18	18	14	5	9	53	117
Subtotal	544	544	44	35	213	234	1614
% of Population	66.8	66.8	16.5	13.1	46.7	14.4	38.1

accounted for 1.9-3.2% of the total calf mortality except during the winter of 1978-79. This was considered a moderately severe winter, and at least 14.9% of the calves died of starvation.

Yearling Mortality

Trends in yearling moose mortality were similar to those of calves, except the magnitude of the mortality was substantially less (Table 12). From 1975-79, hunting mortality (assuming that half of the bull harvest was comprised of yearlings) was the largest source of overall mortality (Fig. 25) even though only affecting males. Beginning with the 1980 season, yearlings were theoretically protected by antler regulations and, therefore, hunting mortality declined to insignificant levels. Mortality attributable to wolf predation declined from 7.6% in 1975 to a low of 3% while wolf control was in effect. Following termination of wolf control, yearling mortality attributable to wolf predation increased. Yearling mortality attributable to brown bears declined during the study period primarily because the model assumed a stable bear population and the moose population was increasing. Winter mortality (starvation) was quite variable even during mild winters. The highest winter mortality occurred during the severe winter of 1978-79.

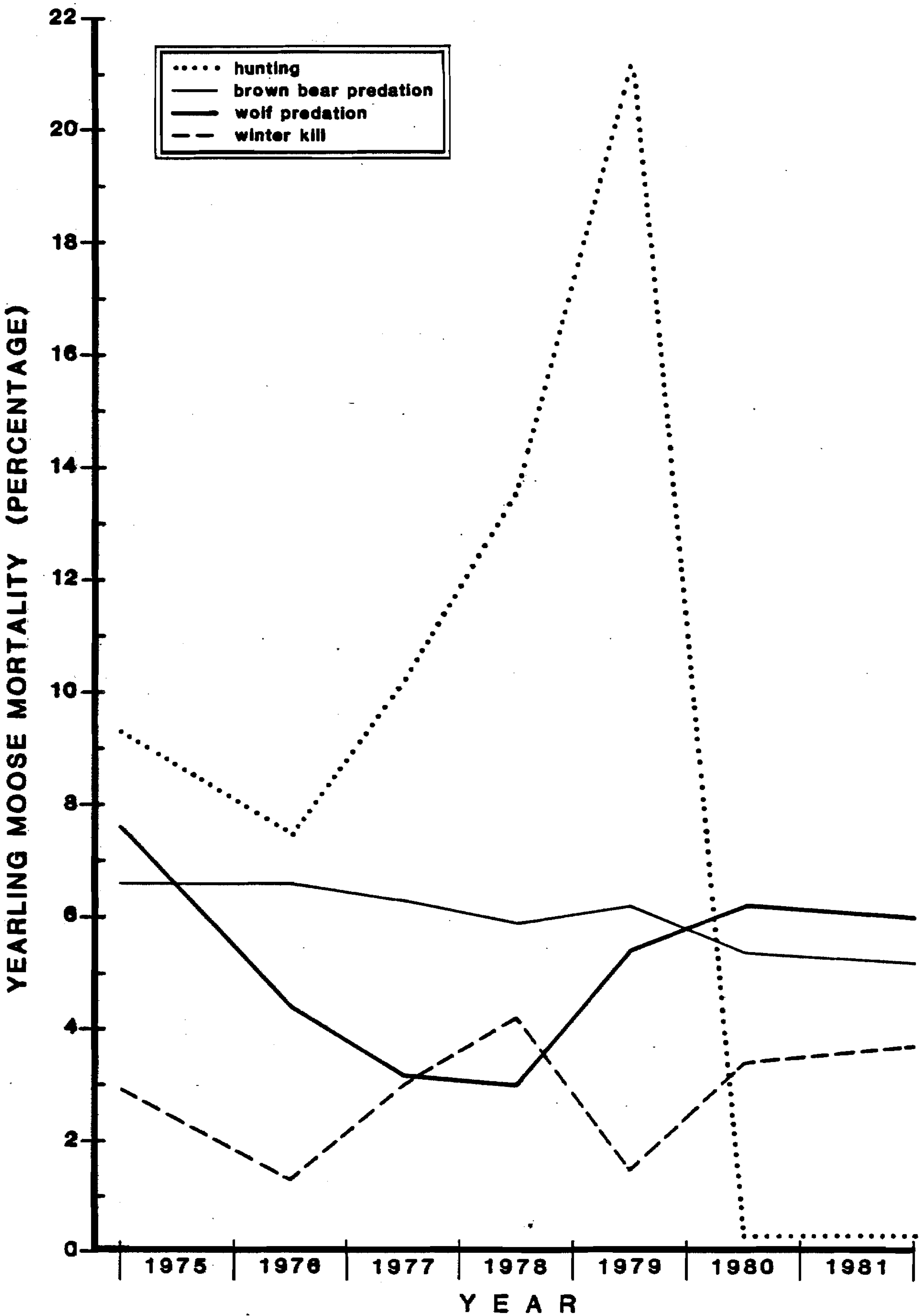


Figure 25. Annual percent yearling bull moose mortality due to several mortality factors as determined from modeling the Susitna River Study Area in southcentral Alaska, 1975-1981.

Adult Mortality

Trends in adult mortality were quite similar to those of yearlings because for both types of predation it was assumed that the sex-age class of kills was dependent on availability (Fig. 26).

GMU 13 Population Model Analyses

Population Size Estimates

The 1975-82 GMU 13 post-calving moose population trend (15.8% increase) was similar in many respects to that of the Susitna River Study Area (16.8%). However, the population declined between 1975-76 and 1976-77 and again in 1978-79 (Table 13). The largest increases occurred between 1979-80 (7.5%) and 1980-81 (9.9%). The estimated fall population size based on the model differed considerably from the population estimate derived from composition counts, particularly for 1975 and 1976 (Fig. 27). This was believed due to underestimation of both yearlings and calves during composition counts.

Calf Mortality

Brown bear predation was responsible for more calf mortality than wolf predation or winter mortality (Fig. 28). Except during the severe winter of 1978-79, wolf predation was the second most

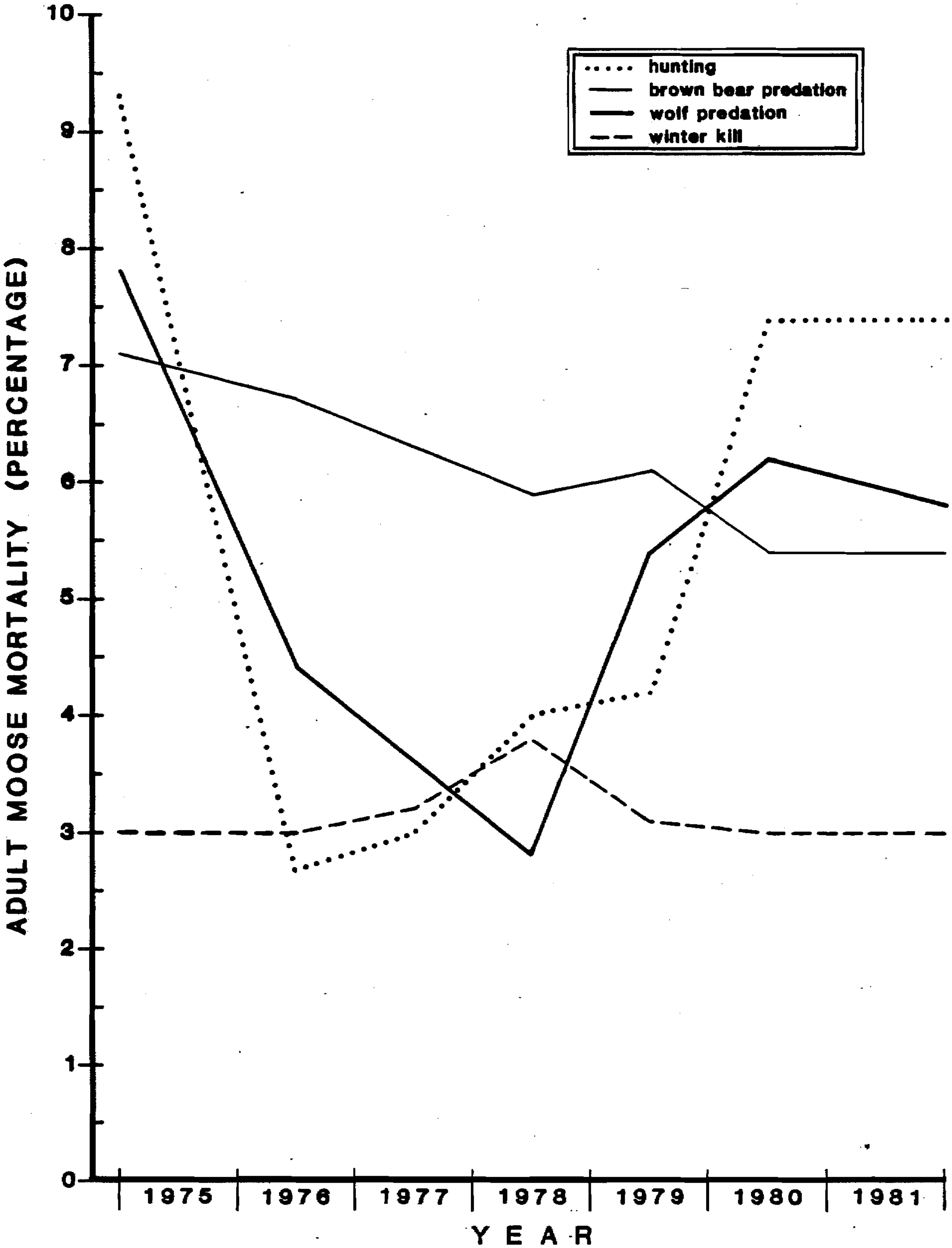


Figure 26. Annual adult moose mortality rates by cause as determined from modeling the Susitna River Study Area moose population in southcentral Alaska, 1975–1981.

Table 13. Estimates of spring moose population size, and causes and magnitude of mortality by sex and age class as determined from modeling the moose population in GMU 13 of southcentral Alaska from 1975-76 to 1981-82.

1975-76

	Calves M	Calves F	Yrlgs. M	Yrlgs. F	Adults M	Adults F	Total Both
Spring Population Est.	7230	7230	1098	1098	1269	11822	29807
Mortality							
Early Spring and Summer	433	433	0	0	0	0	866
Spring Wolf Predation	486	486	11	11	13	123	1130
Summer Wolf Predation	209	209	57	57	66	615	1213
Brown Bear Predation	2124	2124	61	61	70	658	5098
Black Bear Predation	90	90	4	4	5	46	239
Hunting	0	0	358	0	358	0	716
Winter Wolf Predation	299	299	80	80	92	865	1715
Winter Kill	233	233	36	23	27	375	927
Subtotal	3874	3874	607	236	631	2682	11904
% of Population	53.6	53.6	55.3	21.5	49.7	22.6	39.9

1976-77

	Calves M	Calves F	Yrlgs. M	Yrlgs. F	Adults M	Adults F	Total Both
Spring Population Est.	5598	5598	3356	3356	1129	10062	29099
Mortality							
Early Spring and Summer	335	335	0	0	0	0	670
Spring Wolf Predation	535	535	33	33	11	98	1245
Summer Wolf Predation	156	156	111	111	37	333	904
Brown Bear Predation	2124	2124	159	159	54	477	5097
Black Bear Predation	90	90	11	11	4	34	240
Hunting	0	0	366	0	366	0	732
Winter Wolf Predation	250	250	176	176	59	526	1437
Winter Kill	141	141	160	73	23	328	866
Subtotal	3631	3631	1016	563	554	1796	11191
% of Population	64.9	64.9	30.3	16.8	49.1	17.9	38.5

1977-78

	Calves M	Calves F	Yrlgs. M	Yrlgs. F	Adults M	Adults F	Total M F
Spring Population Est.	5322	5322	1657	1967	2915	11059	28552
Mortality							
Early Spring and Summer	319	319	0	0	0	0	638
Spring Wolf Predation	333	333	12	12	18	67	775
Summer Wolf Predation	157	157	65	65	97	368	909
Brown Bear Predation	2124	2124	93	93	138	525	5097
Black Bear Predation	90	90	7	7	10	37	241
Hunting	0	0	428	0	428	0	856
Winter Wolf Predation	190	190	78	78	116	440	1092
Winter Kill	137	137	81	42	80	362	839
Subtotal	3350	3350	764	297	887	1799	10447
% of Population	62.9	62.9	38.8	15.1	30.4	16.3	36.6

1978-79

	Calves M	Calves F	Yrlgs. M	Yrlgs. F	Adults M	Adults F	Total Both
Spring Population Est.	5751	5751	1972	1972	3231	10930	29607
Mortality							
Early Spring and Summer	345	345	0	0	0	0	69
Spring Wolf Predation	247	247	9	9	14	49	575
Summer Wolf Predation	128	128	53	53	87	294	743
Brown Bear Predation	2124	2124	93	93	152	513	5099
Black Bear Predation	90	90	7	7	11	36	241
Hunting	0	0	432	0	432	0	864
Winter Wolf Predation	173	173	70	70	115	390	991
Winter Kill	1608	397	137	43	182	361	2728
Subtotal	4652	4652	801	275	993	1643	11868
% of Population	80.9	60.9	40.6	13.9	30.7	15.0	40.5

Table 13. (cont'd)

	1979-80							1980-81						
	Calves		Yrlgs.		Adults		Total	Calves		Yrlgs.		Adults		Total
	M	F	M	F	M	F	Both	M	F	M	F	M	F	Both
Spring Population Est.	5571	5571	1036	2247	3409	10984	29218	5958	5958	2555	2555	2833	11509	31418
Mortality														
Early Spring and Summer	346	346	0	0	0	0	692	337	337	0	0	0	0	674
Spring Wolf Predation	281	281	5	12	18	57	654	258	285	11	11	12	50	600
Summer Wolf Predation	88	88	18	40	61	195	490	123	123	57	57	65	258	683
Brown Bear Predation	2124	2124	50	108	164	528	5098	2124	2124	111	111	126	501	5097
Black Bear Predation	90	90	4	8	12	37	241	90	90	8	8	9	35	240
Hunting	0	0	500	0	500	0	1000	0	0	0	0	557	0	557
Winter Wolf Predation	117	117	25	55	83	267	664	106	106	51	51	58	231	603
Winter Kill	170	170	27	49	95	366	877	180	180	142	56	76	383	1017
Subtotal	3216	3216	629	272	933	1450	9716	3218	3218	380	294	903	1458	9471
% of Population	55.7	55.7	60.7	12.1	27.4	13.2	33.3	54.0	54.0	14.9	11.5	31.3	12.7	30.1

	1981-82						
	Calves		Yrlgs.		Adults		Total
	M	F	M	F	M	F	Both
Spring Population Est.	6307	6307	2720	2720	4155	12312	34521
Mortality							
Early Spring and Summer	378	378	0	0	0	0	756
Spring Wolf Predation	218	218	9	9	13	40	507
Summer Wolf Predation	97	97	43	43	66	195	541
Brown Bear Predation	2124	2124	105	105	161	477	5096
Black Bear Predation	90	90	7	7	11	34	239
Hunting	0	0	0	0	794	0	794
Winter Wolf Predation	123	123	56	56	86	255	699
Winter Kill	204	204	153	61	111	416	1149
Subtotal	3234	3234	373	281	1242	1417	9781
% of Population	51.3	51.3	13.7	10.3	29.9	11.5	28.3

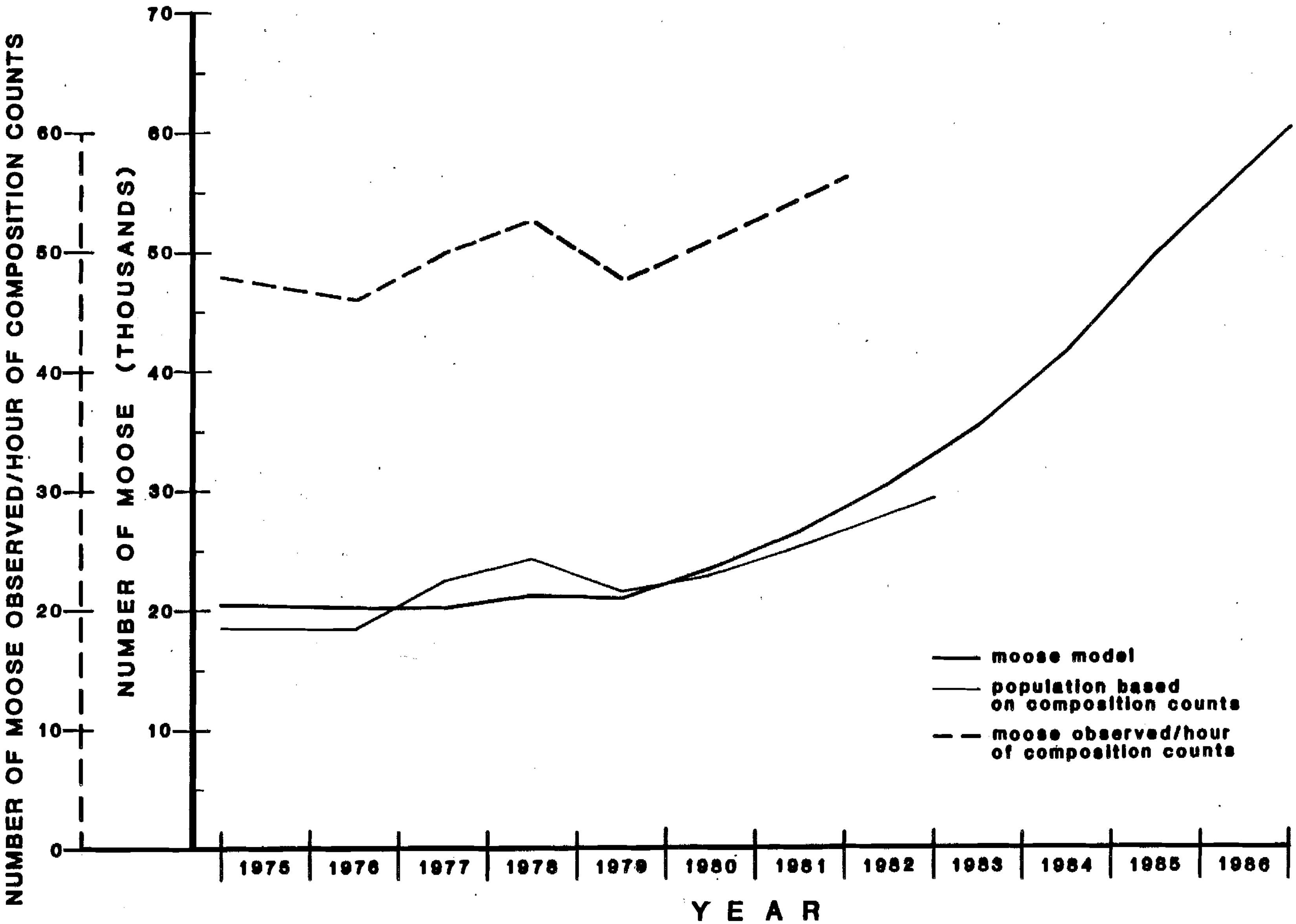


Figure 27. Fall moose population estimates as derived from modeling versus annual composition counts for Game Management Unit 13 of southcentral Alaska, 1975-1986.

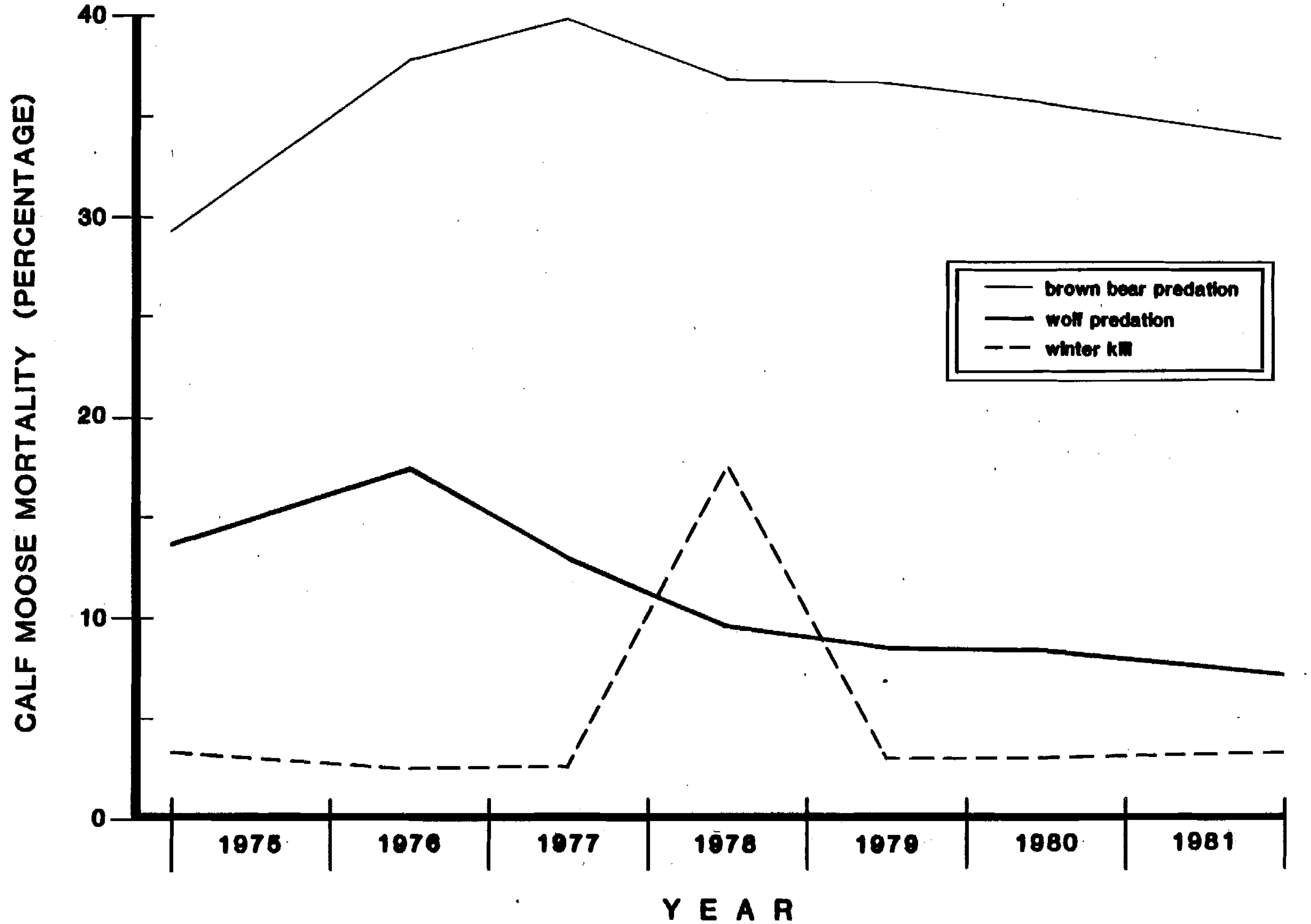


Figure 28. Estimated annual rates of calf mortality from predation and winter kill determined from modeling the Game Management Unit 13 moose population of southcentral Alaska, 1975–1981.

important cause of calf mortality (Fig. 28). Mortality of calf moose was higher in the GMU 13 than in the wolf control area, particularly in 1976-77 when wolves preyed upon 17.3% of the estimated numbers of calves produced. As wolf densities declined in the unit, primarily from hunting and trapping activities, the estimated percentage of calves preyed upon by wolves declined each year, reaching a low of 7.0% during 1981-82. Calf mortality studies conducted in 1977 and 1978 suggested that 3% of the calf mortalities during the first 6 weeks following birth were attributable to wolf predation (Ballard et al. 1981). Independent modeling estimates suggested that calf mortality attributable to wolf predation ranged from 4.3 to 6.3% during the same years. Therefore, both approaches suggested that wolf predation on newborn moose calves was a secondary source of calf mortality.

Adult Mortality

Wolf predation on adult moose in the GMU 13 also declined during the study period (Fig. 29), ranging from 13.5% in 1975 to 4.0% in 1981. The decline in wolf-related adult mortality was due to a decrease in the wolf population and concurrent increases in the moose population. Similarly, percent annual adult mortality from brown bear predation also declined (5.5 to 4.8%) but this was primarily the result of increases in the moose population since we assumed that bear populations were stable during the study.

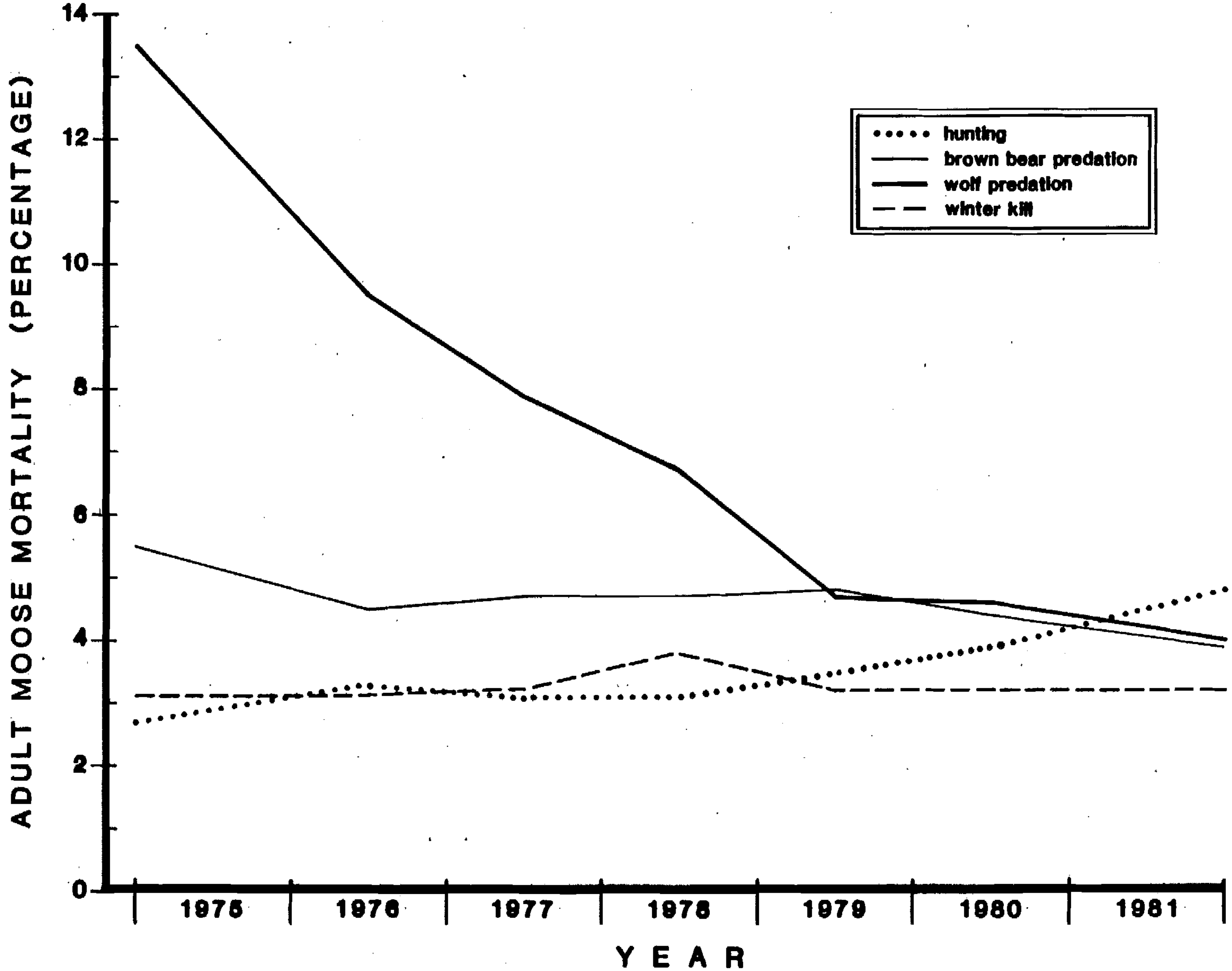


Figure 29. Annual Game Management Unit 13 adult moose mortality rates from four factors estimated from modeling, 1975–1981.

During the study, adult mortality attributable to hunting increased primarily because of changes in hunting regulations in 1980 which placed all harvest pressure on adult bulls only.

Wolf Predation

Earlier analyses of the effects of decreased wolf densities (from wolf control) on moose calf survival suggested that no significant increases had occurred because ratios of various sex and age classifications had fluctuated similarly between control and non-control areas (Ballard et al. 1981). Although the reductions in wolf density were substantially larger in the wolf control area, wolf densities in both the wolf control area and GMU 13 decreased from 1975 levels, while moose populations in both areas increased (Fig. 30). Reductions in both calf mortality from 9-17% annual mortality to 4-7%, and adult moose mortality from 8-10% to 3-4% annual mortality probably contributed to the increases in the moose populations. Because wolf densities declined in both areas, it would be expected that the sex-age ratios would fluctuate similarly. Although wolf predation was not the primary source of moose mortality, its reduction in combination with several mild winters appears to have allowed both moose populations to increase. Substantially larger increases could probably be anticipated if the level of bear predation was also reduced.

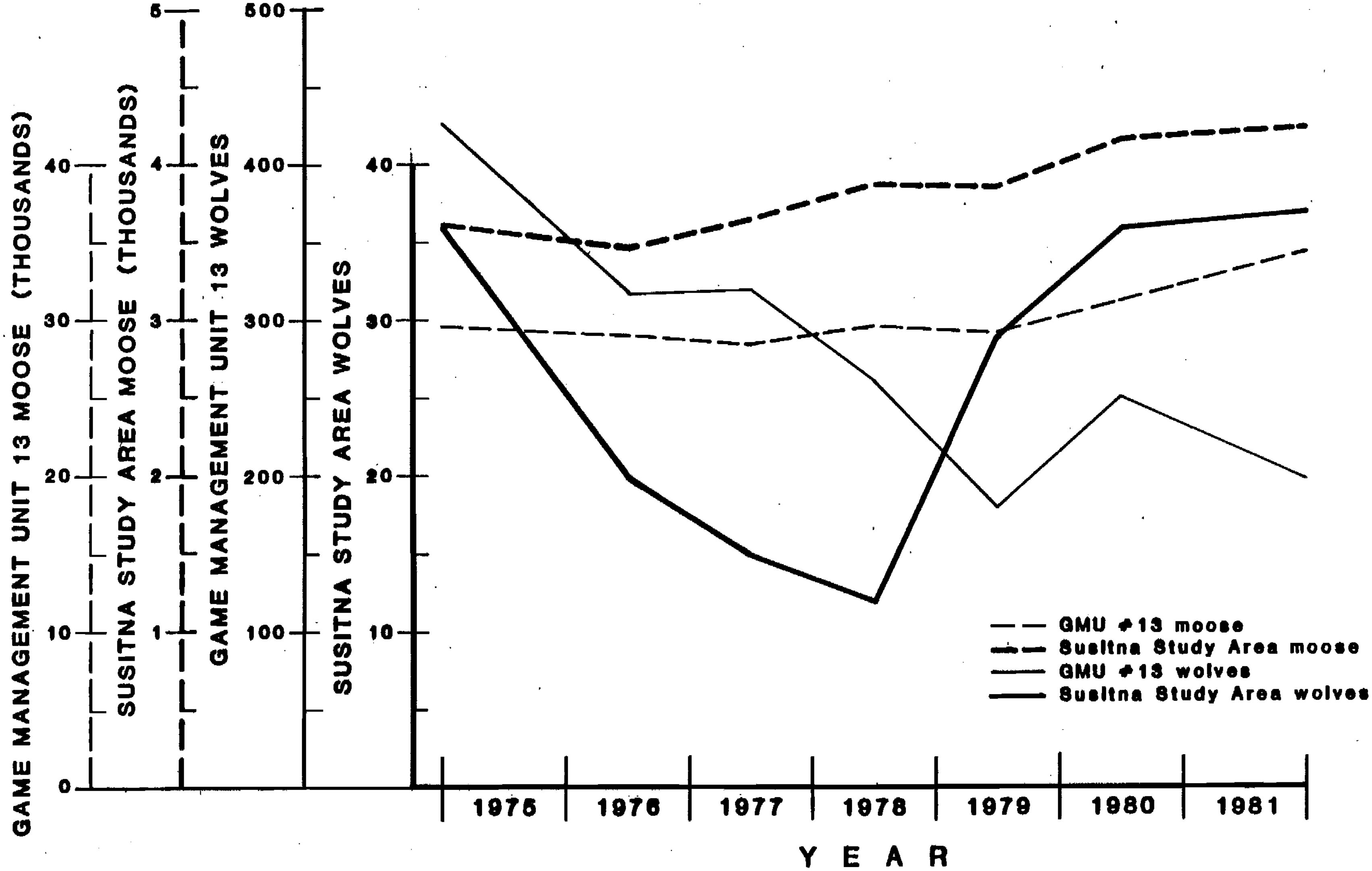


Figure 30. Annual fall moose and wolf population trends between Game Management Unit 13 and the Susitna River Study Area of southcentral Alaska, 1975–1981.

From 1 November through 15 May each year, mortality of moose from wolf predation is relatively high on a superficial basis but on a population level is relatively minor. For example, in both the experimental area and GMU 13 wolf predation accounted for 6.5 and 7.7% mortality, respectively, of the calves present on 1 November 1975. However, of the total calves produced, this source of mortality represented only 2.3 and 4.1% respectively. From this comparison, it would be easy to conclude from flights made during winter when wolf kills are most noticeable that wolf predation was a much more important source of moose mortality than what it actually represents on a population basis.

SECTION V. IMPACT MECHANISMS

Table 14 summarizes the major structural features associated with the construction and operation of the Susitna Hydroelectric Project and a description of their potential impact on moose. In an effort to assess the effects of these impacts on moose, they were related to the basic components of the moose model described in the previous section (Table 15). Based upon this assessment, the proposed project will affect the population dynamics of upper Susitna moose and their predators. The exact magnitude of these effects, however, will require refinement as studies proceed and actual operation is commenced. Earlier (see section on Zone of Impact) we estimated that based upon numbers of radio-collared moose utilizing the impoundment areas in relation to the 1980

Table 14. Susitna Hydroelectric Project actions and their potential effect on moose numbers, distribution and habitat in the Susitna River Area.

Project Action	Environmental Effect
Construction and operation of dams (staging zone, camps, and structures)	Loss of winter range. Avoidance of adjacent winter range. Loss of spring-summer range. Avoidance of spring-summer range. Possible impedence to migration.
Spoil sites	Temporary loss of winter-summer range. Temporary avoidance of adjacent habitat.
Borrow areas	Permanent and temporary loss of winter habitat. Permanent and temporary loss of spring-summer habitat. Temporary avoidance of habitat.
Reservoir clearing	Loss of habitat. Temporary avoidance of adjacent areas.
Permanent village facilities	Loss of habitat. Avoidance of adjacent areas.
Main and accessory roads and railroads.	Loss of habitat. Permanent and temporary avoidance (disturbance) of adjacent habitat. Mortality from collisions. Increased human-related mortality (hunting, defense of life, etc.).
Airstrips	Increased commercial and recreational development on adjacent lands. Loss of habitat. Temporary avoidance (disturbance) of adjacent areas. Increased human access and human-related mortality.
Transmission line construction, access and operation	Temporary avoidance of habitat. Increased access. Temporary loss of habitat. Eventual summer habitat improvement. Potential for increased commercial and recreational development
Fill and operation of impoundments	Permanent inundation of winter range. Permanent inundation of spring-summer range. Increased snow depths on adjacent area. Increased snow drifting on adjacent areas. Icing on vegetation due to open water. Impedence of movements due to open water during subfreezing temperatures. Increased mortality from attempting to cross thin ice. Impedence of movements and increased mortality due to ice shelving. Increased mortality crossing mud flats. Unstable slopes causing habitat loss. Crowding on adjacent habitat. Increased human access. Decreased vegetation productivity on adjacent lands due to climatic changes.

Table 15. Potential impacts of Susitna Hydroelectric development on annual moose population parameters.

Moose Population Parameters	Projected Impact of Project Events
Reproduction	Decline in reproduction due to lower population size resulting from increases in winter mortality, accidental mortality, hunting and predator mortality from abnormal concentration of moose and predator.
	Decreased productivity resulting from decreased vigor because of increased snow depths, decreased quality and quantity of forage from weather, icing, and overbrowsing; increased disturbance (both human and predator), and delayed spring green up.
Early spring and summer mortality (excluding predation)	Increase in still births due to reduced vigor of cows.
	Increases in drowning and accidental deaths.
	Increase in incidence of disease and pneumonia from delayed greenup, poor nutrition, and more severe weather conditions.
Spring wolf predation	Temporary increases in numbers of wolves may be influenced by increased availability of prey leading to increased fecundity, double denning and greater pup survival. Results in increased predation on both calf and adult moose because of abnormal concentrations of moose and their reduced health following winter.
	Short term severe overbrowsing of moose habitat and increased mortality result in lower moose moose densities.
	Lack of rapid wolf population response to lower moose numbers intensifies effects of predation and lowers moose population further. Eventually results in lower numbers of predators and prey which "stabilize" at low level.
Summer wolf predation	Similar to above.
Brown bear predation	Temporary increases in density of bears due to decreased availability of south facing slopes and forced concentrations.
	Result: Increased predation on calf and adult moose due to abnormal conditions of moose and reduced vigor of adults and calves from poor nutrition and increased winter severity.
	Bear productivity and survival increase responding to increased availability of prey. Results in increases in bear predation on moose and drives moose population lower. Bears' ability to utilize alternate food source maintains abnormal densities of bears for long period and decreases moose population further. Ultimately both bear population and moose population stabilize at lower level.
Black bear predation	Short term:
	Bears lose den sites and for short period prey intensively on moose before population declines.
	Long term:
	Due to decline in black bear population this source of mortality declines.

Table 15. (cont'd)

Moose Population Parameters	Projected Impact of Project Events
Hunter harvest	Potential increase in harvest due to improved access and increased vulnerability caused by moose occupying new habitat areas not previously occupied. Depresses bull:cow ratios, possibly leading to decreased productivity.
	Probable that harvests will be limited by regulations; however, dispersal of moose from impoundment areas could temporarily increase and cause temporary increase in numbers of available moose elsewhere in GMU 13. Ultimately, however, declines in population size will reduce dispersals and reduce numbers of moose available for harvest.
Winter mortality	Winter mortality from starvation increases due to overbrowsed range in areas adjacent to impoundments, loss of habitat, icing on vegetation, increased snow depths and delayed spring green-up.
	Accidents increase from open water, ice shelving, and unstable reservoir ice.
Winter wolf predation	Concentrated wolf and moose populations on winter range result in increases in surplus killing by wolves. Moose more vulnerable due to increased snow depths, lower availability of forage, poorer quality and quantity of remaining forage.
	In addition, traditional escape routes no longer available due to ice shelving and unstable ice conditions. Increased availability of prey result in wolf population increase. Time lag in response of wolf population to decreased moose density further depresses moose population. Eventually wolf population declines and adjusts to lower moose density. Both populations "stabilize" at lower levels.

census, from 1900 to 2600 moose could be directly impacted by construction and operation of the Watana and Devil Canyon impoundments. These estimates comprised 8 to 11% of the total numbers of moose occurring in GMU-13. Including moose which could be secondarily impacted by the project through increased competition from displaced moose, etc., approximately 45% of the GMU-13 moose population could be affected to varying degrees by the proposed projects. Moose modeling efforts currently underway will be adapted to incorporate anticipated effects of the project on the individual components of the moose population.

SECTION VI. MITIGATION

Current investigation is focused on an experimental burn to improve moose habitat described in Section I.

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Appendix A. Seasonal and total home range sizes of individual radio-collared moose studied in the Nelchina and upper Susitna River Basins of southcentral Alaska from October 1976 through early June 1982.

Moose ID #	Sex-Age at Capture	Period Monitored (mo., yr)	Total # locations	Summer Home Range 1/		Winter Home Range 1/		Total Home Range 2/		Maximum length of range	
				km^2	mi^2	km^2	mi^2	km^2	mi^2	km	mi
249	M-Calf	3/79-5/81	10	--	--	128.0	49.4	232.5	89.8	23.7	14.7
268	M-Calf	3/79-3/80	7	--	--	45.9	17.7	150.8	58.2	20.8	13.0
271	M-Calf	3/79-8/80	8	159.4	61.5	70.6	27.3	1252.9	483.8	60.8	37.8
294	M-Calf	4/79-5/81	9	32.2	12.4	322.9	124.7	537.6	207.6	88.5	55.0
301	M-Calf	4/79-5/81	7	--	--	151.3	58.4	163.9	63.3	32.9	20.5
375	M-Calf	11/79-5/81	8	--	--	14.9	5.8	285.4	110.2	37.4	23.3
376	M-Calf	11/79-5/81	7	--	--	186.8	82.1	358.5	138.4	56.3	35.0
379	M-Calf	11/79-5/81	7	--	--	177.5	68.5	177.5	68.5	25.1	15.6
381	M-Calf	11/79-5/81	8	--	--	2.0	0.8	3.8	1.5	5.1	3.1
382	M-Calf	11/79-5/81	8	--	--	138.3	53.4	138.3	53.4	18.0	11.2
388	M-Calf	11/79-5/81	9	--	--	438.0	169.1	583.5	225.3	50.2	31.2
391	M Calf	11/79-6/81	8	--	--	79.2	30.6	108.8	42.0	33.6	20.9
392	M-Calf	11/79-5/81	8	--	--	72.7	28.1	134.2	51.8	36.4	22.6
393	M-Calf	11/79-3/81	7	--	--	37.0	14.3	37.0	14.3	12.1	7.5
395	M-Calf	11/79-5/81	7	--	--	103.3	40.0	256.8	99.2	41.1	25.5
396	M-Calf	11/79-6/81	8	--	--	35.2	13.6	44.4	16.0	16.0	10.0
398	M-Calf	11/79-9/81	9	--	--	74.4	28.7	85.2	32.9	21.4	13.3
399	M-Calf	11/79-12/80	7	--	--	78.6	30.3	78.6	30.3	15.1	9.4
400	M-Calf	11/79-6/81	9	--	--	46.9	18.1	64.5	24.9	15.2	9.4
402	M-Calf	11/79-6/81	8	--	--	56.3	21.7	86.7	33.5	22.2	13.8
408	M-Calf	11/79-5/81	9	--	--	9.4	3.6	48.0	18.5	19.2	11.9
670	M-Calf	3/81-6/82	4	--	--	--	--	16.9		7.9	
672	M-Calf	3/81-6/82	20	168.9	--	790.7	--	1001.1	--	51.0	--
674	M-Calf	3/81-6/82	22	694.8	--	305.4	--	1112.1	--	69.2	--
675	M-Calf	3/81-6/82	18	324.7		48.4		411.2		44.1	
676	M-Calf	3/81-6/82	20	424.2		207.7		542.0		50.2	
677	M-Calf	3/81-4/82	17	409.4		211.9		512.0		33.3	
690	M-Calf	3/81-6/82	18	70.0		41.7		137.5		21.4	
696	M-Calf	5/81-6/82	15	191.8		440.7		579.0		64.0	
667	M-2 yr.	3/81-6/82	18	261.7		48.7		261.7		19.4	
626	M-5 yr.	4/80-8/81	19	91.1	35.2	21.0	8.1	91.1	35.2	16.2	10.1
627	M-4 yr.	4/80-9/80	12	50.7	19.6	--	--	127.6	49.3	22.4	13.9
642	M-4 yr.	4/80-5/82	34	148.0		118.5		214.1		21.5	
682	M-Adult	3/81-5/81	5	--	--	5.5	2.1	75.7	29.2	14.4	9.0
225	F-Calf	3/79-11/80	7	--	--	43.3	16.7	43.3	16.7	19.3	12.0
262	F-Calf	3/79-11/81	8	36.7	14.2	--	189.7	73.3	26.5	16.4	
264	F-Calf	3/79-5/81	11	58.9	22.7	153.1	59.1	174.2	67.3	23.4	14.5
269	F-Calf	3/79-5/81	13	40.2	15.5	70.6	27.3	166.2	64.2	29.6	18.4
274	F-Calf	3/79-7/79	5	--	--	--	--	97.0	37.5	37.0	23.0
290	F-Calf	4/79-5/81	11	75.6	29.2	846.2	326.7	1833.5	708.0	131.0	81.4
291	F-Calf	4/79-5/81	9	12.5	4.8	136.3	52.6	155.0	59.8	20.4	12.7
293	F-Calf	4/79-5/81	9	2.3	0.9	161.5	62.4	161.6	62.4	40.5	25.2
297	F-Calf	4/79-5/81	9	18.8	7.3	191.1	73.8	213.9	82.6	37.2	23.1
298	F-Calf	4/79-5/81	9	10.7	4.1	37.5	14.5	186.9	72.2	48.4	30.1
299	F-Calf	4/79-5/81	8	12.7	4.9	82.5	31.8	136.2	52.6	30.8	19.2
300	F-Calf	4/79-5/81	8	3.2	1.2	--	--	16.1	6.2	8.2	5.1

Appendix A. (cont'd)

Moose ID #	Sex-Age at Capture	Period Monitored (mo., yr)	Total # locations	Summer Home Range 1/ km²	Summer Home Range 1/ mi²	Winter Home Range 1/ km²	Winter Home Range 1/ mi²	Total Home Range 2/ km²	Total Home Range 2/ mi²	Maximum length of range km	Maximum length of range mi
302	F-Calf	4/79-5/81	10	258.5	99.8	91.7	35.4	462.6	178.6	54.9	34.1
303	F-Calf	4/79-5/81	9	99.4	38.4	22.5	8.7	152.5	58.9	19.8	12.3
305	F-Calf	4/79-3/81	9	5.3	2.0	162.0	62.5	172.6	66.6	25.5	15.9
306	F-Calf	4/79-12/81	8	--	--	227.2	87.7	312.1	120.5	32.3	20.1
307	F-Calf	4/79-5/81	8	7.2	2.8	96.3	37.2	201.7	77.9	58.8	36.2
308	F-Calf	4/79-5/81	7	13.5	5.2	--	--	73.0	28.2	20.5	12.7
377	F-Calf	11/79-6/81	8	--	--	221.8	85.6	224.4	86.6	33.2	20.6
378	F-Calf	11/79-5/81	8	--	--	223.2	86.2	225.1	86.9	33.2	20.6
380	F-Calf	11/79-5/81	8	--	--	112.5	43.5	183.9	71.0	36.7	22.8
383	F-Calf	11/79-7/80	5	--	--	26.9	10.4	85.0	32.8	23.2	14.4
384	F-Calf	11/79-5/81	8	--	--	37.9	14.6	83.5	32.3	31.6	19.6
386	F-Calf	11/79-5/81	8	--	--	186.9	72.1	257.1	99.3	68.8	42.7
387	F-Calf	11/79-5/81	9	--	--	96.8	37.4	112.1	43.3	28.7	17.8
389	F-Calf	11/79-5/81	7	--	--	161.1	62.2	206.7	79.8	27.6	17.1
390	F-Calf	11/79-5/81	8	--	--	131.2	50.7	143.8	55.5	25.2	15.7
394	F-Calf	11/79-5/81	6	--	--	88.7	34.2	169.8	65.6	26.4	16.4
397	F-Calf	11/79-9/81	8	--	--	7.5	2.9	34.4	13.3	16.3	10.1
403	F-Calf	11/79-5/81	8	--	--	156.3	60.4	167.1	64.5	23.5	14.5
404	F-Calf	11/79-5/81	10	--	--	34.9	13.5	47.8	18.2	15.7	9.8
406	F-Calf	11/79-6/81	9	--	--	119.4	46.1	121.1	46.8	26.2	16.3
407	F-Calf	11/79-5/81	8	--	--	95.8	37.0	95.8	37.0	21.4	13.3
669	F-Calf	3/81-12/81	12	305.2	--	391.5		668.9		44.4	
678	F-Calf	3/81-6/82	20	185.1		132.1		430.9		41.9	
679	F-Calf	3/81-2/82	16	92.1		39.2		132.6		20.2	
681	F-Calf	3/81-4/81	4			4.3		4.3		3.9	
685	F-Calf	3/81-6/82	19	458.5		3247.5		3979.3		107.8	
686	F-Calf	3/81-6/82	19	549.2		22.8		549.2		54.6	
689	F-Calf	3/81-5/82	15	142.8		149.1		443.0		62.4	
693	F-Calf	3/81-6/82	17	148.3		53.1		433.6		33.8	
246	F-2 yr.	3/79-8/79	6	5.9	2.3	--	--	15.9	6.1	8.4	5.3
633	F-2 yr.	4/80-6/80	5	--	--	--	--	3.6	1.4	9.2	5.7
680	F-2 yr.	3/81-8/81	5	--	--	2.6	1.0	7.8	3.0	5.7	3.6
701	F-2 yr.	10/76-9/78	32	914.3	353.0	638.7	246.6	1321.8	510.4	66.6	41.4
726	F-2 yr.	3/77-4/79	28	409.4	158.1	237.3	91.6	539.0	208.1	47.2	29.3
617	F-Adult	4/80-6/82	42	69.3		60.9		88.9		14.7	
618	F-13 yr.	3/77-5/79									
		4/80-7/81	47	78.4	30.3	59.6	23.0	112.4	43.4	22.8	14.2
619	F-9 yr.	4/80-6/82	37	162.5		202.3		237.9		45.7	
622	F-12 yr.	4/80-6/82	38	156.4		68.9		171.3		22.0	
623	F-8 yr.	8/78-12/78									
		4/80-6/82	25	1507.2		815.8		1703.4		63.0	
624	F-10 yr.	4/80-5/82	32	303.9		155.8		370.9		45.6	
625	F-13 yr.	4/80-6/80	6	5.0	1.9	--	--	12.8	4.9	9.7	6.0
628	F-12 yr.	4/80-6/72	36	101.9		281.2		312.7		51.3	
629	F-3 yr.	4/80-6/82	35	42.2		33.5		78.6		15.1	
630	F-6 yr.	4/80-6/82	36	117.7		9.1		131.9		29.8	
631	F-10 yr.	3/77-4/77									
		4/80-10/81	27	50.5		73.8		130.8		21.0	

Appendix A. (cont'd)

Moose ID #	Sex-Age at Capture	Period Monitored (mo., yr)	Total # locations	Summer Home Range 1/ km²	Summer Home Range 1/ mi²	Winter Home Range 1/ km²	Winter Home Range 1/ mi²	Total Home Range 2/ km²	Total Home Range 2/ mi²	Maximum length of range km	Maximum length of range mi
632	F-11 yr.	4/80-9/80	14	40.7	15.7	--	--	48.6	18.8	16.3	10.1
634	F-12 yr.	4/80-6/82	35	156.5		48.6		187.5		20.1	
635	F-Adult	4/80-6/82	38	152.1		242.9		475.7		43.4	
636	F-4 yr.	4/80-6/82	33	65.8		204.6		222.0		26.2	
637	F-Adult	4/80-6/82	36	190.1		122.6		206.9		22.9	
638	F-Adult	4/80-7/81	20	62.8	24.3	58.5	22.6	78.6	30.3	25.1	15.6
639	F-4 yr.	4/80-6/82	36	386.9		553.2		700.8		46.2	
640	F-5 yr.	4/80-6/82	32	49.9		171.7		197.9		20.5	
641	F-12 yr.	4/80-5/82	38	121.8		127.2		163.4		18.0	
643	F-Adult	4/80-6/82	36	115.4		92.8		149.8		25.5	
644	F-Adult	4/80-6/82	36	124.6		104.9		158.4		21.8	
645	F-10 yr.	4/80-6/82	34	49.8		180.6		241.6		25.3	
647	F-13 yr.	4/80-3/82	35	108.8		200.3		299.9		28.1	
648	F-4 yr.	4/80-6/82	35	151.4		124.2		273.8		38.7	
649	F-Adult	4/80-6/82	36	36.8		108.7		115.2		16.8	
650	F-4 yr.	4/80-6/82	39	317.8		193.2		550.2		50.5	
651	F-6 yr.	8/78-3/79									
		4/80-1/81	23	47.3	18.3	42.6	16.5	70.9	27.4	13.4	8.3
652	F-13 yr.	4/80-6/82	36	177.0		71.7		177.0		27.0	
653	F-13 yr	4/80-6/82	37	55.6		178.7		198.1		26.3	
654	F-9 yr.	4/80-6/82	33	68.3		82.7		122.5		17.8	
655	F-16 yr.	4/80-6/82	34	114.7		61.7		187.7		20.6	
656	F-13 yr.	4/80-1/81	18	43.6	16.8	0.4	0.2	44.3	17.1	9.3	5.8
662	F-4 yr.	3/77-10/77									
		6/80-6/82	46	63.0		49.3		69.6		13.6	
663	F-8 yr.	10/76-4/79									
		8/80-6/82	76	428.3		318.4		515.0		42.2	
664	F-Adult	10/76-4/79									
		6/80-4/82	56	73.1	28.2	2388.9	922.4	2910.5	1123.8	106.3	66.1
666	F-9 yr.	3/81-10/81	10	50.5		--	--	100.1		17.1	
668	F-8 yr.	3/81-6/82	19	241.0		169.3		715.7		49.4	
671	F-4 yr.	3/81-6/82	18	81.2		240.8		542.7		46.6	
683	F-9 yr.	3/81-6/82	19	59.3		28.4		68.8		14.0	
684	F-8 yr.	3/81-6/82	19	89.7		62.3		168.5		28.8	
687	F-4 yr.	3/81-5/82	17	212.0		52.3		493.0		50.4	
688	F-Adult	3/81-5/82	18	124.7		41.1		222.1		35.9	
691	F-9 yr.	3/81-6/82	19	76.7		33.8		130.6		27.9	
692	F-9 yr.	3/81-12/81	11	82.7		--	--	313.6		51.8	
694	F-13 yr.	3/81-6/82	19	22.9		48.5		96.0		20.2	
695	F-Adult	5/81-6/82	17	143.9		62.7		171.2		26.8	
697	F-Adult	3/81-6/82	17	261.5		78.6		443.2		37.1	
698	F-8 yr.	3/77-11/78	21	38.3	14.8	68.9	26.6	90.9	35.1	20.0	12.4
700	F-7 yr.	10/76-11/77	21	880.6	340.0	627.1	242.1	1353.3	522.5	66.1	41.0
702	F-7 yr.	10/76-5/79	40	148.3	57.3	173.8	67.1	567.6	219.1	43.8	27.2
703	F-10 yr.	10/76-3/79	30	193.1	74.5	93.5	36.1	261.6	101.0	24.1	15.0
704	F-Adult	10/76-4/79	22	151.2	58.4	121.7	47.0	283.6	109.5	29.8	18.5
705	F-9 yr.	10/76-3/79	32	99.2	38.3	334.9	129.3	352.5	136.1	33.1	20.6
706	F-Adult	10/76-4/79	42	157.1	60.7	93.6	36.1	185.2	71.5	21.8	13.6

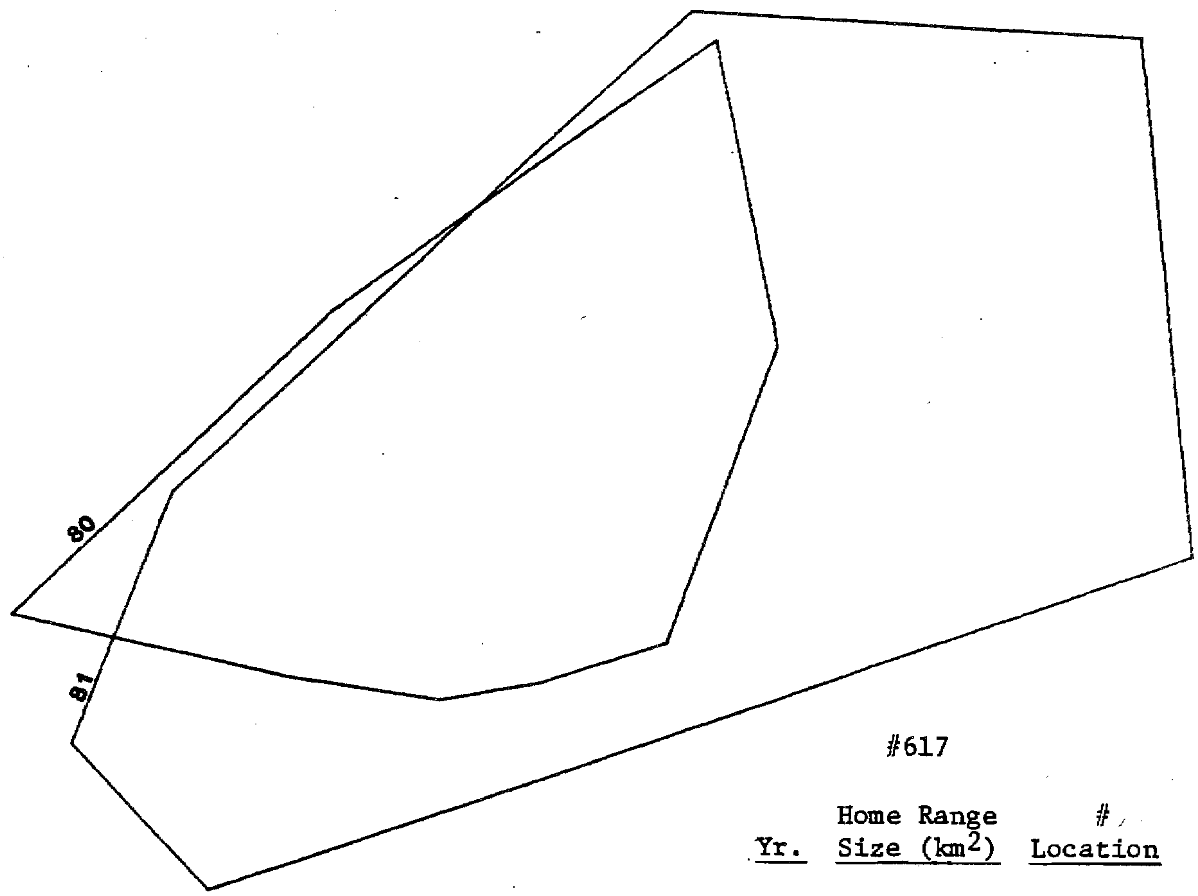
Appendix A. (cont'd)

Moose ID #	Sex-Age at Capture	Period Monitored (mo., yr)	Total # locations	Summer Home Range 1/ km²	Summer Home Range 1/ mi²	Winter Home Range 1/ km²	Winter Home Range 1/ mi²	Total Home Range 2/ km²	Total Home Range 2/ mi²	Maximum length of range km	Maximum length of range mi
707	F-7 yr.	10/76-3/79	43	344.5	133.0	516.6	199.5	657.4	253.8	52.9	32.9
708	F-8 yr.	10/76-4/79	39	252.1	97.3	136.8	52.8	454.1	175.4	50.0	31.0
709	F-4 yr.	10/76-3/79	29	361.3	139.5	111.2	42.9	390.0	150.6	30.4	18.9
710	F-6 yr.	10/76-10/77	16	39.8	15.4	33.0	12.8	57.7	23.0	13.5	8.4
711	F-7 yr.	10/76-3/79	31	143.4	55.4	48.3	18.6	141.0	48.3	17.9	11.1
712	F-7 hr.	10/76-10/78	38	628.7	242.7	20.7	8.0	717.2	276.9	61.1	38.0
713	F-9 yr.	10/76-5/78	23	42.6	16.5	41.9	20.0	81.1	31.3	13.5	8.4
714	F-7 hr.	10/76-10/78	40	268.9	103.8	246.8	95.3	411.3	158.8	33.6	20.9
715	F-Adult	10/76-4/78	21	46.2	17.8	15.0	5.8	59.9	23.1	15.7	9.7
716	F-Adult	10/76-3/79	31	118.3	45.7	32.0	12.3	149.5	57.7	24.9	15.4
717	F-4 yr.	10/76-4/79	30	287.5	111.0	224.5	86.7	377.4	145.7	33.6	20.8
718	F-7 yr.	3/77-5/79	26	544.6	210.3	143.9	55.6	544.6	210.3	39.1	24.3
719	F-4 yr.	3/77-4/79	35	96.7	37.3	14.0	5.4	104.8	40.5	16.5	10.2
720	F-12 yr.	3/77-2/79	35	565	21.8	73.6	28.4	106.7	41.2	14.9	9.3
721	F-3 yr.	3/77-3/79	25	48.2	18.6	101.2	39.1	173.0	66.8	19.7	12.2
722	F-13 yr.	3/77-3/79	28	1131.3	436.8	155.8	60.2	1182.7	456.7	99.8	62.0
723	F-8 yr.	3/77-4/80	28	53.1	20.5	28.7	11.1	64.2	24.8	12.0	7.5
724	F-13 yr.	3/77-1/79	38	163.7	63.2	214.0	83.0	271.3	104.7	34.8	21.6
725	F-4 yr.	3/77-10/79	33	1139.1	439.8	725.4	280.1	2269.0	876.1	169.4	105.2
728	F-Adult	3/77-5/79	28	197.7	76.3	12.9	5.0	236.7	91.4	35.5	22.1
729	F-7 yr.	3/77-6/79	38	122.0	47.1	81.8	31.2	172.1	66.4	26.8	16.7
730	F-11 yr.	3/77-3/79	28	47.4	18.3	64.1	24.8	121.7	47.0	19.8	12.3
731	F-Adult	3/77-4/79	35	42.0	16.2	37.9	14.6	63.3	24.4	15.1	9.4
732	F-10 yr.	3/77-3/79	25	32.1	12.4	41.0	15.8	76.1	29.4	16.9	10.5
733	F-3 yr.	3/77-3/79	26	49.9	19.3	35.0	13.5	99.4	38.4	14.8	9.8
735	F-16 yr.	8/78-3/79	8	10.5	4.1	18.4	7.1	37.7	14.5	14.4	9.0
736	F-Adult	10/77-2/79	8	--	--	21.3	8.2	64.9	25.1	29.1	18.1
737	F-Adult	10/77-11/79	6	--	--	--	--	72.7	28.1	23.7	14.7
739	F-Adult	10/77-2/79	8	16.0	6.2	18.9	7.3	53.4	20.6	12.5	7.7
740	F-Adult	10/77-10/78	9	12.3	4.8	8.2	3.2	32.1	12.4	8.9	5.5
741	F-Adult	8/78-4/79	8	--	--	--	--	179.0	69.1	23.8	14.8
761	F-4 yr.	4/82-6/82	6	--	--	--	--	344.6	--	36.3	--
762	F-4 yr.	4/82-6/82	6	--	--	--	--	142.5	--	29.3	--
763	F-4 yr.	4/82-6/82	8	12.2	--	--	--	41.9	--	22.5	
764	F-4 yr.	4/82-6/82	9	57.8	--	19.0	--	106.4	--	35.9	--
765	F-14 yr	4/82-6/82	8	18.7	--	7.0	--	89.9	--	53.8	--

1/ Not determined if 3 or less observations; summer = months of May, June, July,August, September, and October; winter = months of November, December, January, February, March and April.

2/ Not determined if 4 or less observations.

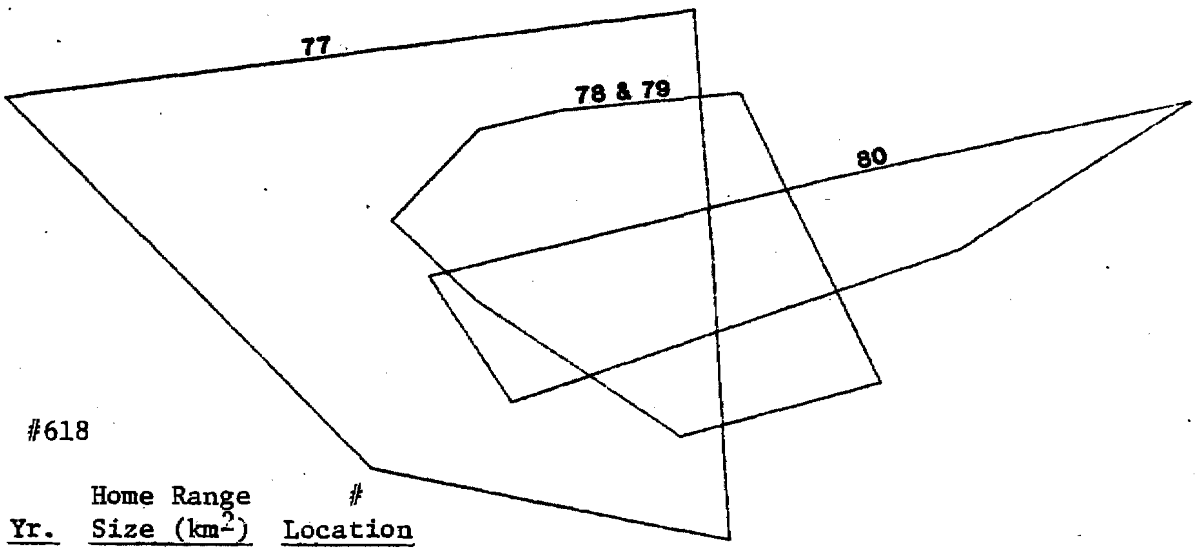
APPENDIX B



#617

Yr.	Home Range Size (km^2)	# Location
80	3,456	22
81	7,972	15

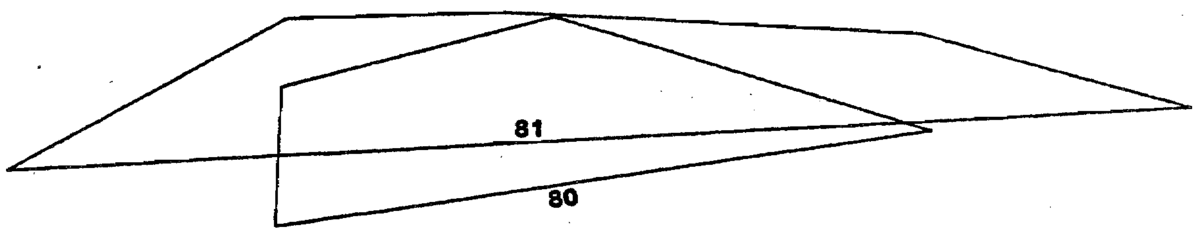
Area of overlap = 3,224 km^2



#618

Yr.	Home Range Size (km^2)	# Location
77	6,061	13
78	2,615	12
79	2,615	5
80	1,854	12

Area of 77-78 overlap = 1,786 km^2
Area of 78-79 overlap = 2,614 km^2
Area of 79-80 overlap = 983 km^2



#619

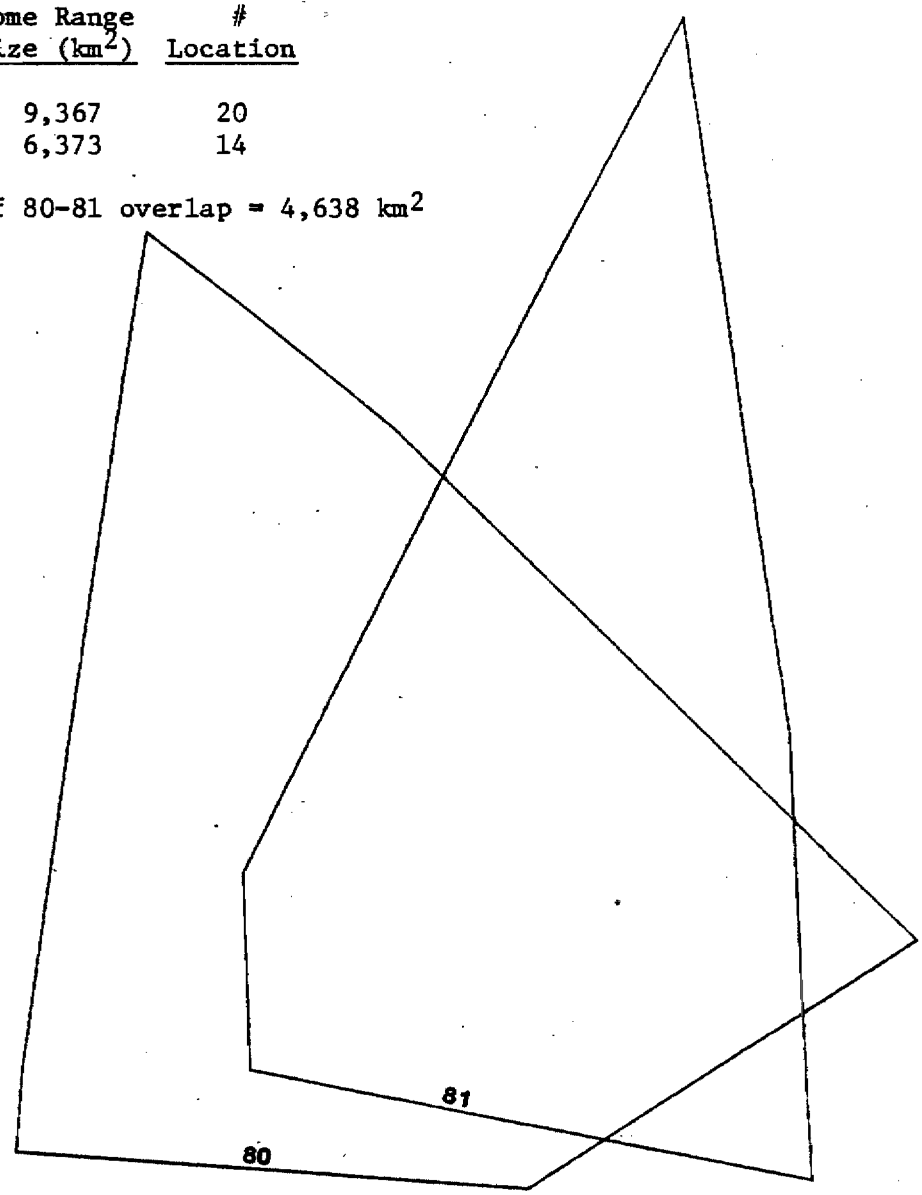
Yr.	Home Range Size (km^2)	# Location
80	9,593	16
81	13,770	16

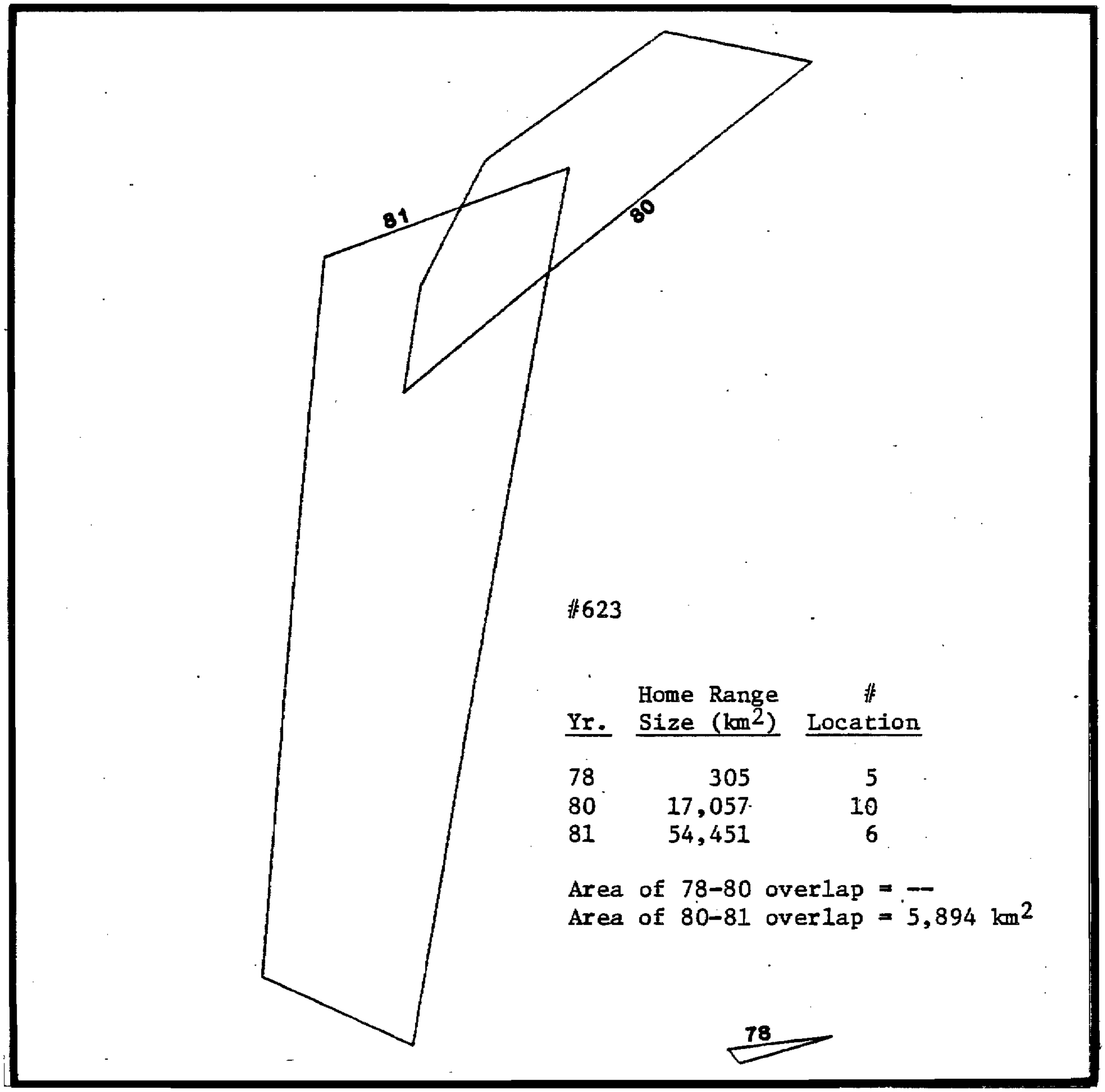
Area of 80-81 overlap = 6,198 km^2

#622

Yr.	Home Range Size (km^2)	# Location
80	9,367	20
81	6,373	14

Area of 80-81 overlap = 4,638 km^2

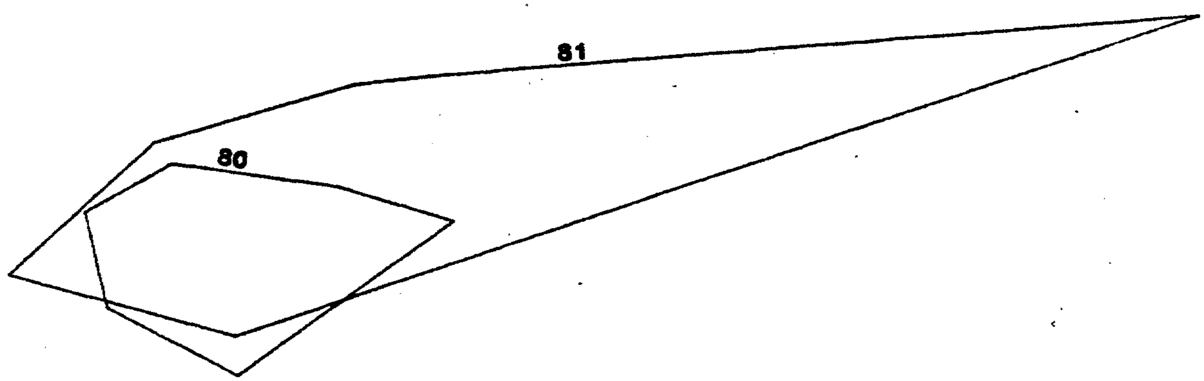




#623

Yr.	Home Range Size (km^2)	# Location
78	305	5
80	17,057	10
81	54,451	6

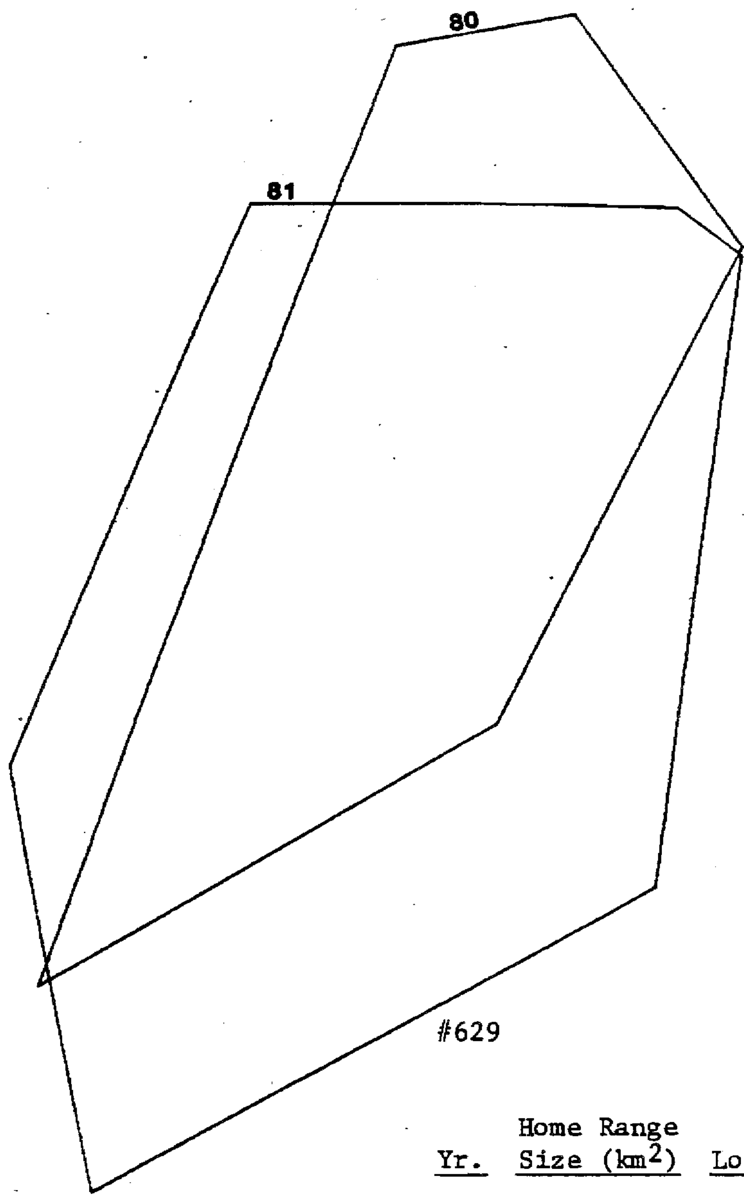
Area of 78-80 overlap = --
Area of 80-81 overlap = 5,894 km^2



#628

Yr.	Home Range Size (km^2)	# Location
80	8,093	16
81	25,668	15

Area of 80-81 overlap = 7,238 km^2



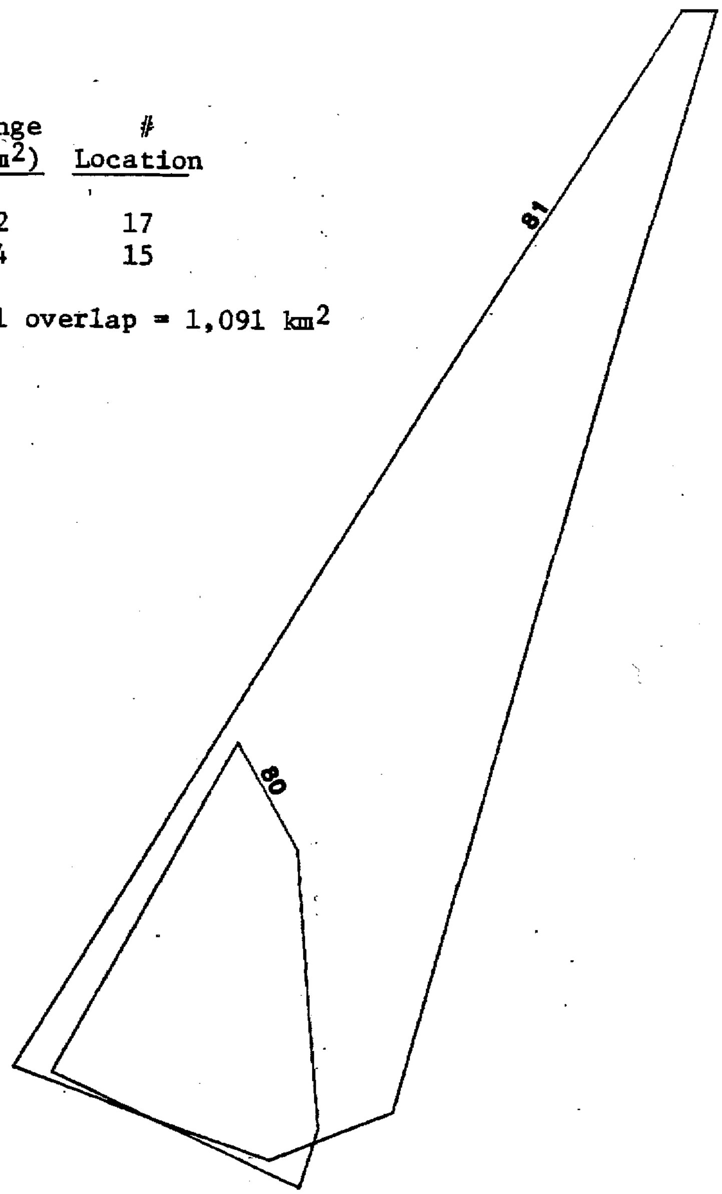
Yr.	Home Range Size (km^2)	# Location
80	4,209	16
81	6,940	14

Area of 80-81 overlap = 3,493 km^2

#630

Yr.	Home Range Size (km^2)	# Location
80	1,122	17
81	4,244	15

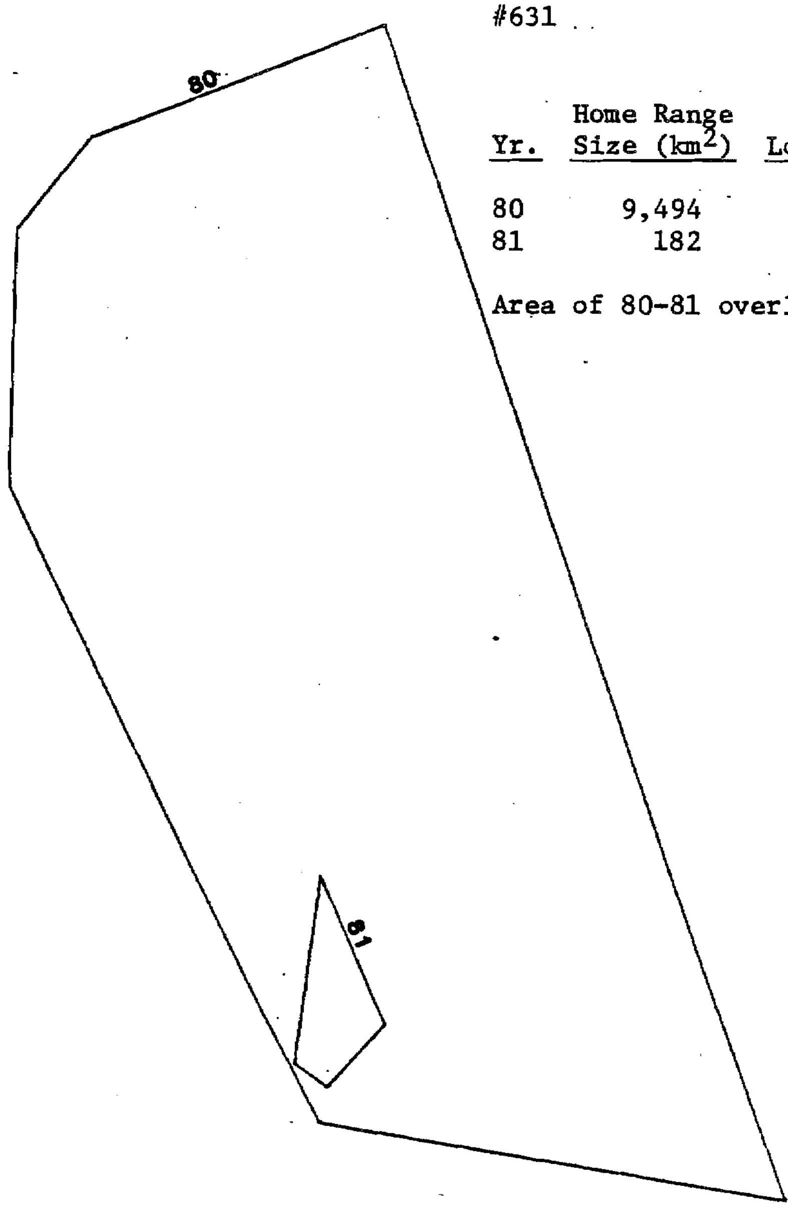
Area of 80-81 overlap = 1,091 km^2

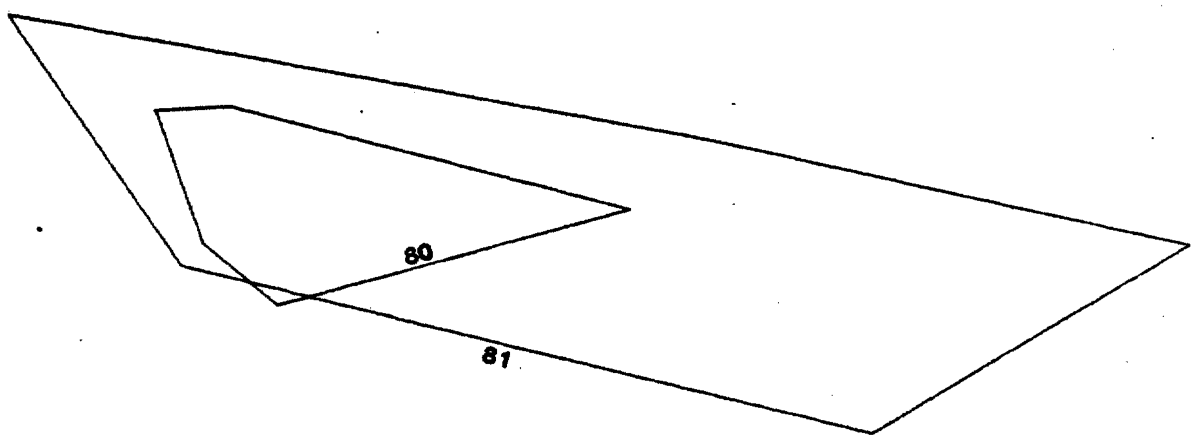


#631

Yr.	Home Range Size (km^2)	# Location
80	9,494	15
81	182	7

Area of 80-81 overlap = 181 km^2

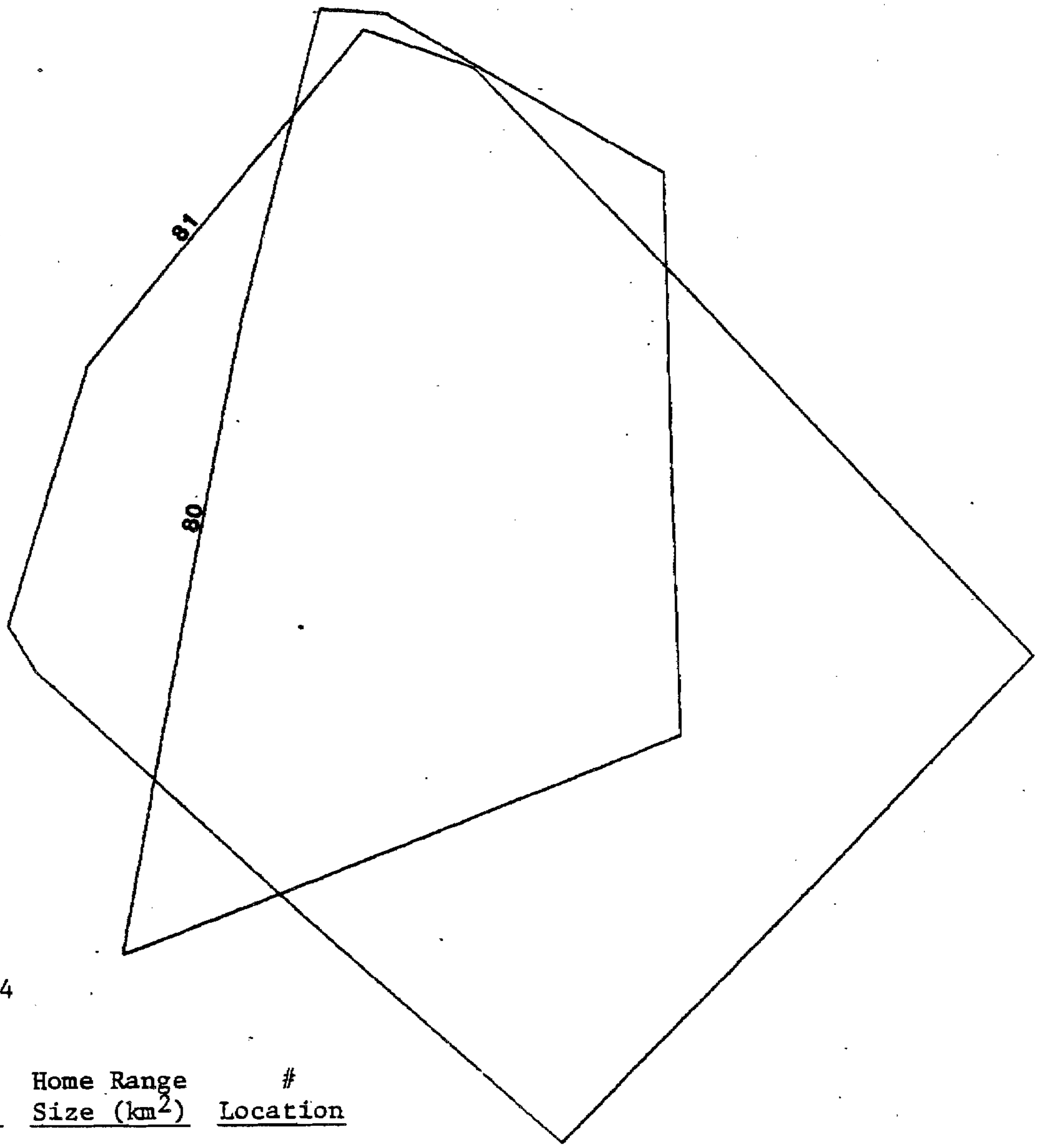




#635

Yr.	Home Range Size (km^2)	# Location
80	6,205	19
81	29,244	14

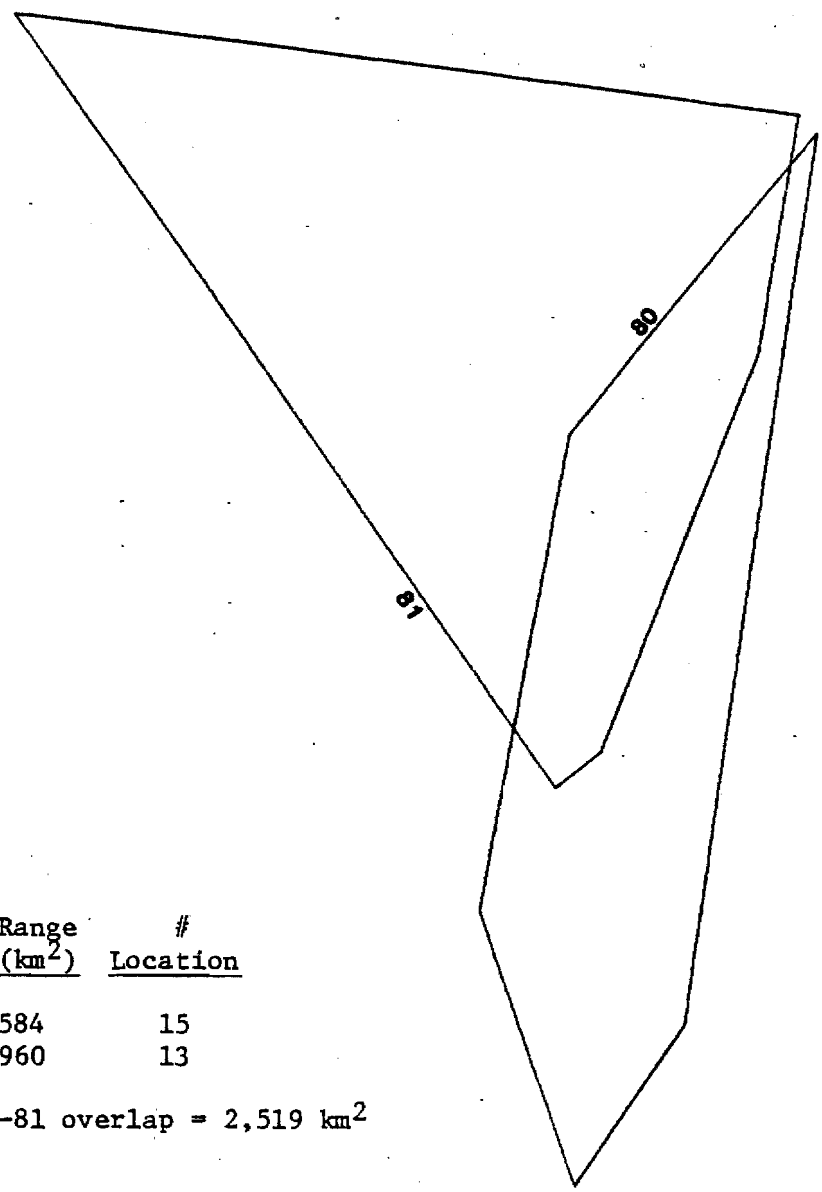
Area of 80-81 overlap = 6,143 km^2



#634

Yr.	Home Range Size (km^2)	# Location
80	8,912	15
81	15,894	15

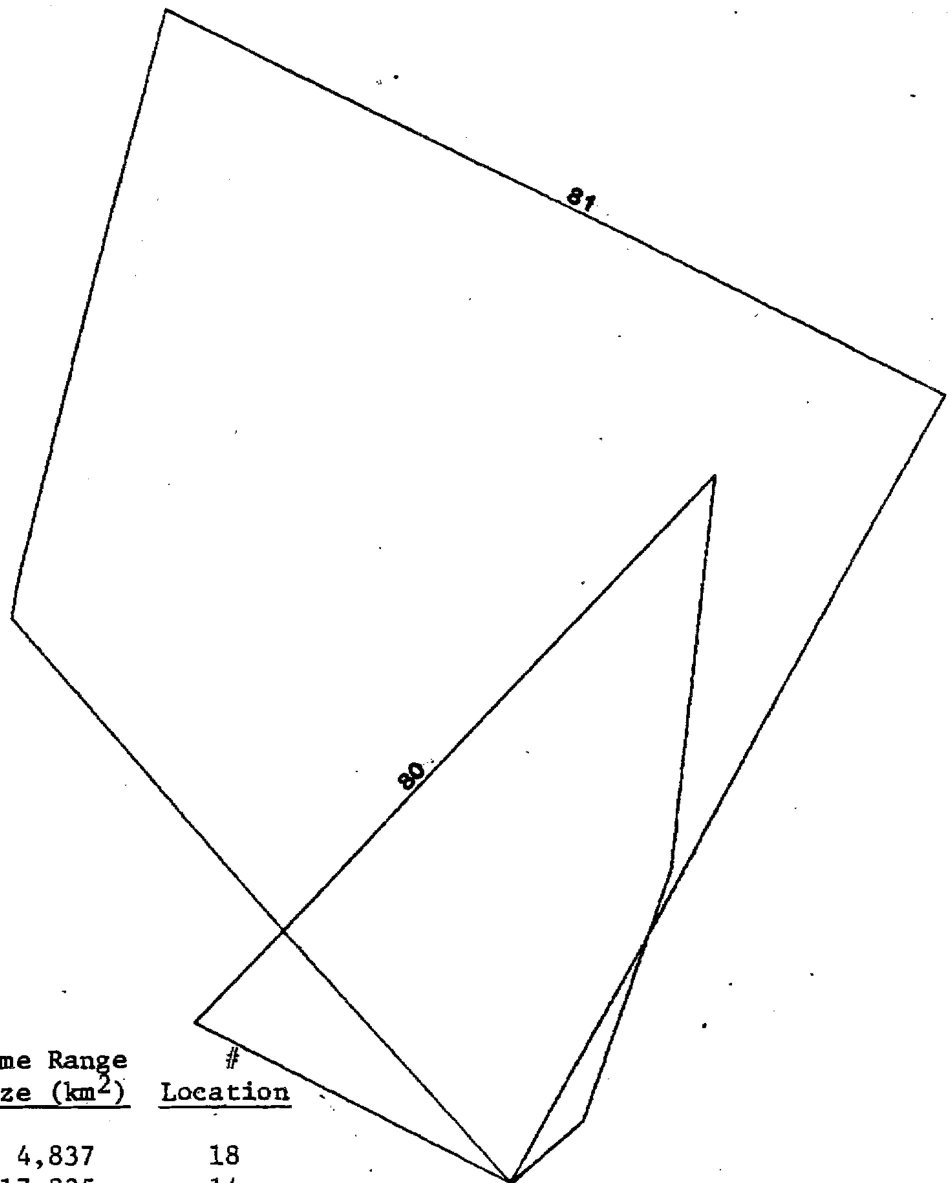
Area of 80-81 overlap = 8,243 km^2



#636

Yr.	Home Range Size (km^2)	# Location
80	6,584	15
81	11,960	13

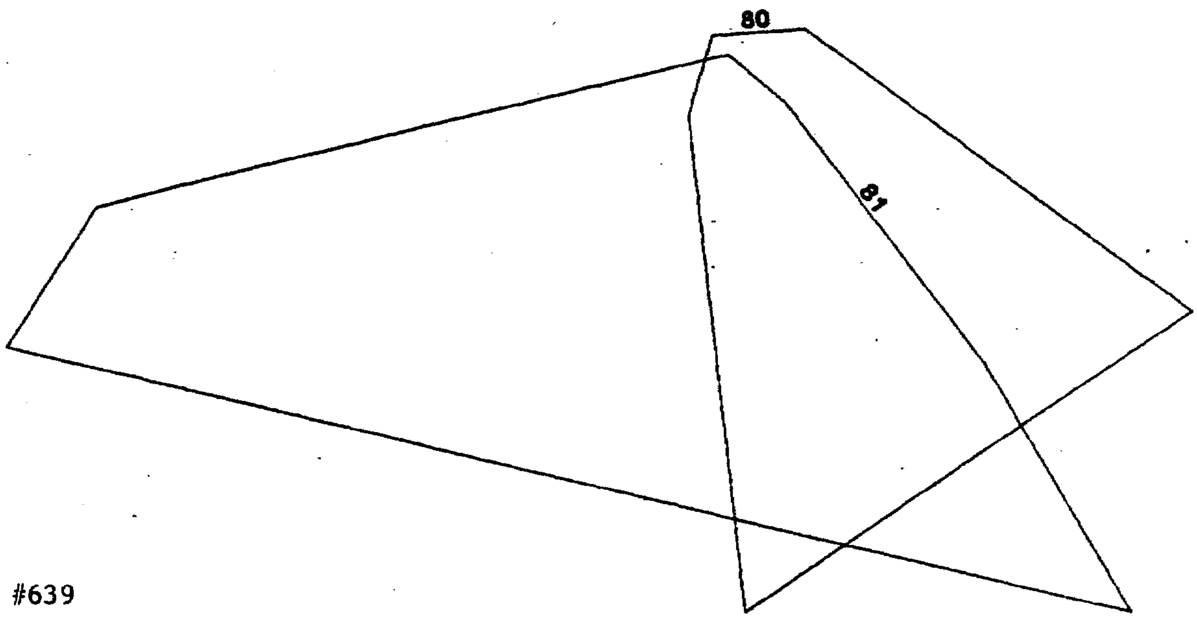
Area of 80-81 overlap = 2,519 km^2



#637

Yr.	Home Range Size (km^2)	# Location
80	4,837	18
81	17,835	14

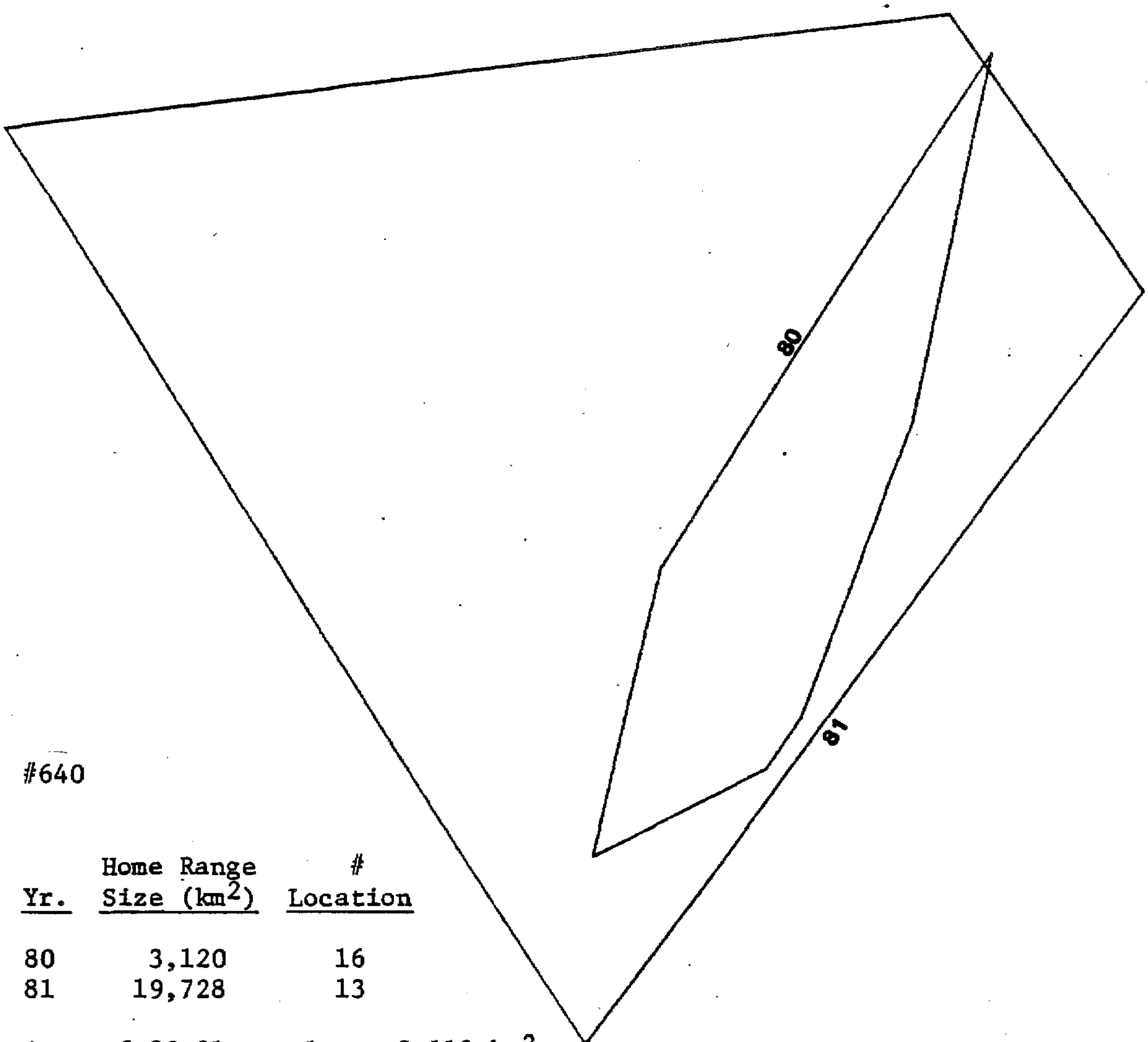
Area of 80-81 overlap = 4,018 km^2



#639

Yr.	Home Range Size (km^2)	# Location
80	20,471	18
81	40,773	13

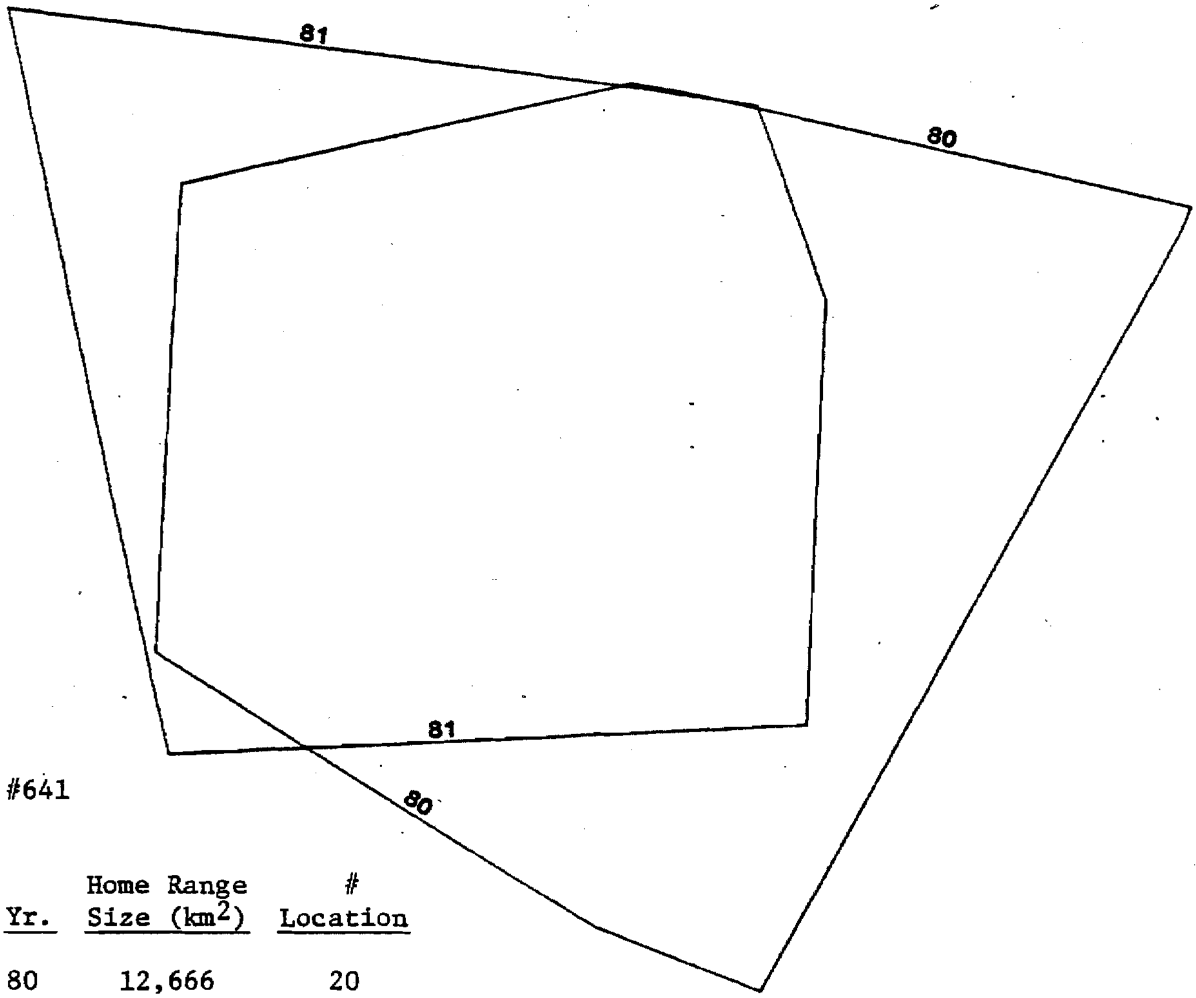
Area of 80-81 overlap = 11,888 km^2



#640

Yr.	Home Range Size (km^2)	# Location
80	3,120	16
81	19,728	13

Area of 80-81 overlap = 3,118 km^2



#641

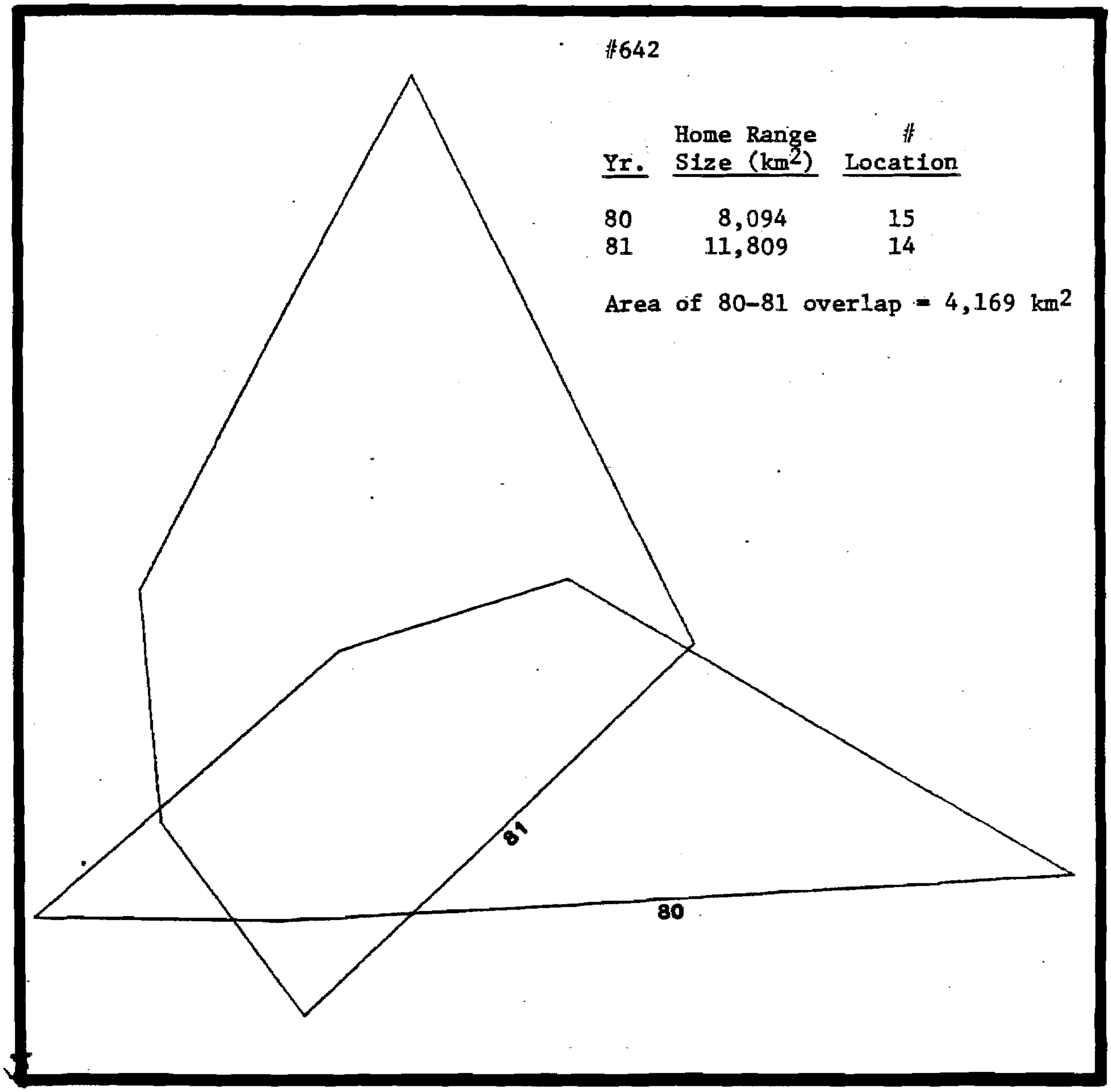
Yr.	Home Range Size (km^2)	# Location
80	12,666	20
81	10,106	14

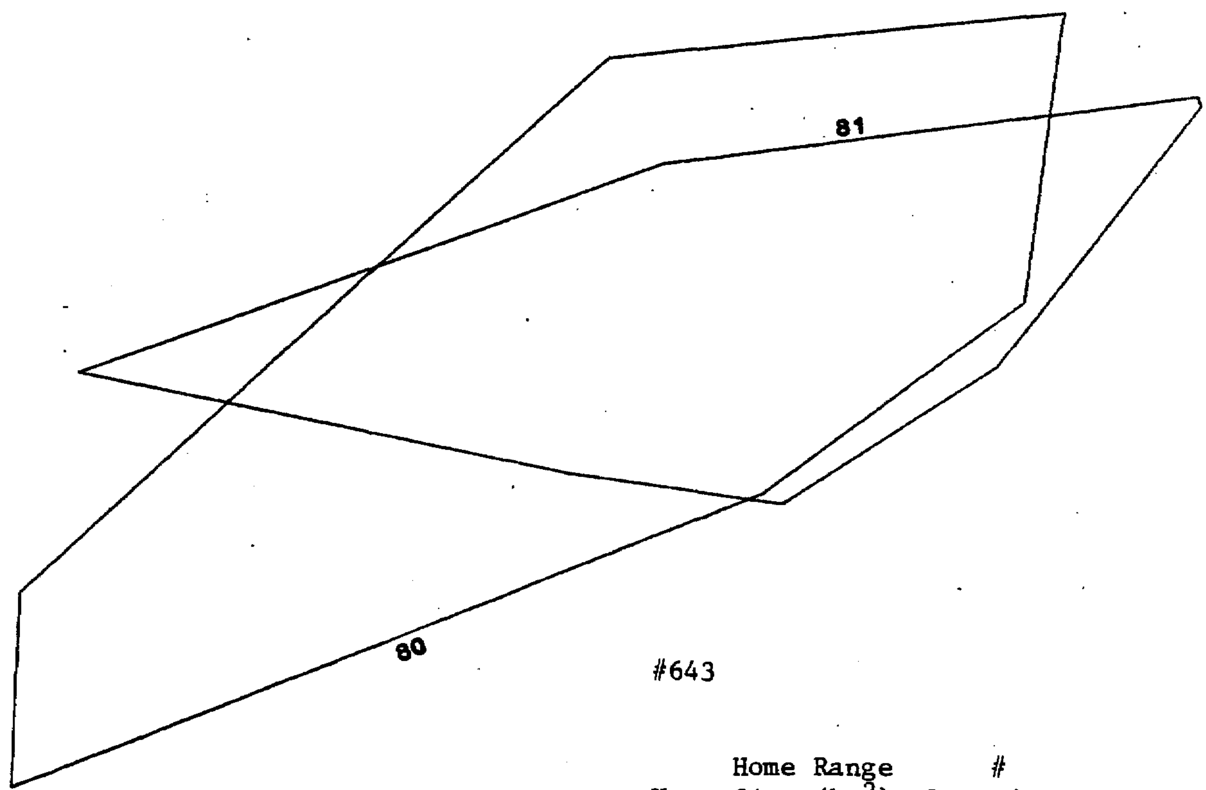
Area of 80-81 overlap = 7,988 km^2

#642

Yr.	Home Range Size (km^2)	# Location
80	8,094	15
81	11,809	14

Area of 80-81 overlap = 4,169 km^2





#643

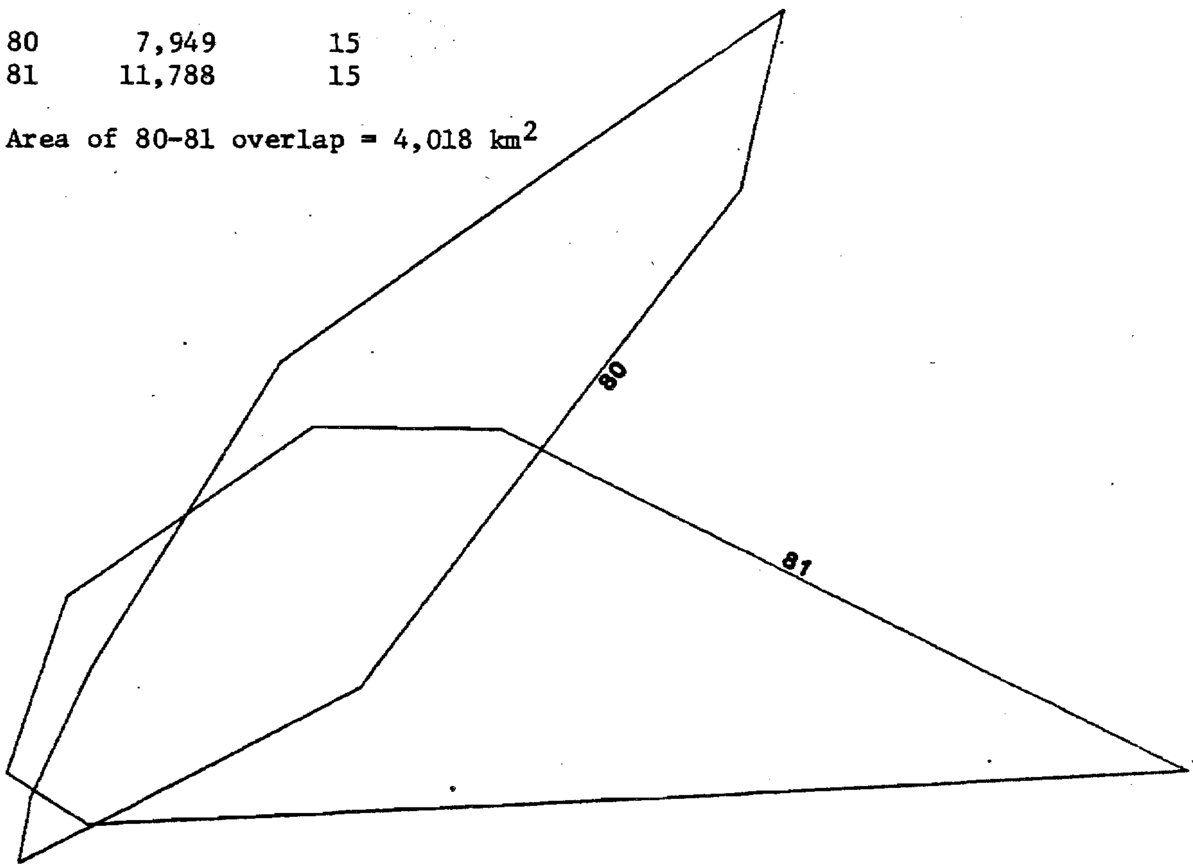
Yr.	Home Range Size (km^2)	# Location
80	10,030	19
81	5,979	12

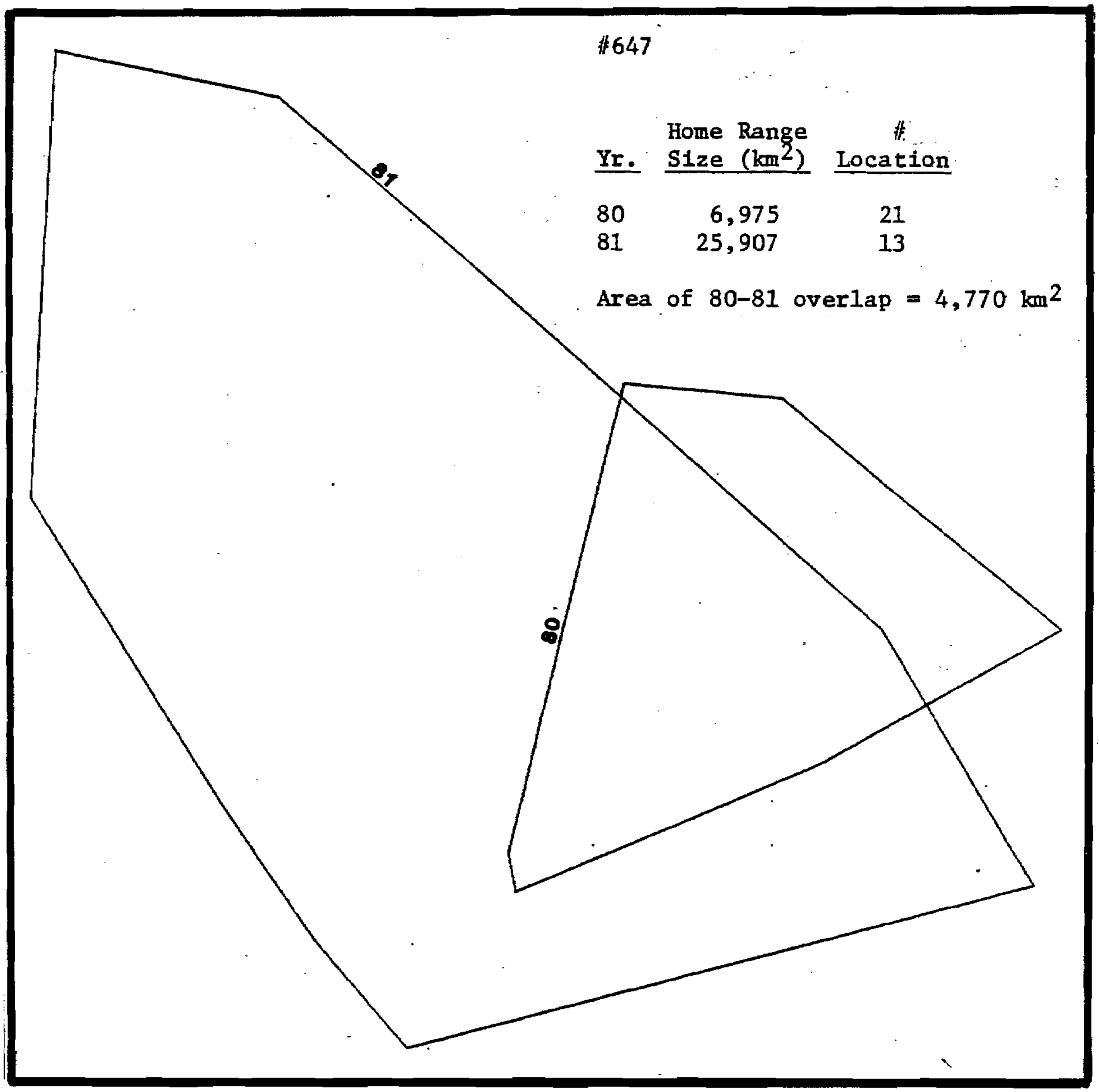
Area of 80-81 overlap = 4,960 km^2

#645

Yr.	Home Range Size (km^2)	# Location
80	7,949	15
81	11,788	15

Area of 80-81 overlap = 4,018 km^2

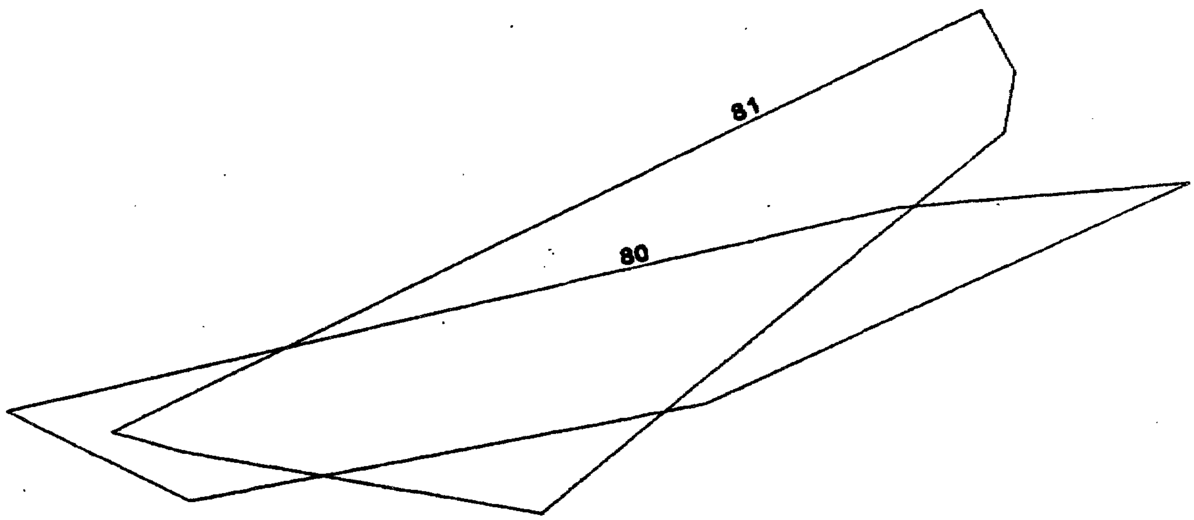



#647
Yr. Home Range Size (km2) # Location
80 6,975 21
81 25,907 13
Area of 80-81 overlap = 4,770 km2
81
80

#648

Yr.	Home Range Size (km^2)	# Location
80	12,930	17
81	16,522	15

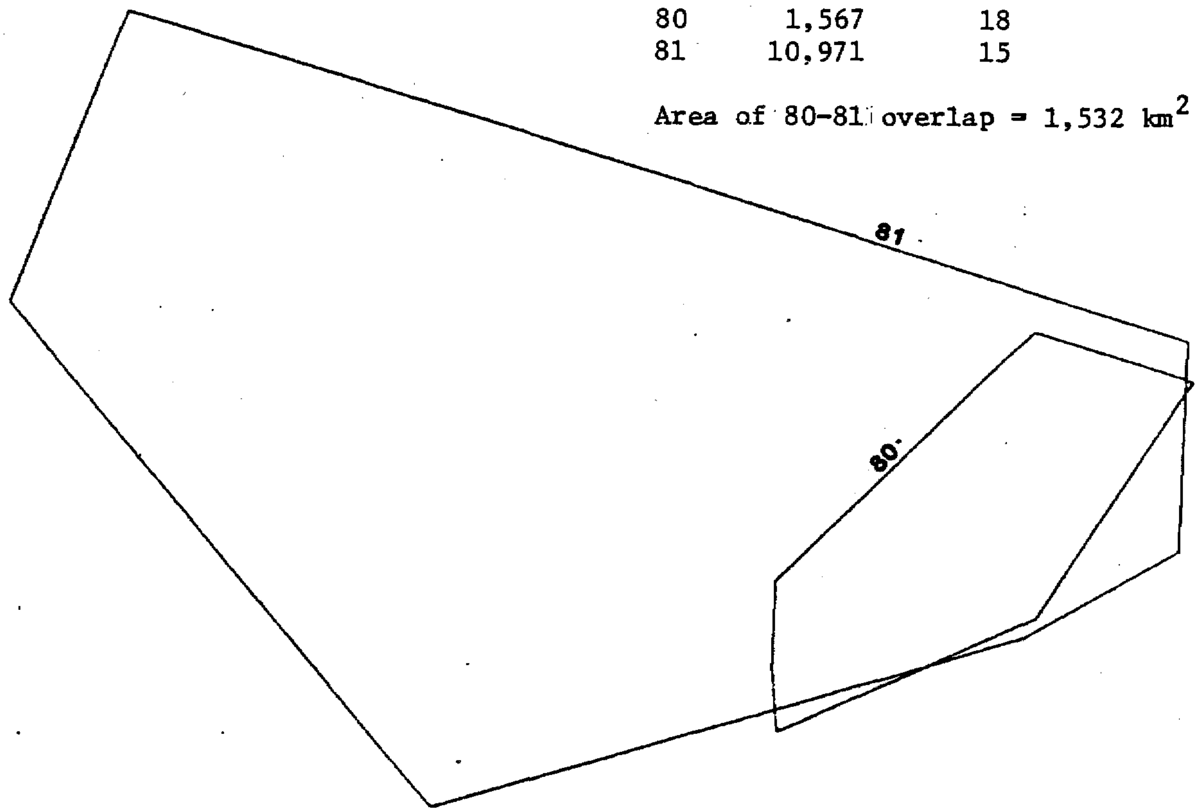
Area of 80-81 overlap = 8,608 km^2



#649

Yr.	Home Range Size (km^2)	# Location
80	1,567	18
81	10,971	15

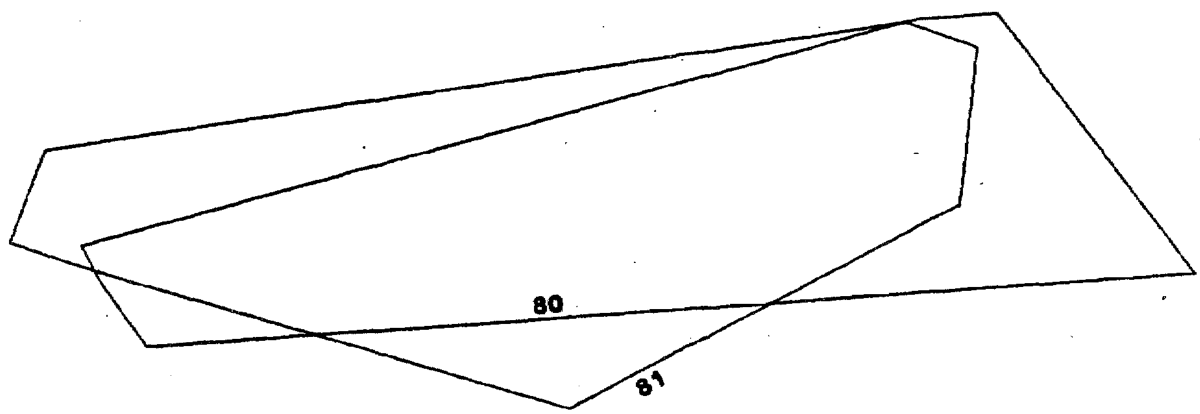
Area of 80-81 overlap = 1,532 km^2



#650

Yr.	Home Range Size (km^2)	# Location
80	37,010	21
81	39,954	15

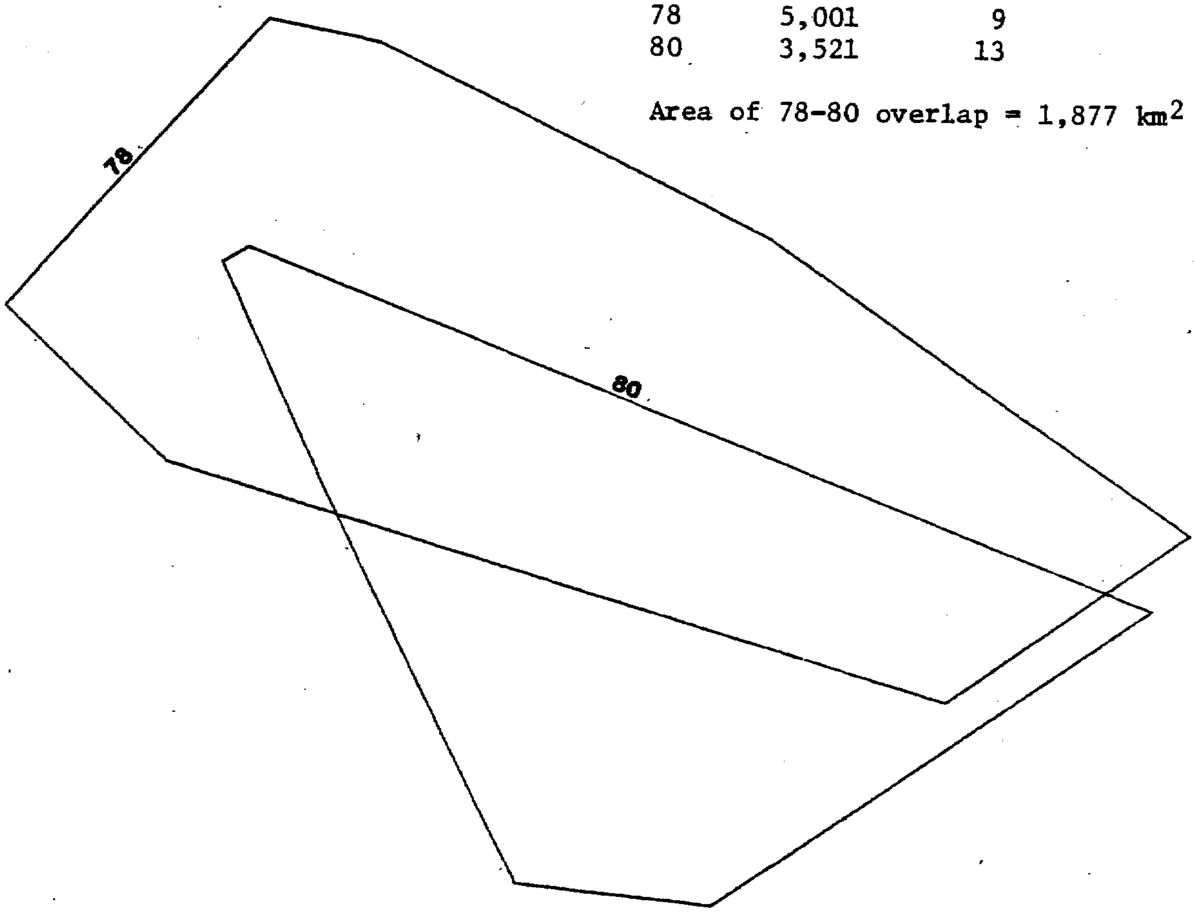
Area of 80-81 overlap = 27,704 km^2



#651

Yr.	Home Range Size (km^2)	# Location
78	5,001	9
80	3,521	13

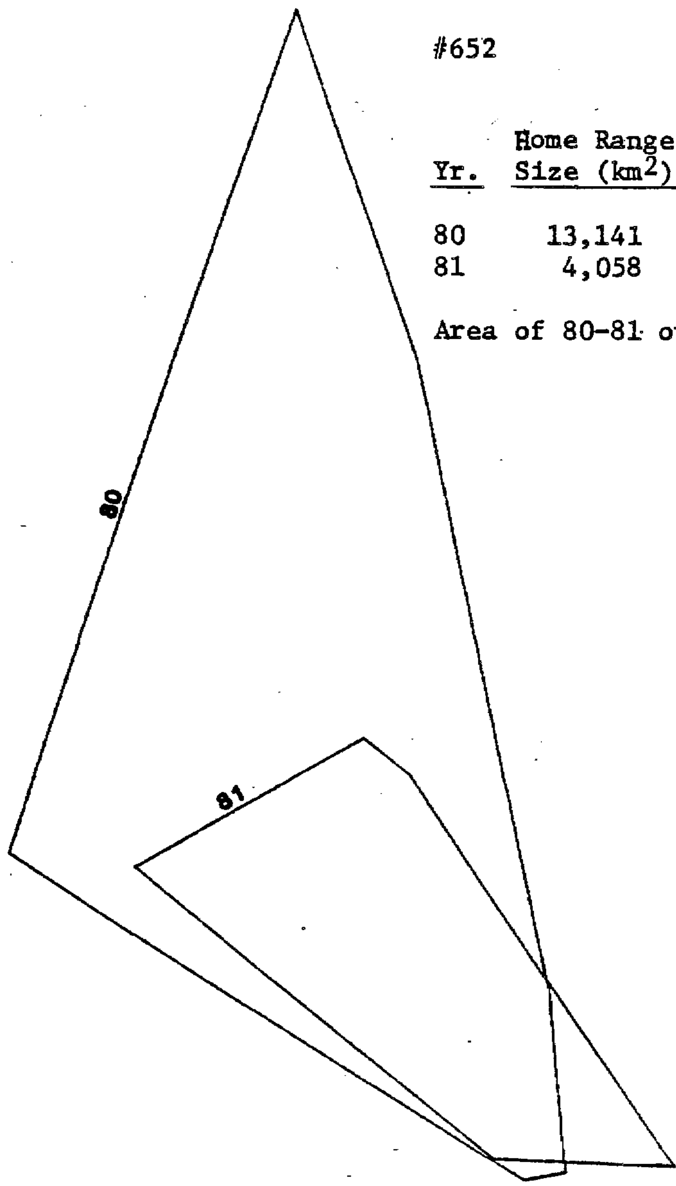
Area of 78-80 overlap = 1,877 km^2

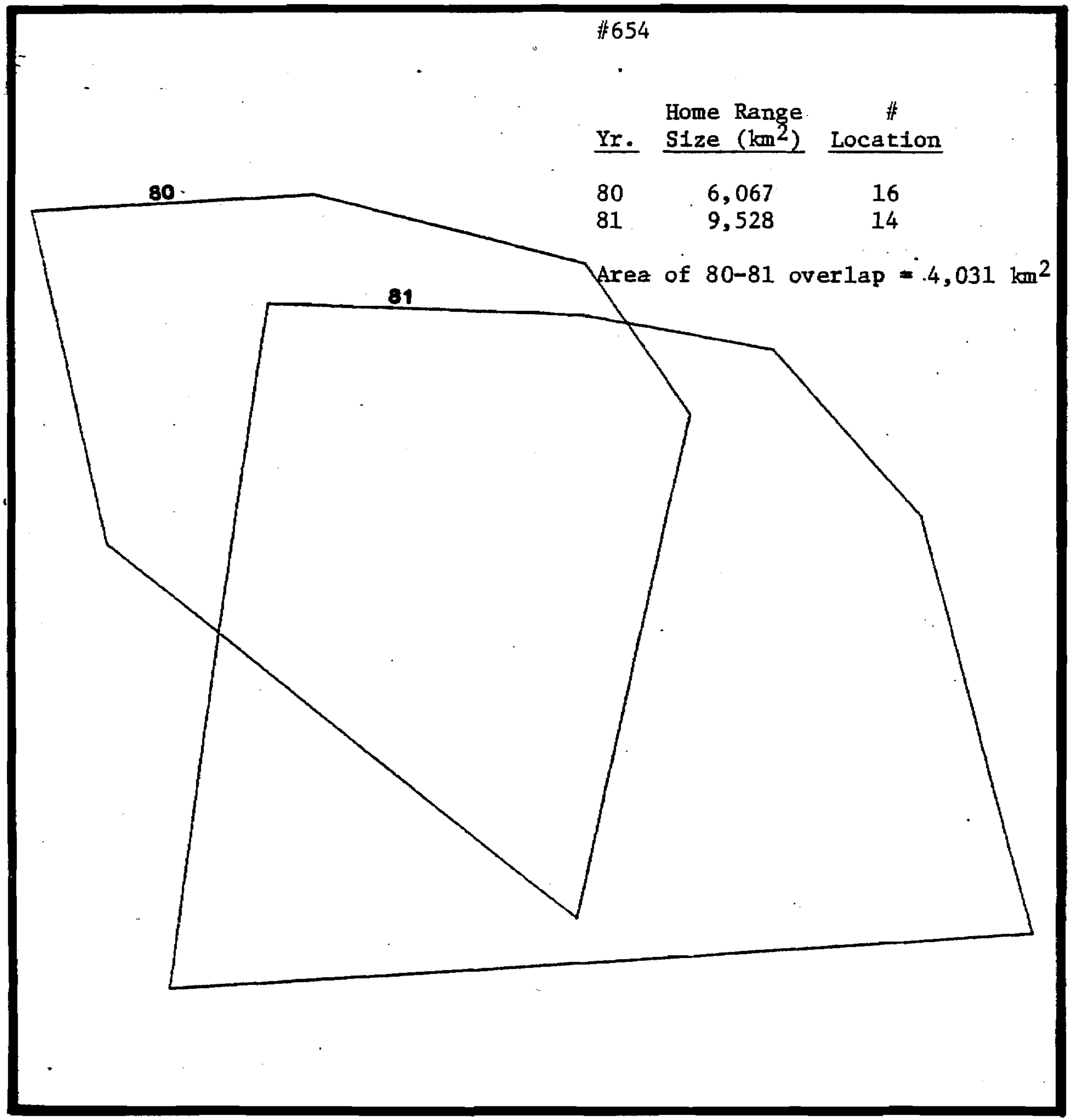


#652

Yr.	Home Range Size (km^2)	# Location
80	13,141	20
81	4,058	13

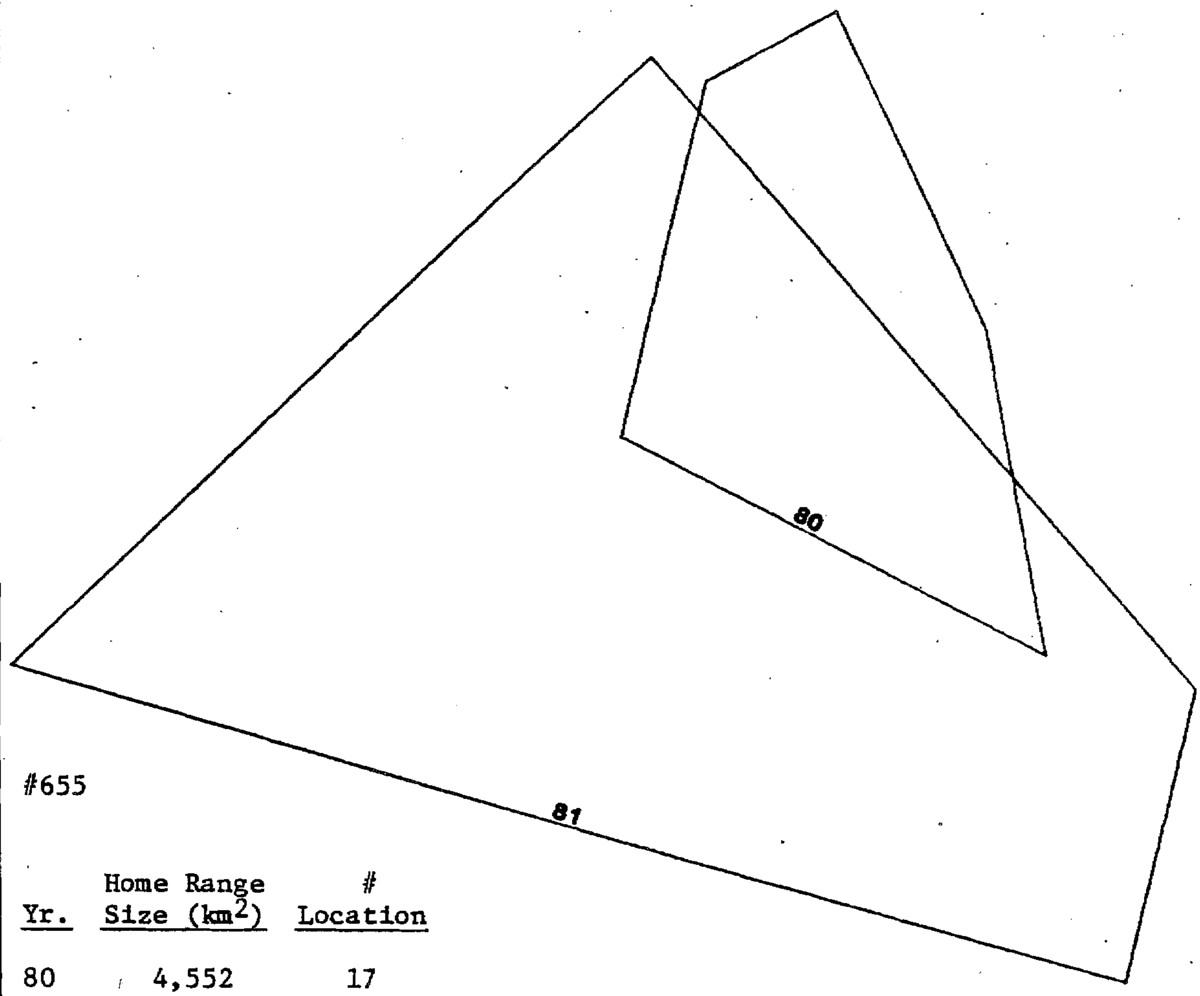
Area of 80-81 overlap = 3,633 km^2





Yr.	Home Range Size (km^2)	# Location
80	6,067	16
81	9,528	14

Area of 80-81 overlap = 4,031 km^2



#655

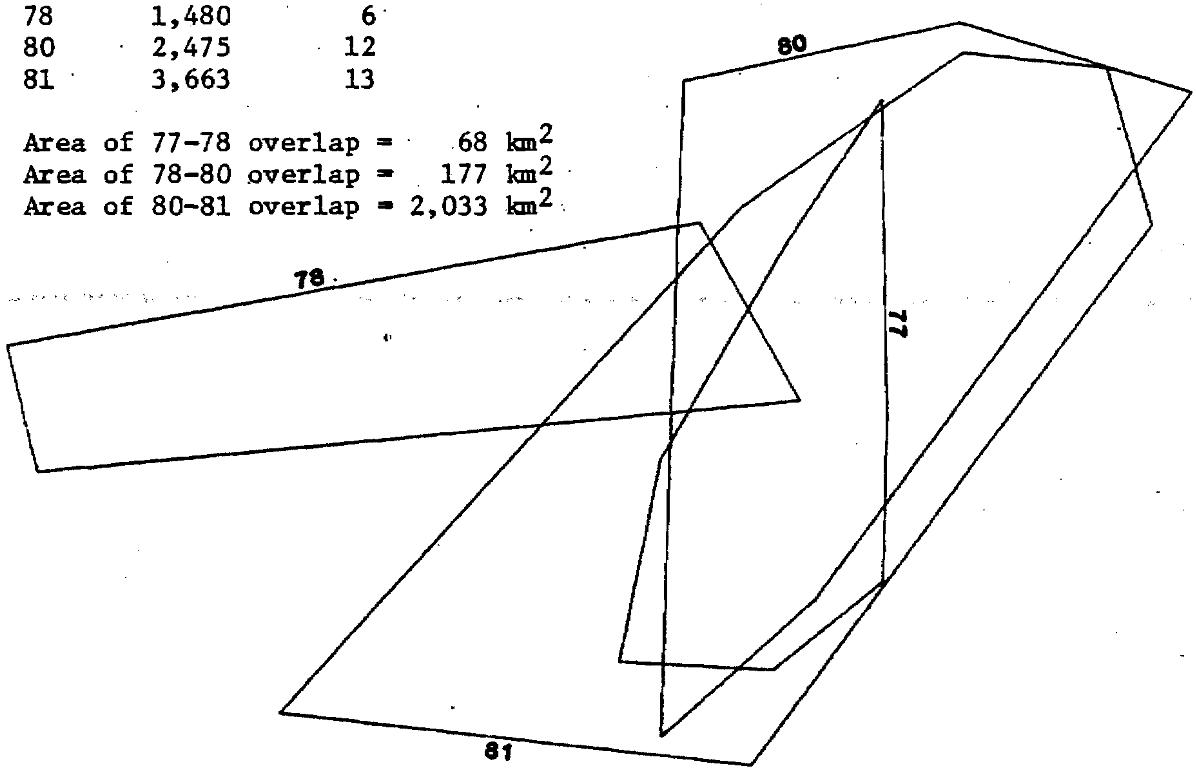
Yr.	Home Range Size (km^2)	# Location
80	4,552	17
81	16,585	14

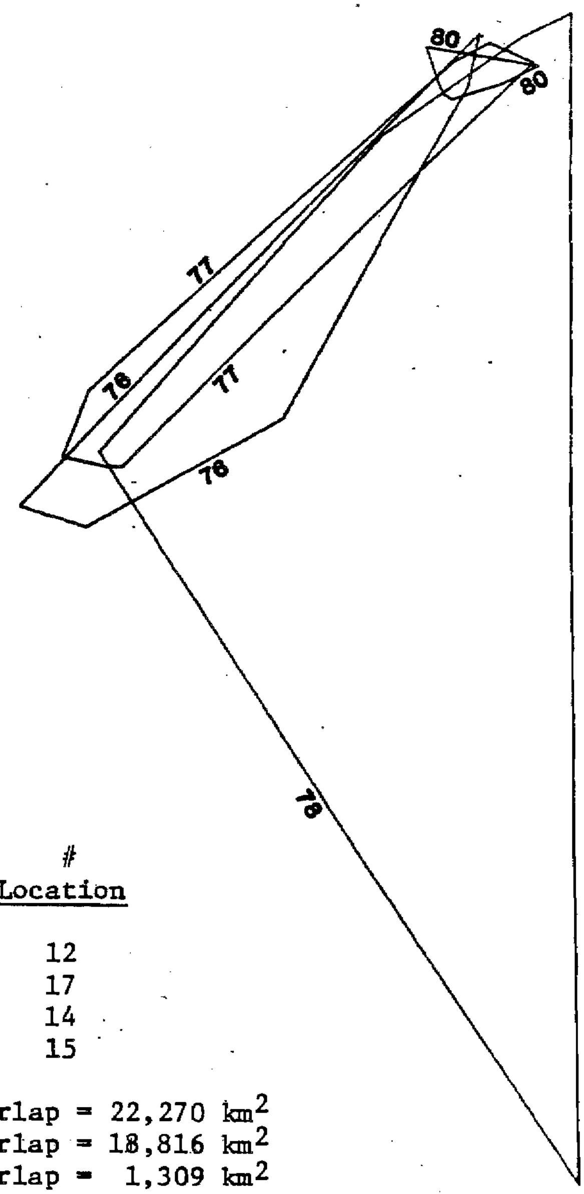
Area of 80-81 overlap = 3,031 km^2

#662

Yr.	Home Range Size (km^2)	# Location
77	1,108	9
78	1,480	6
80	2,475	12
81	3,663	13

Area of 77-78 overlap = 68 km^2
Area of 78-80 overlap = 177 km^2
Area of 80-81 overlap = 2,033 km^2

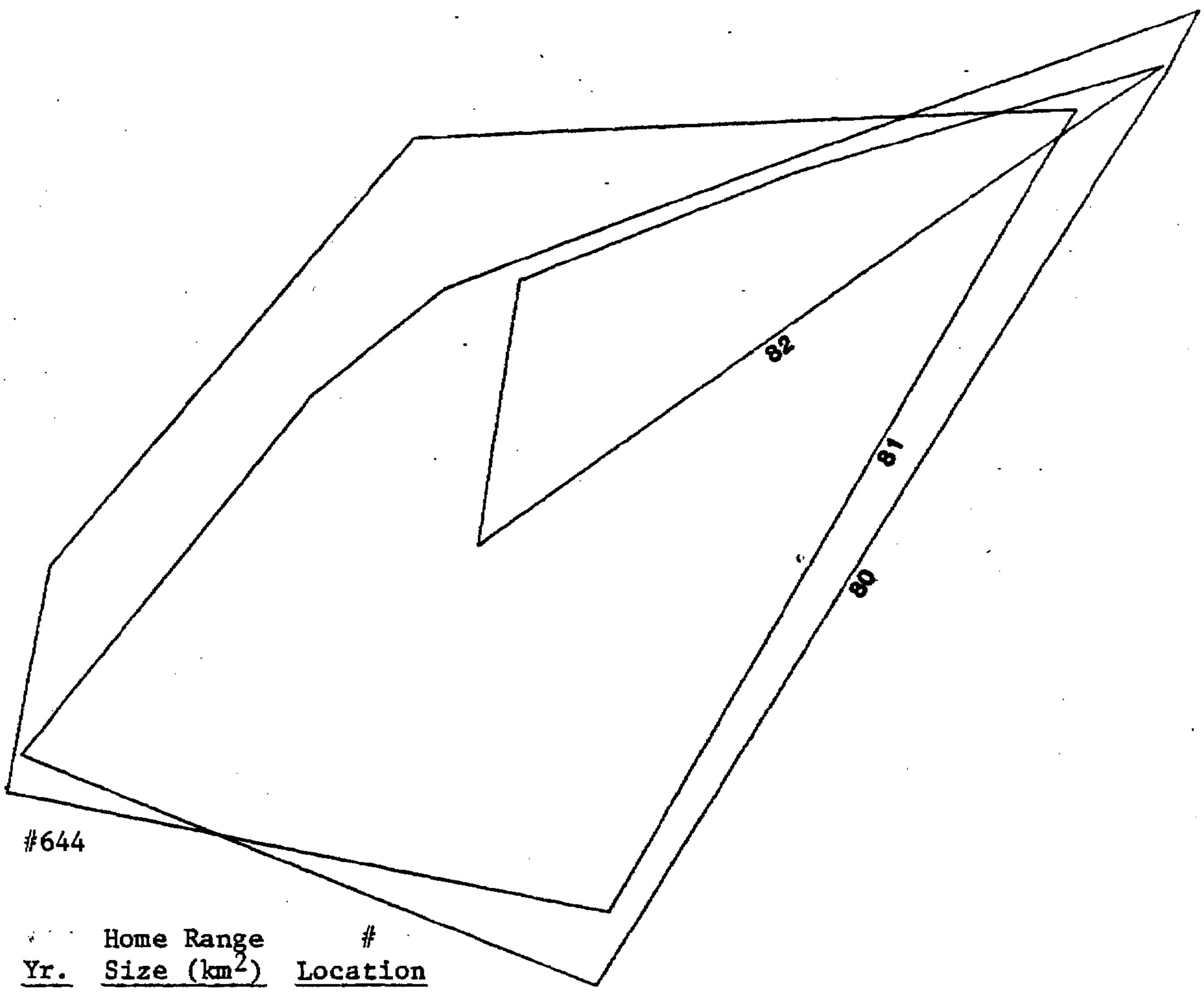




#664

Yr.	Home Range Size (km^2)	# Location
76	42,256	12
77	31,473	17
78	235,778	14
80	2,531	15

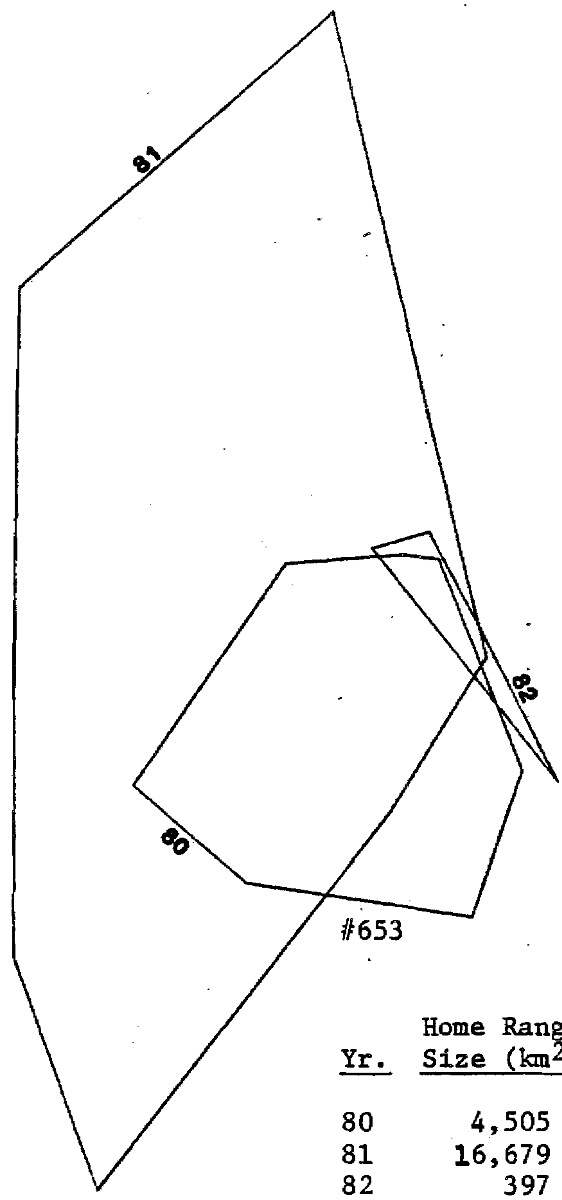
Area of 76-77 overlap = 22,270 km^2
Area of 77-78 overlap = 18,816 km^2
Area of 78-80 overlap = 1,309 km^2



#644

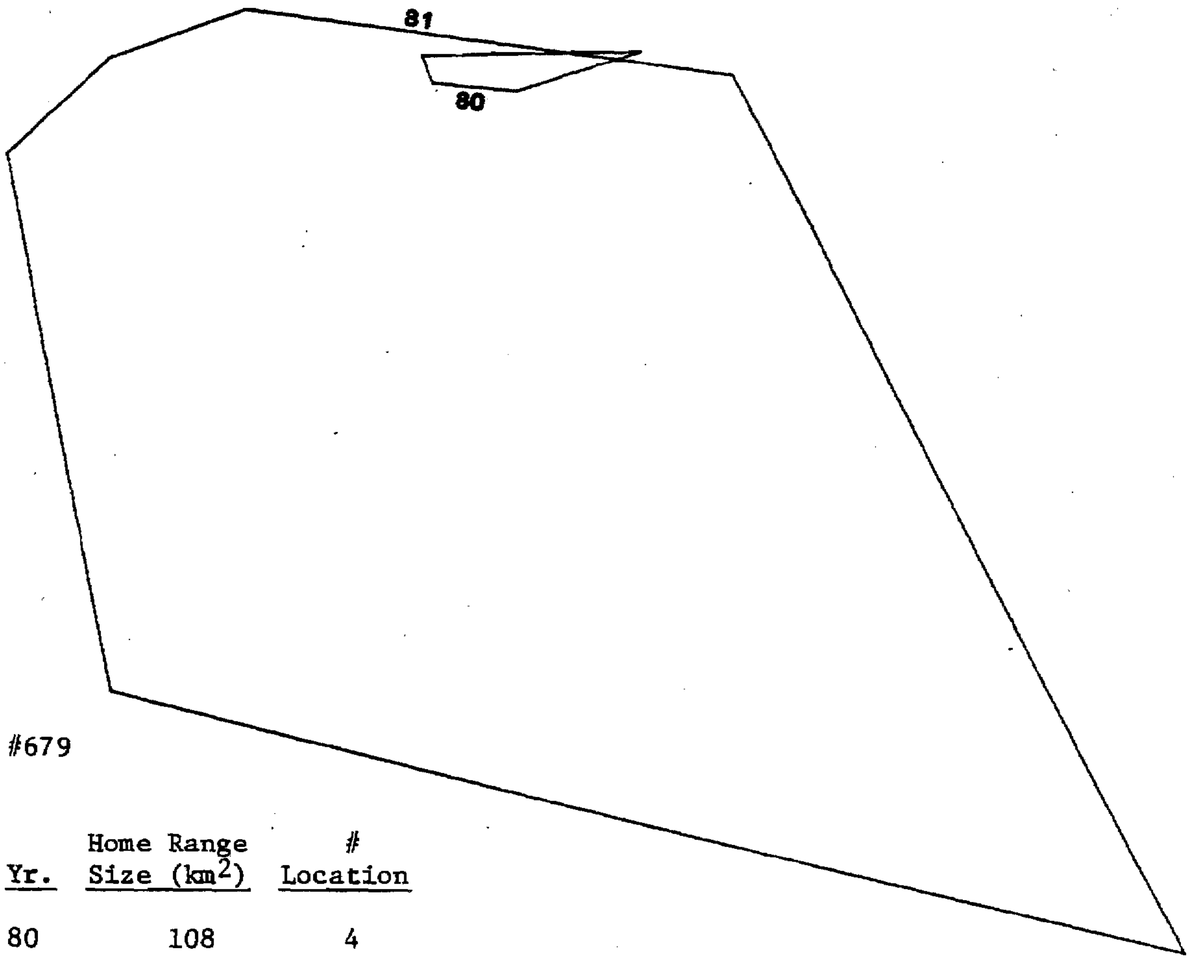
Yr.	Home Range Size (km^2)	# Location
80	11,186	15
81	12,018	15
82	1,997	4

Area of 80–81 overlap = 9,616 km^2
Area of 81–82 overlap = 1,940 km^2



Yr.	Home Range Size (km^2)	# Location
80	4,505	18
81	16,679	14
82	397	4

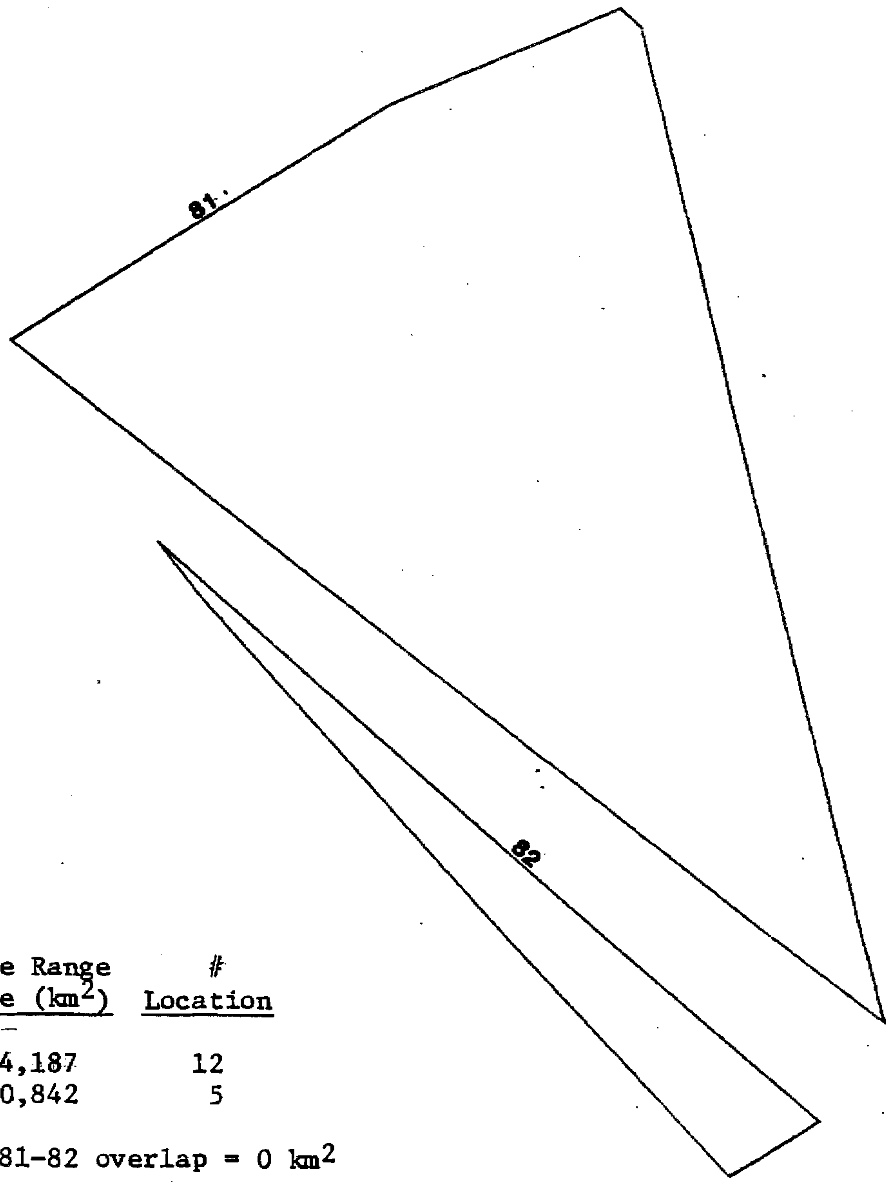
Area of 80-81 overlap = 3,413 km^2
Area of 81-82 overlap = 294 km^2



#679

Yr.	Home Range Size (km^2)	# Location
80	108	4
81	13,204	13

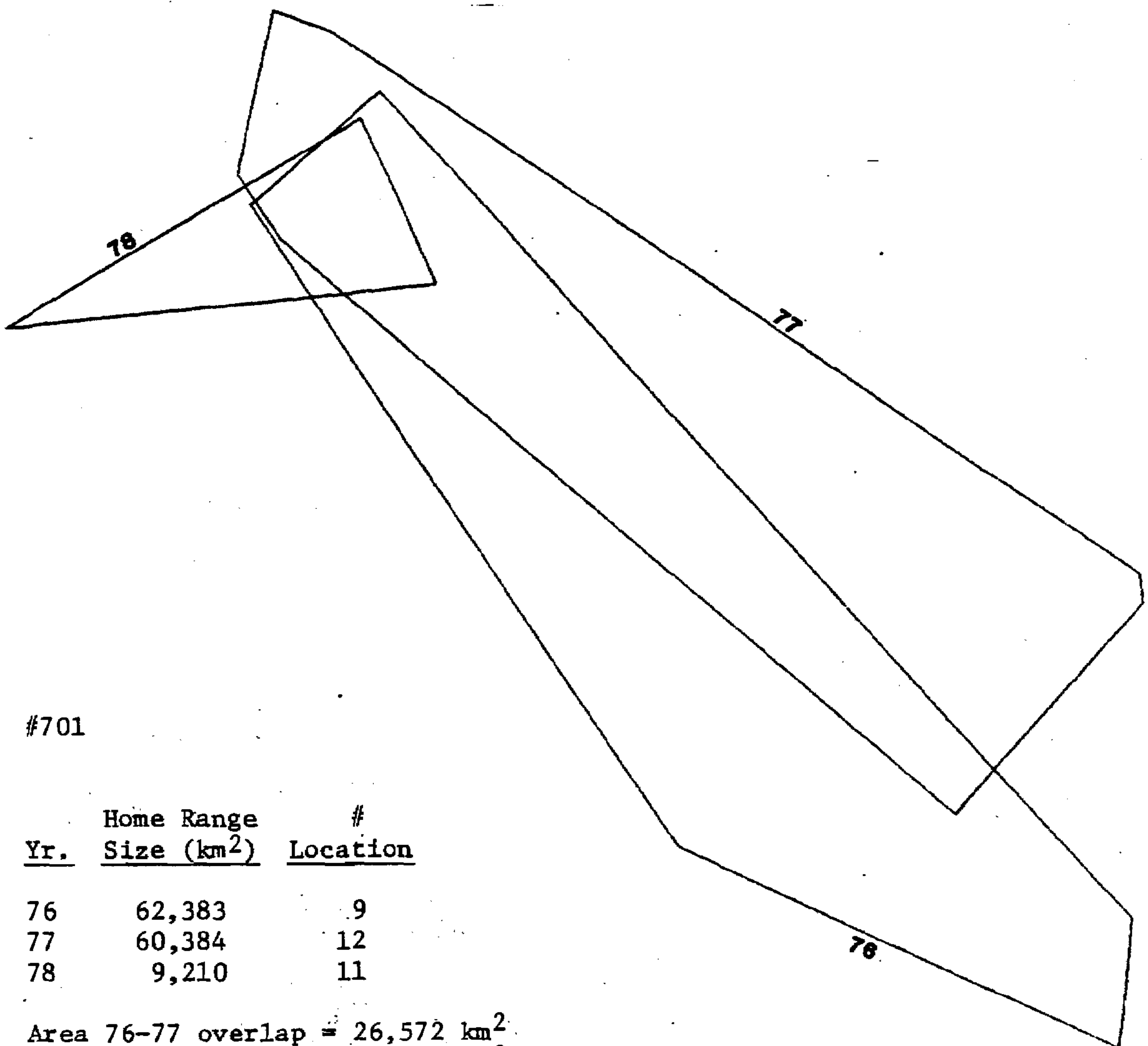
Area of 80-81 overlap = 102 km^2



#685

Yr.	Home Range Size (km^2)	# Location
81	164,187	12
82	20,842	5

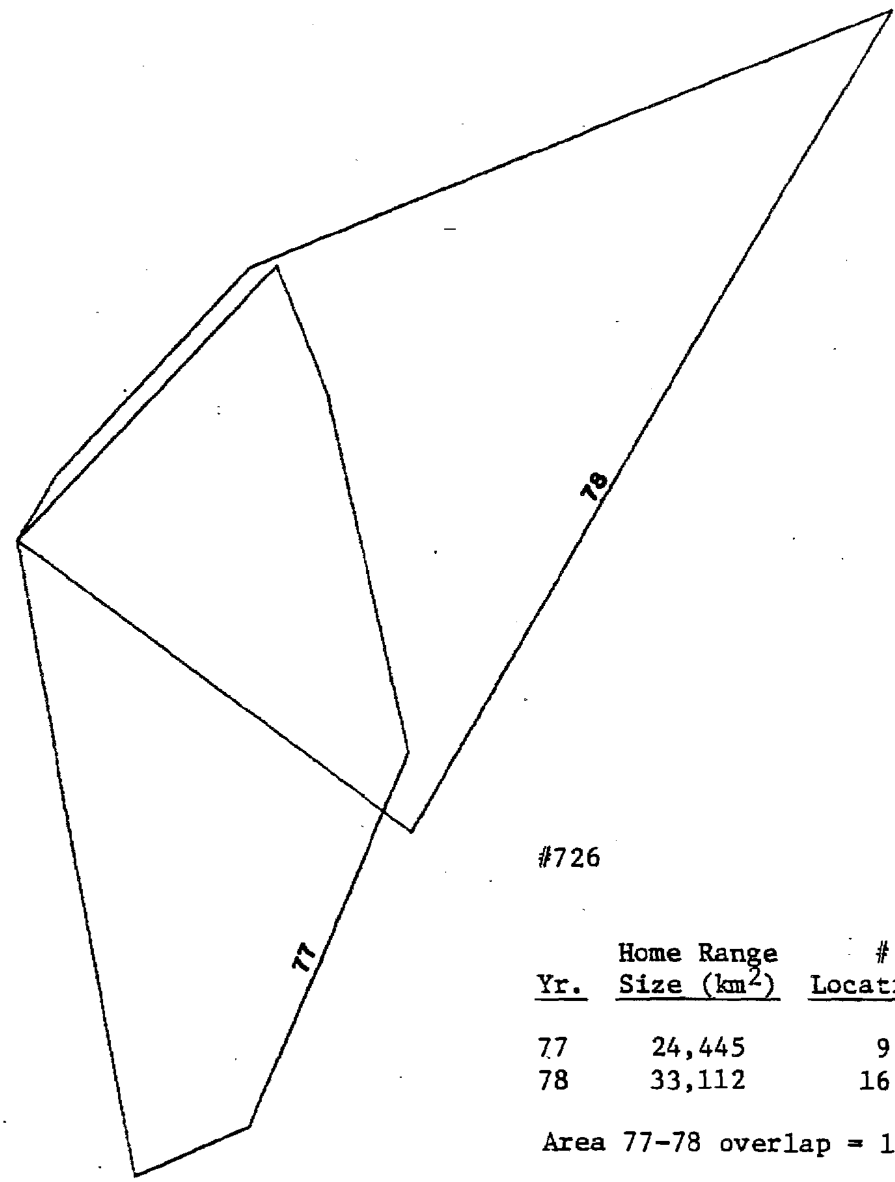
Area of 81-82 overlap = 0 km^2



#701

Yr.	Home Range Size (km^2)	# Location
76	62,383	9
77	60,384	12
78	9,210	11

Area 76-77 overlap = 26,572 km^2
Area 77-78 overlap = 4,534 km^2



#726

Yr.	Home Range Size (km^2)	# Location
77	24,445	9
78	33,112	16

Area 77-78 overlap = 11,191 km^2