# ECOLOGICAL INVESTIGATION OF DALL SHEEP (*OVIS DALLI DALLI*, NELSON) AND THEIR HABITAT ON SHEEP MOUNTAIN, KLUANE NATIONAL PARK, YUKON TERRITORY, CANADA

by

MANFRED HOEFS
B.Sc. Hons., University of Manitoba, 1966
M.Sc., University of Manitoba, 1968

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

in the Department
of
Zoology

We accept this thesis as conforming to the
required standard

THE UNIVERSITY OF BRITISH COLUMBIA

© Manfred Hoefs, 1976

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the Head of my Department or by his representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Zoology

The University of British Columbia
2075 Wesbrook Place
Vancouver, Canada
V6T 1W5

Date December 19/1975

# ABSTRACT

An investigation was carried out on a population of Dall sheep and their range in southwestern Yukon from 1969 to 1973. The results are presented in two separate, distinct portions.

Part I deals with the geography, geology, glaciology, soils and climate of the study area. It describes in detail the vegetation of the three biogeoclimatic zones and breaks it down into 32 plant associations, grouped into 23 alliances and 17 orders, following the Braun-Blanquet methods of phytosociology.

Part II covers the sheep population, which has during the study period remained fairly constant at a level of about 200 adults. Detailed population statistics are presented on such parameters as: natality and mortality rates, productivity, sex ratios, densities and historical information about this herd is reviewed. The range use pattern and the forages selected by this population are discussed on a monthly basis. The response of sheep to some environmental variables as temperature, wind, snow depths is analysed. Based on a life table and classified counts a model of the population structure is presented which is useful for management questions such as calculating "allowable" harvests.

TABLE OF CONTENTS

Page

LIST OF TABLES . . . . . ix

LIST OF FIGURES . . . . . xv

Part I

INTRODUCTION . . . . . 1

Location of Study Area . . . . . 2

Physiography and Geology . . . . . 4

Glaciology and Soils . . . . . 12

Weather and Climate . . . . . 20

Regional Climate . . . . . 20

Local Modifications . . . . . 23

Previous Botanical Work in the Kluane Area . . . . . 27

Methods and Materials . . . . . 33

Analyses of Vegetation . . . . . 34

Analyses of Environmental Factors . . . . . 35

Vegetation Tables . . . . . 37

Vegetation Map . . . . . 39

CLASSIFICATION OF VEGETATION ON SHEEP MOUNTAIN . . . . . 41

The boreal (montane) biogeoclimatic zone . . . . . 42

The subalpine willow-birch biogeoclimatic zone . . . . . 80

The alpine tundra biogeoclimatic zone . . . . . 94

DISCUSSION . . . . . 130

Page

SUGGESTIONS FOR FURTHER SYNECOLOGICAL WORK . . . . . 143

SUMMARY . . . . . 145

LITERATURE CITED . . . . . 149

APPENDIX . . . . . 157

Synthesis Tables of Orders and their Lower Units . . . . . 158

List of Vascular Plants . . . . . 175

List of Lichens . . . . . 185

List of Mosses and Hepaticae . . . . . 187

Standard Ecological Forms . . . . . 189

Condensed Table of Floristic Structure of Plant Associations and their Higher Units . . . . . 192

Vegetation Map of Sheep Mountain . . . . . (in pocket) V. 2

Part II

INTRODUCTION . . . . . 194

Methods and Materials . . . . . 196

Population Dynamics and Range Utilization . . . . . 197

Forage Utilization . . . . . 203

Direct Observations . . . . . 204

Rumen Sample Analyses . . . . . 205

Snow Conditions . . . . . 206

Temperatures . . . . . 207

Wind . . . . . 208

Plant Phenology . . . . . 209

Page

RESULTS AND DISCUSSIONS . . . . . 212

Numbers . . . . . 212

Range of the Population . . . . . 216

Migration Pattern . . . . . 217

Population Characteristics . . . . . 222

Densities . . . . . 222

Sex Ratios . . . . . 225

Breeding Age and Longevity . . . . . 228

Reproductive Performance . . . . . 232

Pregnancy Rate; Twinning . . . . . 232

Lamb to Ewe Ratios; Mortality During the First Year of Life . . . . . 233

Yearling to Ewe Ratios; Mortality During the Second Year of Life . . . . . 244

Productivity of the Population . . . . . 248

Composition of Nursery Bands . . . . . 250

Structure of the Ram Segment of the Population . . . . . 251

Adult Mortalities; Mortality Factors . . . . . 254

Man-inflicted Mortalities . . . . . 257

Accidents . . . . . 258

Predation . . . . . 261

Coyote . . . . . 261

Eagles . . . . . 262

Wolves . . . . . 264

Wolverine . . . . . 267

Page

Lynx . . . . . 267

Cougar . . . . . 268

Grizzly Bear, Black Bear, Fox, Raven, and Magpie . . . . 269

Dispersal . . . . . 271

Diseases, Parasites, Toothwear . . . . . 273

Weather . . . . . 278

Competition . . . . . 280

Life Table . . . . . 282

Historical Review of the Population Trend in this Herd . . . . . 290

RESPONSE TO ENVIRONMENTAL FACTORS . . . . . 297

Plant Phenology . . . . . 297

Dates of First Flowering . . . . . 297

Rates of Growth and Drying-up of Important Winter Range Forage Plants . . . . . 299

The Altitudinal Advance of Plant Development . . . . . 302

Response to Snow Conditions . . . . . 304

Response to Temperature . . . . . 312

Response to Wind . . . . . 319

Vertical Migration of Sheep Population . . . . . 328

Diurnal Feeding Rhythm . . . . . 335

RANGE USE AND FORAGE SELECTION . . . . . 340

Range Use During January . . . . . 346

Forage Use During January . . . . . 349

Page

Range Use During February . . . . . 352

Forage Use During February . . . . . 355

Range Use During March . . . . . 358

Forage Use During March . . . . . 361

Range Use During April . . . . . 364

Forage Use During April . . . . . 368

Range Use During May . . . . . 370

Forage Use During May . . . . . 374

Range Use During June . . . . . 377

Forage Use During June . . . . . 384

Range Use During July . . . . . 387

Forage Use During July . . . . . 391

Range Use During August . . . . . 396

Forage Use During August . . . . . 397

Range Use During September . . . . . 402

Forage Use During September . . . . . 405

Range Use During October . . . . . 409

Forage Use During October . . . . . 411

Range Use During November . . . . . 415

Forage Use During November . . . . . 417

Range Use During December . . . . . 419

Forage Use During December . . . . . 422

General Discussion on the Utilization of Forages . . . . . 424

Selection of Forages . . . . . 427

Page

Utilization of Broad Forage Types . . . . . 430

Comparisons to Forage Utilization Studies in Other Areas . . . . . 433

General Discussion on the Range Utilization Over the Annual Cycle . . . . . 439

Sex-Specific Range Use . . . . . 443

The Relationships of This Sheep Population to its Winter Range . . . . . 445

MANAGEMENT RECOMMENDATIONS . . . . . 452

Sheep Censuses and Classifications . . . . . 452

Horn Growth Rates . . . . . 459

Optimizing of Harvests . . . . . 466

SUMMARY . . . . . 473

LITERATURE CITED . . . . . 478

APPENDIX . . . . . 491

Numbers of Dall Sheep (excluding new born lambs) Counted on Sheep Mountain "Winter Ranges" . . . . . 492

Horn Data From the Kluane Game Sanctuary . . . . . 495

# LIST OF TABLES

Table Page

Part I

1. Climatological data for stations in the Kluane area . . . . . 21
2. Synopsis of the synsystematic units of the study area . . . . . 43
3. Sizes of the associations of the mapped area in acres . . . . . 44
4. Puccinellio (deschampsioidis) - Taraxacetum laceri . . . . . 49
5. Astero (yukonensis) - Hordeo (jubati) - Puccinellietum deschampsioidis . . . . . 50
6. Hordeo (jubati) - Asteretum yukonensis . . . . . 51
7. Astero (yukonensis) - Deschampsietum caespitosae . . . . 52
8. Triglochino (palustris) - Juncetum arctici . . . . . 56
9. Triglochino (palustris) - Caricetum aquatilis . . . . . 57
10. Astero (yukonensis) - Junco (artici) - Salicetum brachycarpae . . . . . 61
11. Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae . . . . . 62
12. Dryadetum drummondii . . . . . 65
13. Roso (acicularis) - Shepherdio (canadensis) - Populetum balsamiferae . . . . . 67
14. Calamagrostido (purpurascentis) - Arctostaphyletum uvae - ursi . . . . . 71
15. Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae . . . . . 74
16. Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis . . . . . 81

Table | Page

17. Artemisio (frigidae) - Agropyro (yukonensis) - Eurotietum lanatae . . . . . 82

18. Pentstemono (gormanii) - Artemisietum frigidae . . . . . 83

19. Agropyro (yukonensis) - Artemisietum frigidae - rupestris . . . . . 84

20. Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum filifoliae . . . . . 85

21. Arctostaphylo (rubrae - uvae ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae . . . . . 89

22. Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - lanatae - glaucae . . . . . 90

23. Artemisietum alaskanae . . . . . 95

24. Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae . . . . . 96

25. Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae . . . . . 101

26. Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae . . . . . 102

27. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati . . . . . 107

28. Oxytropo (huddelsonii) - Salicetum dodgeanae . . . . . 108

29. Agropyretum violacei . . . . . 111

30. Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae . . . . . 114

31. Salicetum barrattianae . . . . . 117

32. Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris . . . . . 122

33. Seneciono (lugentis) - Salicetum polaris - reticulatae . . . . . 123

34. Oxyrio (digynae) - Artemisietum arcticae - tilesii . . . . . 127

| Table | | Page |
|---|---|---|
| 35. | Saxifrago (hirculi) - Caricetum membranaceae | 128 |
| 36. | PUCCINELLIO - SALICORNIETALIA | 158 |
| 37. | CARICETALIA AQUATILIS | 159 |
| 38. | SALICETALIA PLANIFOLIAE | 160 |
| 39. | DRYADETALIA DRUMMONDII | 161 |
| 40. | POPULETALIA BALSAMIFERAE | 162 |
| 41. | CALAMAGROSTIDO (PURPURASCENTIS) - ARCTOSTAPHYLETALIA UVAE-URSI | 163 |
| 42. | PICEETALIA GLAUCAE - MARIANAE | 164 |
| 43. | ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS | 165 |
| 44. | BETULETALIA GLANDULOSAE | 166 |
| 45. | ARTEMISIETALIA ALASKANAE | 167 |
| 46. | DRYADETALIA INTEGRIFOLIAE | 168 |
| 47. | OXYTROPO (VISCIDAE) - ARTEMISIO (HYPERBOREAE) - FESTUCO (BRACHYPHYLLAE) - TRISETETALIA SPICATI | 169 |
| 48. | AGROPYRETALIA VIOLACEI | 170 |
| 49. | FESTUCETALIA ALTAICAE | 171 |
| 50. | SALICETALIA BARRATTIANAE | 172 |
| 51. | SALICETALIA POLARIS | 173 |
| 52. | PETASITETALIA FRIGIDI | 174 |
| 53. | Condensed table of floristic structure of plant associations and their higher units | ~~192~~ in pocket v. 2 |

Part II

| | | |
|---|---|---|
| 1. | Numbers of Dall sheep counted on Sheep Mountain "winter ranges" | 492 |
| 2. | Highest numbers of sheep observed on Sheep Mountain | 213 |

| Table | | Page |
|---|---|---|
| 3. | Composition of the population | 214 |
| 4. | Migration distances of "northern" sheep | 221 |
| 5. | Densities of "northern" sheep | 224 |
| 6. | Sex ratios of Dall sheep | 226 |
| 7a. | Survival of the 1971 lamb crop to yearlings' age | 235 |
| 7b. | Survival of the 1972 lamb crop to yearlings' age | 236 |
| 8a. | Reproductive performance | 238 |
| 8b. | Reproductive performance | 239 |
| 9. | Classification of rams | 251 |
| 10. | Comparisons of classification of rams | 253 |
| 11a. | Adult mortality 1970 to 1971 | 255 |
| 11b. | Adult mortality 1971 to 1972 | 256 |
| 12. | Life table for rams of the Sheep Mountain population | 285 |
| 13. | Dates of first flowering of Sheep Mountain plants | 298 |
| 14. | Average temperatures at Sheep Mountain during 1970/71 | 313 |
| 15. | Altitudinal movement of sheep in response to temperature | 315 |
| 16. | Average monthly wind speed during 1970/71 | 320 |
| 17. | Response of Dall sheep to wind chill | 323 |
| 18. | Statistics on vertical migration | 329 |
| 19. | Origins of rumen samples | 342 |
| 20. | Utilization of different habitat types (plant associations) over the annual cycle | 343 |
| 21. | Statistics on range utilization | 344 |
| 22. | Statistics on forage utilization | 345 |

| Table | | Page |
|---|---|---|
| 23. | Feeding observations during late winter and spring | 350 |
| 24. | Rumen sample analyses for January | 351 |
| 25. | Rumen sample analyses for February | 356 |
| 26. | Rumen sample analyses for March | 362 |
| 27. | Rumen sample analyses for April | 369 |
| 28. | Rumen sample analyses for May | 375 |
| 29. | Feeding observations during summer and early fall | 385 |
| 30. | Rumen sample analyses for June | 386 |
| 31. | Rumen sample analyses for July | 393 |
| 32. | Rumen sample analyses for August | 400 |
| 33. | Rumen sample analyses for September | 408 |
| 34. | Rumen sample analyses for October and November | 413 |
| 35. | Feeding observations during fall and early winter | 414 |
| 36. | Rumen sample analyses for December | 423 |
| 37. | Summary statistics on range utilization | 440 |
| 38. | Summary of forage composition over the annual cycle | 425 |
| 39. | Horn data from the Kluane Game Sanctuary | 495 |
| 40a. | Horn statistics (annual increments in lengths) | 454 |
| 40b. | Horn statistics (annual increments in degree curl) | 455 |
| 41. | Horn statistics for Dall ewes | 460 |
| 42. | Comparisons of annual increments in horn growth of Dall rams | 461 |

Table | Page

43. Numbers of "trophies" in the legal age classes of rams . . . . . 469

44. Horn lengths of rams taken in the 1973 hunting season in southern Yukon . . . . . 470

# LIST OF FIGURES

Figure Page

Part I


1. Map of study area . . . . . 3
2. Geology and physiography of study area . . . . . 7
3. Generalized soil profile of Kluane Lake basin . . . . . 16
4. Puccinellio (deschampsioidis) - Taraxacetum laceri . . . . . 48
5. Zonation of Slims River flood plain . . . . . 48
6. Triglochino (palustris) - Juncetum arctici . . . . . 53
7. Triglochino (palustris) - Caricetum aquatilis . . . . . 53
8. Astero (yukonensis) - Junco (arctici) - Salicetum brachycarpae . . . . . 59
9. Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae . . . . . 59
10. Dryadetum drummondii . . . . . 64
11. Roso (acicularis) - Shepherdio (canadensis) - Populetum tremuloidis . . . . . 64
12. Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi . . . . . 70
13. Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae . . . . . 70
14. General aspect of grassland distribution . . . . . 77
15. Ecotone in grassland associations . . . . . 77
16. Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae . . . . . 88
17. Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - lanatae - glaucae . . . . . 88

Figure Page

18. Artemisietum alaskanae . . . . . 93

19. Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae . . . . . 93

20. Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae . . . . 100

21. Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae . . . . . 100

22. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati . . . . . 105

23. Oxytropo (huddelsonii) - Salicetum dodgeanae . . . . . 105

24. Agropyretum violacei . . . . . 110

25. Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae . . . . . 113

26. Salicetum barrattianae . . . . . 113

27. Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris . . . . . 120

28. Seneciono (lugentis) - Salicetum polaris - reticulatae . . . . . 120

29. Oxyrio (digynae) - Artemisietum arcticae - tilesii . . . . . 126

30. Saxifrago (hirculi) - Caricetum membranaceae . . . . . 126

31. Altitudinal range of plant associations . . . . . 131

32. Soil moisture characteristics of plant associations . . . . . 132

33. Duration of snow cover and depths . . . . . 133

Part II

1a. Range of the Sheep Mountain population of Dall Sheep . . . 199

1b. Sheep Mountain . . . . . 200

Figure Page

2. Phenological sequence of growth and drying up of important winter range forage plants . . . . . 300

3. Growth of Carex filifolia at various altitudes demonstrating vertical phenological advance . . . . . 303

4. Average and maximum snow depths during March 1971 . . . . . 305

5. Snow depths in feeding areas . . . . . 307

6. Photograph of Sheep Mountain from late February showing extent of bare, wind-swept areas . . . . . 309

7. Typical winter scene: sheep utilizing wind-swept areas . . . . . 309

8. Response of Dall sheep to winter temperatures . . . . . 317

9. Response of Dall sheep to wind chill . . . . . 325

10. Vertical migration of sheep population . . . . . 330

11. Diurnal feeding rhythm of sheep . . . . . 336

12. Distribution of grazing sites during January 1971 . . . . . 347

13. Distribution of grazing sites during February 1971 . . . . . 354

14. Distribution of grazing sites during March 1971 . . . . . 359

15. Photograph of sheep at mineral lick . . . . . 365

16. Distribution of grazing sites during April 1971 . . . . . 367

17. Sheep feeding on Calamagrostis and Artemisia . . . . . 365

18. Distribution of grazing sites during May 1971 . . . . . 372

19. Sheep feeding on Carex filifolia . . . . . 378

20ab. Grazed and ungrazed clump of Carex filifolia . . . . . 379

21ab. Grazed and ungrazed bunch of Calamagrostis purpurascens . . . . . 380

| Figure | | Page |
|---|---|---|
| 22. | Sheep feeding on Agropyron yukonense | 378 |
| 23. | Distribution of grazing sites during June 1971 | 383 |
| 24abc. | Sheep utilizing browse species during June | 388<br>389 |
| 25. | Distribution of grazing sites during July 1971 | 392 |
| 26. | Goats using dry, alpine grasslands | 395 |
| 27. | Large nursery band of sheep using Dryas sites | 395 |
| 28. | Large nursery band grazing on moist, shady north slope | 398 |
| 29. | Nursery band on alpine meadow in late August/ early September | 398 |
| 30. | Distribution of grazing sites during August 1971 | 399 |
| 31. | "Social gathering" of nursery sheep on large south-east facing slope during September | 404 |
| 32. | Distribution of grazing sites during September | 406 |
| 33. | Sheep feeding on Salix glauca | 407 |
| 34. | Sheep feeding on Salix myrtillifolia | 407 |
| 35. | Distribution of grazing sites during October 1970 | 412 |
| 36. | Distribution of grazing sites during November 1970 | 418 |
| 37. | Distribution of grazing sites during December 1970 | 421 |
| 38. | Distribution of grazing sites over 1970/71 | 431 |
| 39. | Dall sheep forage composition | 432 |
| 40. | Sheep Creek slopes - a heavily utilized winter range | 446 |

Figure | Page

41. West flank of Mount Wallace and north slope of Sheep Mountain - a heavily utilized summer range . . . . . 446

42. Structure of the sheep population . . . . . 457

43. Relation between age of rams and horn lengths . . . . . 462

44. Relation between age of rams and horn bases . . . . . 463

# ACKNOWLEDGMENTS

The study presented here is in two parts--Part I is the plant ecological study as part of an investigation of Dall Sheep and their habitat; and Part II presents the study of an investigation dealing with the ecology of Dall Sheep and their habitat--done at the University of British Columbia, Department of Zoology, under the guidance of Dr. I. McT. Cowan. I am grateful to Dr. Cowan for his encouragement and support throughout the study period and for making funds available for this project through the University of British Columbia, the Arctic Institute of North America, the Canadian Wildlife Service, the Boone and Crockett Club, and the National Research Council.

Thanks are also due to Mr. J. B. Fitzgerald, Director of the Yukon Game Branch, and Mr. S. Rolfson, Superintendent of Kluane National Park, for making available additional manpower and for providing logistic support. The assistance of the following students during field work is gratefully acknowledged: Cathy Young, Bill Richards, Rob Gordon, Ken Summers, and Terry Kennedy.

I am grateful to the following experts for providing help with the identification of Plants: Dr. J. W. Thomson, University of Wisconsin, with lichens; Dr. W. B. Schofield, University of British Columbia, with mosses and hepaticae; Dr. G. Argus, National Museum of Natural History, Ottawa, with many willow specimens; Dr. D. Murray, University of Alaska, with many Carex spp.; and Dr. V. C. Brink, University of British Columbia.

I am particularly thankful to Dr. V. Krajina, University of British Columbia, who provided indispensable assistance throughout this

study with field work, plant identifications and classification of synecological units.

Lastly, the writer benefitted greatly from frequent correspondence with the following two 'sheep experts': Dr. V. Geist, University of Calgary; and Dr. N. Simmonds, Canadian Wildlife Service.

To all the above-mentioned individuals and agencies, and to all others who indirectly contributed to this investigation, I extend my most sincere gratitude.

# PART I

## PHYTOSOCIOLOGICAL ANALYSIS AND SYNTHESIS OF SHEEP MOUNTAIN, S.W. YUKON TERRITORY, CANADA

by

MANFRED HOEFS

## INTRODUCTION

The phytosociological analysis and the vegetation map presented in this work are portions of a larger investigation dealing with the ecology of a Dall Sheep population.

Throughout the Yukon the study area is known to support a very high density of Dall Sheep and the unofficial name "Sheep Mountain" was given to the area for that reason. Our investigation tried to assess the status of the Dall Sheep population of the area, compare it to populations reported on from other areas, and evaluate some of the environmental factors which may be responsible to explain the high sheep densities encountered.

Sheep Mountain supports up to 200 Dall Sheep during the winter months on its 9.3 square mile area, of which less than 6.5 square miles are actually sheep habitat.

When trying to explain the performance of an ungulate population a number of factors need to be looked into; these include the quantity and quality of its range, particularly its winter range, the type of weather encountered during winter, the possible impacts of predators, parasites and diseases as well as the impact of man through hunting or other types of activities. While all these potential limiting factors were looked into in some detail the major emphasis was placed on the investigation of this sheep population's range, particularly its winter range.

Only limited botanical information was available for the area when this

study started, and it consisted almost entirely of plant collections. No quantitative synecological work had been done.

It was therefore decided to do a phytosociological investigation on Sheep Mountain using conventional synecological methods of the Zürich - Montpellier School. This vegetation analysis was meant to help in the evaluation of the performance of this sheep population; the European method was chosen to enable synecologist to compare and integrate this study with similar ones carried out in a number of locations of western and arctic Canada, which used the same analytical methods [Becking (1954); Orloci (1964); Krajina (1965); Brooke (1966); Lambert (1968); Brooke, Peterson & Krajina (1970); Barrett (1972)] .

Even though the range of the Dall Sheep population extends beyond the boundaries of Sheep Mountain, the latter has representative stands of all major associations found in the region that are utilized by sheep.

One of the major objectives of this phytosociological investigation was to obtain baseline data for the construction of a vegetation map of this area. This map was meant to be used to evaluate the distribution patterns and grazing "strategies" of sheep over the annual cycle.

## Location of Study Area

The study area is located in the centre of the newly-established Kluane National Park, southwest Yukon Territory (Fig. 1). The name "Sheep Mountain" was given to it by local people because of its importance as a Dall Sheep winter range. The name is not official, but it is commonly used in the Yukon Territory and it will be used in this thesis. Its exact location is the southwest corner of Kluane Lake, where the Slims River is building a delta (Fig. 1). As far as floristic composition is

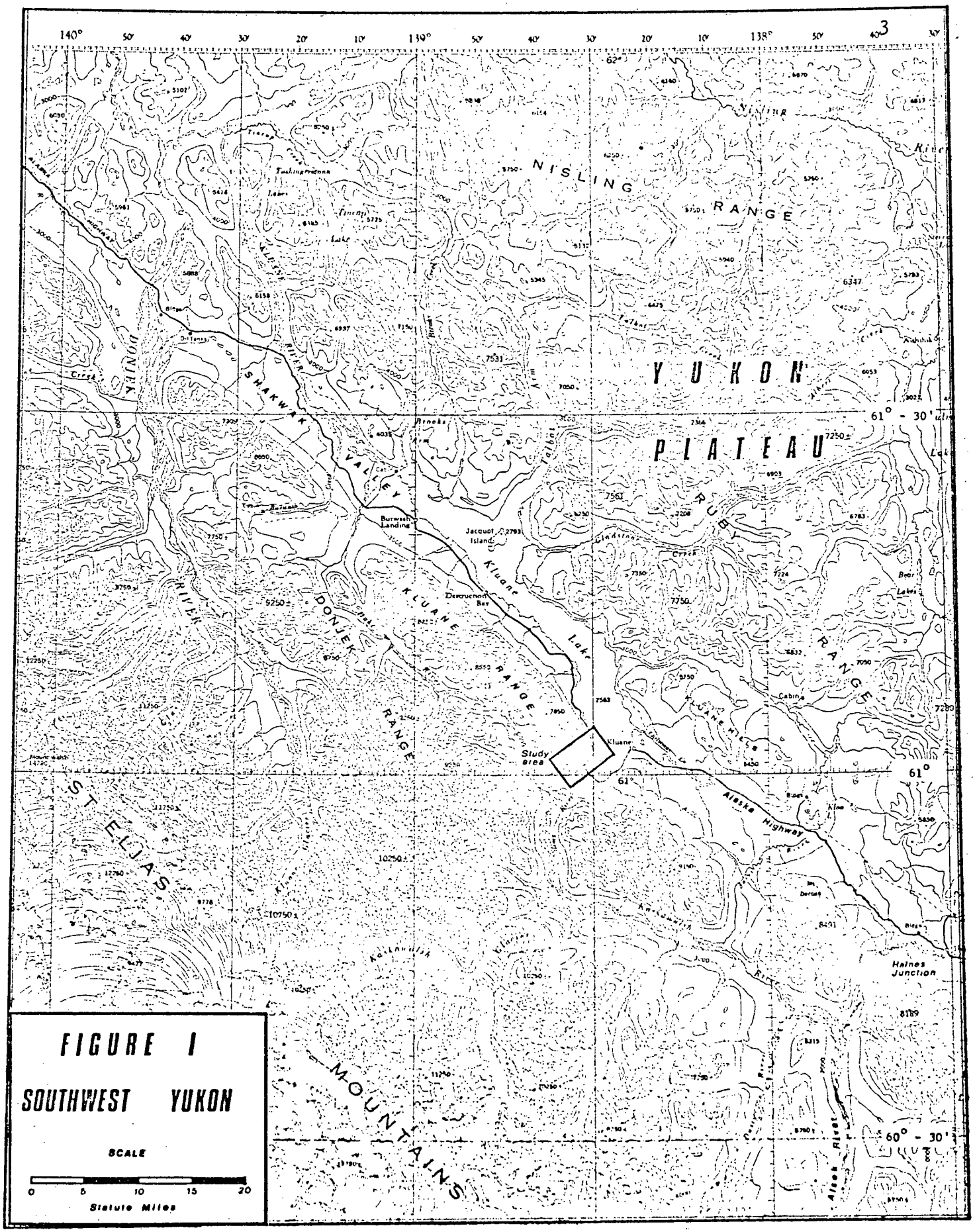



**FIGURE 1**

**SOUTHWEST YUKON**

SCALE

0 5 10 15 20

Statute Miles

concerned, Sheep Mountain is representative for Dall Sheep ranges for the northern half of Kluane National Park, approximately from the Slims River valley to the Donjek River valley. North as well as south of this designated area the climate is moister and the range composition changes accordingly. The map area includes Sheep Mountain as well as part of the Slims River floodplain at its base. The exact boundaries are the shore of Kluane Lake in the east, the Slims River in the south, Sheep Creek in the west, and the depression between Sheep Mountain and the adjacent Mount Wallace in the north. The western portion of this depression is occupied by a small stream called "Fortyeight Pup", while the eastern portion contains an even smaller stream which has no name.

The map area is rectangular in shape; approximately four miles long southwest to northeast, and about 2.2 miles wide on the average. Considering slope the total surface area is about 11 square miles.

The approximate coordinates are 61° - 00' to 61° - 03' latitude north, and 138° - 30' to 138° - 36' longitude west. The altitude of Kluane Lake is given by Bostock (1969) at 2563 feet above sea level. Sheep Mountain does not have a single peak but an undulating ridge along its top, from which three knobs rise to an elevation of about 6400 feet above sea level (Fig. 2). This gives the mountain a height of about 3800 feet above the valley floor.

Physiography and Geology

The physiography of the area has been described by Bostock (1948) and the geology by Muller (1967). The following summary is primarily based on their work.

The study area is located in the St. Elias Mountains. These are the

highest mountains in Canada and together contain the largest group of great peaks in North America. Perhaps few other people have described their grandeur more appropriately and more picturequely than Bostock (1948): "... Besides their colossal size this individual aloofness (of single peaks) adds much to the impressiveness of their vast, wild and icy beauty, and contrasts them sharply with the jumbled rivalry of summits around many of the main peaks of the Coast - , Rocky -, and Mackenzie Mountains, and other mountains of the Canadian Cordillera. Many of these individual peaks and groups are block-like in form, rising on nearly every side with precipitous cliffs, not to pinnacle-like tops, but to broad, still steep, though relatively gentler, summit areas. This gives them an appearance of stupendous massiveness from all directions. Another outstanding feature is the mantle of snow and ice that even in summer cloaks a great part of them. It spreads unbroken over their gentler summit areas, smoothing the contours of their upper slopes and concealing bedrock... Below these dazzling monarchs a sea of lesser peaks, mighty themselves in other company, form a jagged and rocky platform. Such is a general picture of the dominant features of these great mountains beside which the better known ranges of Canada are dwarfed to relative insignificance."

Bostock (1948) divided the St. Elias Mountains into five subdivisions. The Icefield, Alsek and Fairweather Ranges make up the high glacier-clad southwestern portion. They contain Mt. Logan (19,850 feet) and a number of other peaks above 12,000 feet elevation. The Kluane and Donjek Ranges, which are separated by the Duke depression, form the northeastern portion of the St. Elias Mountains. They are lower and appear "foothill-like" by comparison. The Shakwak valley separates the St. Elias Mountains from

the Yukon plateau to the northeast. The alignment of all these physiographic units is southeast to northwest (Fig. 1). Viewed obliquely the general impression of the Kluane Ranges, in which the study area is located, is that of a continuous mountain wall rising in a straight line from the Shakwak Valley (Fig. 2). Slight elevation differences in the peaks and nine large, crosscutting valleys are not conspicuous. They show a particular type of ruggedness that contrasts with that of other nearby ranges. Their slopes are steep and uniform, with long, straight scree slopes. Their ridges are serrate and narrow, the summits fairly uniform in elevation. Most peaks are close to 7000 feet in elevation, while a few may go as high as 8000 feet (Bostock 1948).

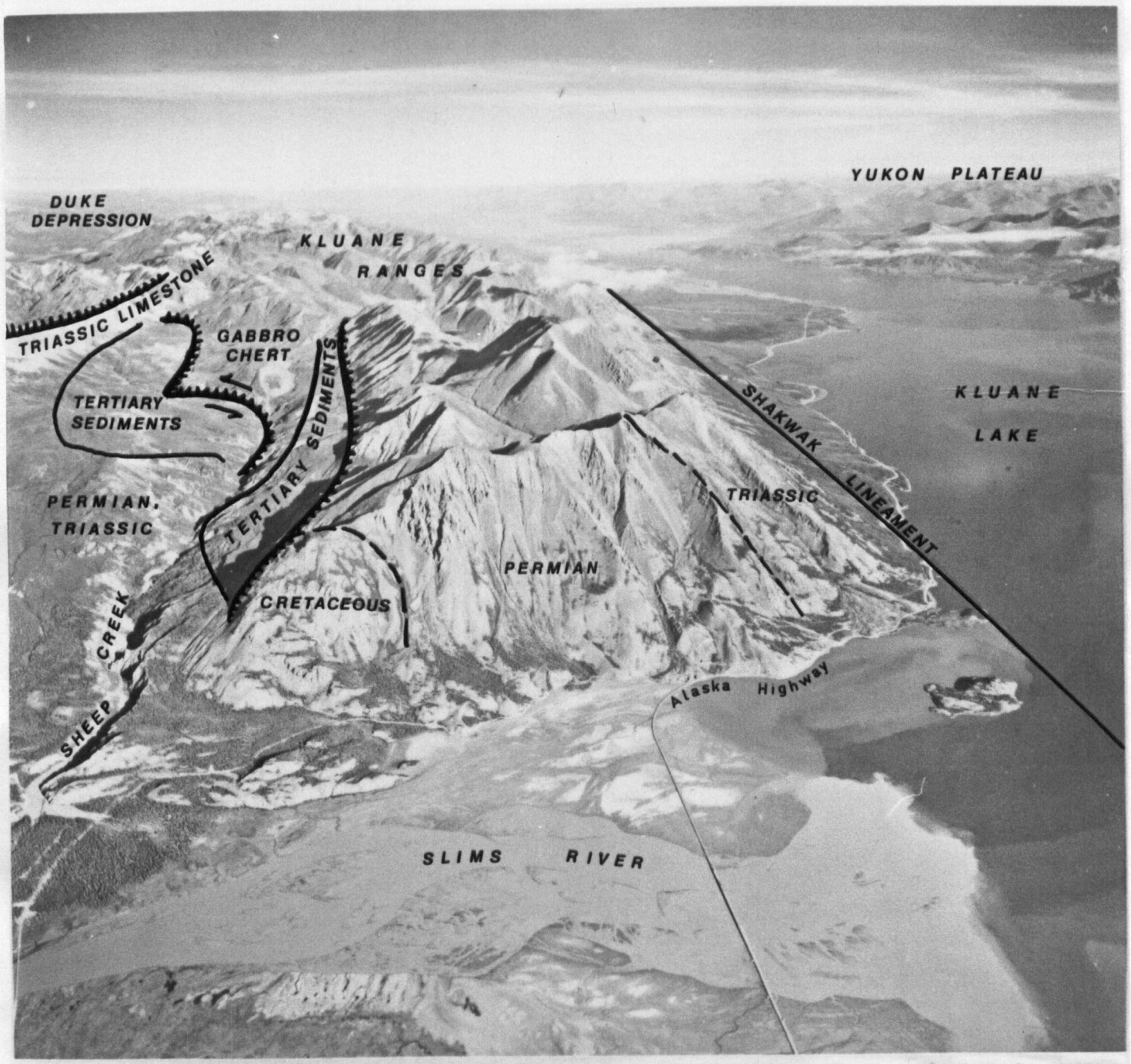
A number of glacier-fed large streams dissect the Kluane area. Listed from north to south, the White, Donjek, Duke and Slims River, which are part of the Yukon River watershed, drain into the Bering Sea, and the Alsek River, which drains into the Pacific Ocean (Fig. 1). The St. Elias Mountains are famous for their large icefields and glaciers, the more important ones being the Klutlan, Donjek, Kluane, Kaskawulsh, Lowell and Fisher Glaciers. Of particular importance to this study is the Kaskawulsh Glacier because of its influence on drainage and loess deposition. Its terminus is about 14 miles upstream from the present mouth of the Slims River (Fig. 1). This glacier also gives rise to the Kaskawulsh River, which drains to the southeast into the Alsek River and thus into the Pacific.

The interactions of Kaskawulsh Glacier, Slims River and Kluane Lake are of importance to the vegetation of Sheep Mountain and will therefore be discussed in more detail.

Kluane Lake, with a length of about 50 miles the largest lake in the Yukon,

# FIGURE 2

## Geology and physiography of the study area




This photograph is modified from Muller (1967, RCAF, T-6 - 117 R ). Sheep Mountain - the study area - is found in the centre of the picture. Note the silt-laden Slims River in the foreground extending its delta into Kluane Lake.

is an outstanding feature of the Shakwak valley. Between Mile 1064 Alaska Highway (north side of Sheep Mountain) at the west side of the lake and a point between Cultus and Christmas Bays at its east side, the lake is about 3.5 miles wide and with 270 feet reaches its greatest depths. Toward the Slims River delta in the south and the outflow of Kluane River in the north it becomes very shallow. The lake level fluctuates considerably with the seasons and evidence collected by Bostock (1952) indicates that the mean level may change as much as 10 feet. The amount of water carried in by the Slims River as well as the amount of sediments deposited by the Duke River near the outflow are the primary reasons for lake level changes. Bostock (1952), furtheron, puts forth the hypothesis that the outflow of Kluane Lake was at one time to the south and lists as evidence drowned estuaries of Christmas and Gladstone Creeks, drowned beaches, sunken forests, and significant changes in the delta of the Duke River. Bostock (1952, 1969) concludes: "... Slims River and Kluane Lake have been in existence as they are today for only a relatively short part of recent time. At the close of the last major glaciation, Kaskawulsh Glacier receded at least some miles above its present position, and the basin of Kluane Lake drained up the Slims valley and thence by Kaskawulsh valley into the Alsek River and Pacific. This condition has persisted through most of recent time. Some centuries ago the outlet was closed by the advance of the glacier, and Slims valley and the basin of Kluane Lake were flooded to a level of 30 feet above that of 1945. The lake then overflowed to westward, developing the present outlet of Kluane River, which has quickly cut through the drift to its present level." Bostock's hypothesis has not been fully accepted yet (Johnson & Raup, 1964).

The morphology of the Slims River has been studied by Fahnestock (1969), and the following data are abstracted from his description.

The valley of the Slims River, like those of many other glacial rivers, has three zones. In the upstream zone one to three channels are cutting down into coarse gravel, where the river emerges from the terminus of the Kaskawulsh Glacier. Here the slope is lower than in the intermediate zone, where the river is multi-channelled with considerable bed load transport and some deposition. In the downstream zone, at the base of Sheep Mountain, the river has at present about twenty channels and as many bars. At high stages these channels may grade into a continuous sheet of flowing water. Here the slope is about 4.5 feet/mile. The valley floor is about 5700 feet wide with an average water depth of 0.8 feet, a maximum depth of 3.5 feet, and an average velocity of 2.3 feet/second. Fahnestock (1969) found that the diurnal fluctuation of about 0.5 feet represented a flow difference of 1000 to 2000 $feet^3$/second, that the "high water" was between 9:00 p.m. and 3:00 a.m. and the "low" between 12:00 noon and 2:00 p.m. He estimated the annual fluctuation in discharge between 0 $feet^3$/second (at -75°F. all flow would stop) to 20,000 $feet^3$/second under optimum conditions of melting and run-off.

The extension of the Slims delta into Kluane Lake and construction of the 14- miles of valley train from the Kaskawulsh Glacier has taken place in less than 2,600 years (Denton & Stuiver, 1966; Borns & Goldthwait, 1966) and possibly no more than 500 years (Bostock, 1952). Bostock (1952) calculated the present rate of delta building at 160 to 240 feet/year. This conveys a good impression of the bed load carried by this river.

Through diurnal and annual changes in water level the Slims River directly

affects the plant communities growing on its flood plain. Since it is the most important source of loess in the area, it indirectly affects also many plant communities in the boreal and subalpine zones.

As already pointed out, the Shakwak valley separates the St. Elias Mountains from the Yukon Plateau to the northeast. Ruby and Nisling Ranges are part of the Yukon Plateau, while the Kluane Range is part of the St. Elias Mountains. These two geological provinces differ considerably in age. "Yukon Complex" metamorphic rocks, with granodiorite of Ruby Range batholiths and some smaller bodies, mainly underlie Yukon Plateau. The probably Precambrian and early Palaeozoic schists were metamorphosed and granitised in Mesozoic and perhaps early Tertiary time. Minor Mesozoic volcanic rocks, some granite, and abundant rhyolite also occur in Nisling Range (Muller, 1967).

The Shakwak trench forms the topographic expression of a major tectonic lineament, extending from southwest Yukon (Dezadeash Lake) into Alaska. It is believed to be a hinge line reflecting mainly vertical movement between the St. Elias geosyncline and the Yukon geoanticline (Muller, 1967, 1958).

Eugeosynclinal deposits of St. Elias Mountains have yielded Middle Devonian, Lower Permian, Upper Triassic, and Jura - Cretaceous fossils. The volcanic rocks are pre-Permian, Permian and Triassic; carbonate - clastic sequences are Devonian, Lower Permian and Upper Triassic; and a Greywacke-argillite sequence is Upper Jurassic to Lower Cretaceous (Muller, 1967).

Only those "rock groups" of Muller's (1967) treatment will be discussed

here, that make up the bedrock formations of Sheep Mountain and may therefore be of significance as substrate of the vegetation.

The "Cache Creek Group" of Permian and earlier age forms the centre portion of Sheep Mountain as well as the lower half of Sheep Creek and the adjacent plateau between Sheep and Bullion Creeks (Fig. 2). The canyon at the mouth of Sheep Creek is made up of limestone. Other rocks in this group include argillite, chlorite schist, greywacke, volcanic breccia, banded cherty tuff and porphyritic basic lava. The "Mush Lake Group" of Upper Triassic age underlies a large part of Kluane front range between Donjek and Slims Rivers. These rocks are described as "...consisting mainly of fine-grained flows of green andesite, spotted with small dark hornblende crystals and with scattered calcite-filled amygdules..." by Kindle (1953). These rocks make up the eastern half of Sheep Mountain and can be observed from the Alaska Highway all along that front range northwestward to Burwash. The boundary between this "Mush Lake Group" and the previously mentioned "Cache Creek Group" is not distinct on Sheep Mountain and its location on Fig. 2 must only be considered as approximate. Basalt and andesite are important rocks here; others in this group include argillite, greywacke, silty limestone, chert and conglomerate.

The "Kluane Ranges Intrusions" of Cretaceous and earlier age make up a small portion of the south-facing slope of Sheep Mountain (Fig. 2). The most common rocks encountered here are diorite and hornfels. The last group which contributes to the bedrocks of Sheep Mountain is the "Amphitheatre Formation" of Paleocene or Eocene age. These sedimentary deposits were named by Muller (1967) after the prominent exposure in the badlands on the southeast side of Amphitheatre Mountain in the Burwash

Uplands. In the study area these sediments are found along the east side of the upper half of Sheep Creek. Sandstone, conglomerate, shale and even some coal make up these sediments. According to Muller (1967) these Tertiary sediments are gently folded in a shallow syncline along the northeast side of their discontinuous belt of exposures, but are thrown in steep open folds on the southwest side. The most intense tectonic movement involving these beds is exhibited on Sheep Creek, where Permian and Triassic gabbro and volcanic rocks overlie the sediments on a flat overthrust (Fig. 2).

Glaciology and Soils

The study area is well south of the unglaciated zone, and evidence of past glaciations is found everywhere in the form of moraines, erratics, scouring of bedrock, outwash, drift and loess deposits. Pleistocene events in the southwest Yukon have in general terms been described by Muller (1967), Kindle (1953), and Bostock (1952). Very detailed work has been done on the Kaskawulsh Glacier - Slims valley - Shakwak trench complex by Denton & Stuiver (1967, 1966) and by Borns & Goldthwait (1966).

According to Denton & Stuiver (1966) and Muller (1967) three large glaciations occurred in southwestern Yukon and a fourth much smaller one, the Neoglaciation, is still current. Using drift morphology and stratigraphy combined with C-14 dates, Denton & Stuiver (1966) worked out the chronology and named the events as given in the following summary. Names used by Muller (1967) are given in brackets.

Glacial events in southwest Yukon:

Neoglaciation: ( Post glacial events )
Start about 2640 B.P.; still current

Slims non-glacial interval
Start about 12500 to 9780 B.P.: end about 2640 B.P.

Kluane Glaciation: ( St. Elias Glacial Advance )
Start before 30100; end about 12500 to 9780 B.P.

Boutellier non-glacial interval
Start about 37700; end before 30100 B.P.

Icefield Glaciation: ( Ruby Icesheet )
Start before 49000; end about 37700 B.P.

Silver non-glacial interval
Prior to 49000 B.P.

Shakwak Glaciation: ( Nisling Icesheet )
Prior to 49000 B.P.

The Shakwak Glaciation (Nisling Icesheet) was the oldest and most extensive glacial period. Most evidence has been eradicated by later advances. It was the only icesheet which covered large parts of the Nisling Range (Muller, 1967). Investigators agree that this icesheet reached an elevation of at least 6000 feet above sea level near the mouth of the Slims River. However, erratics were found on Sheep Mountain near its peaks at 6300 feet. Wheeler (1963) found erratics on Outpost Mountain, about 10 miles south of the study area, at an elevation of 7200 feet, and Muller (1967) assumes these to be of Nisling "age". Further on, the three knobs on the high ridge of Sheep Mountain are well rounded and do not have the appearance usually associated with nunataks. From this I assume, that Sheep Mountain was completely covered by ice during this period. Evidence of this icesheet on the study area is mainly in the form of erratics and some bedrock scouring. This icesheet was derived from the Icefield Ranges and flowed into the Shakwak trench by way of the Slims Valley.

The Silver non-glacial interval was named by Denton & Stuiver (1966) after a weathering zone discovered on the Shakwak drift deposits in the Silver Creek area.

The Icefield Glaciation (Ruby Icesheet) affected the Kluane - as well as parts of the Ruby Range, after which it was named by Muller (1967). Glaciated valleys are the most common expression of this glaciation, in contrast to the glaciated plateau surfaces of the preceding one (Muller, 1967). Glaciers flowed down the Slims, Duke and Donjek valleys and joined a major icefield in the Shakwak trench, where the flow was in general northwesterly, as indicated by the ice gradient and the alignment of drumlins. Muller (1967) gives an elevation of this icesheet for the Sheep Mountain area of about 5000 feet, and a descending gradient toward the northwest part of the Shakwak trench, where the ice reached an elevation of 4000 feet. Denton & Stuiver (1966) give a minimum thickness for this icesheet of 1500 feet, which would put it near the 4000 feet contour at Sheep Mountain.

The Boutellier non-glacial interval is named after a weathering zone exposed in the Boutellier Creek area by Denton & Stuiver (1966). The weathering consisted of a slight oxydation of the uppermost 2 to 3 feet of till deposited by the Icefield (Ruby) Glaciation.

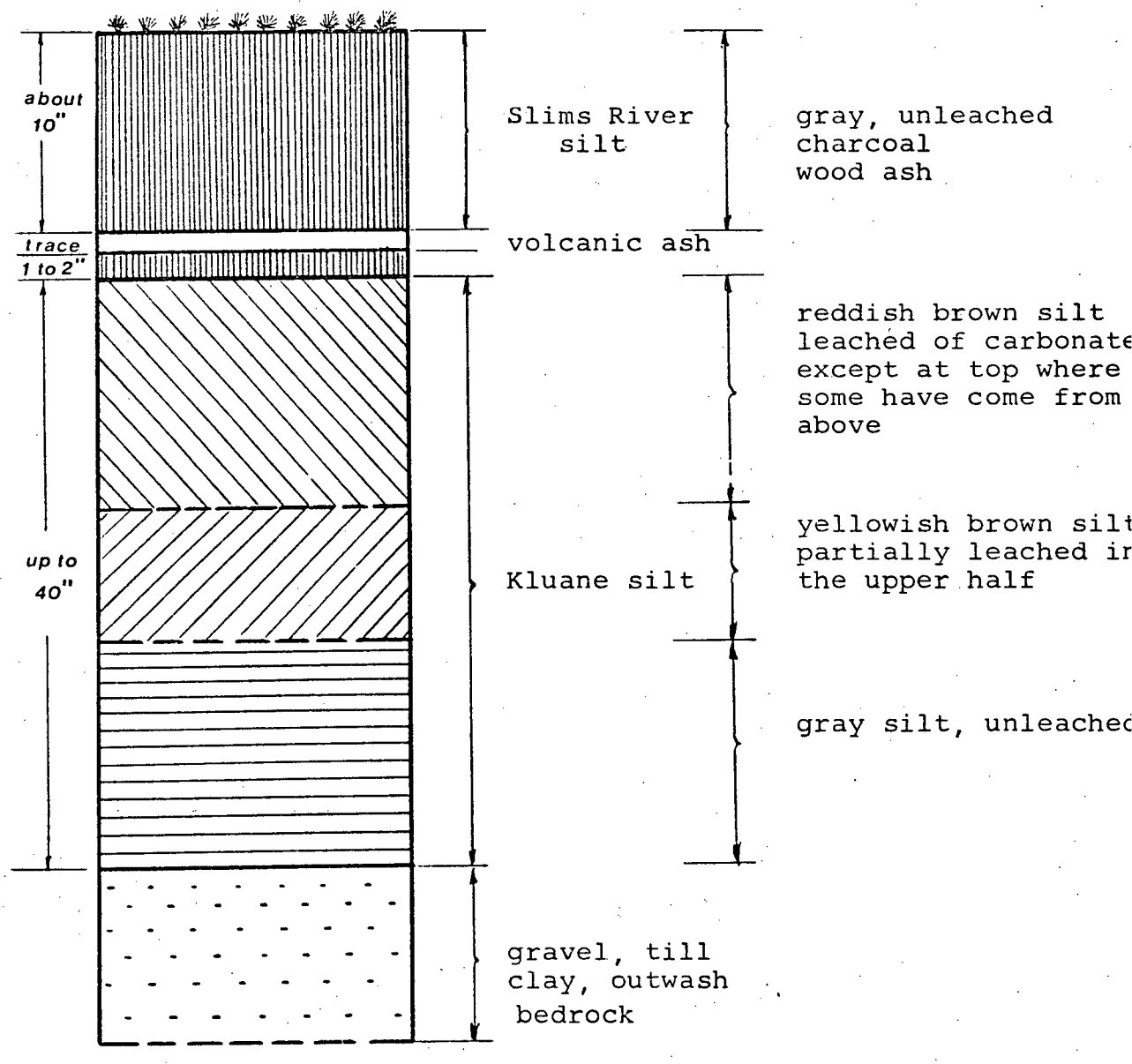
The Kluane Glaciation (St. Elias Glacial Advance) was the climatic episode, characterized by glacial expansion, during which the Kluane tills were deposited. Following the close of the Boutellier non-glacial interval, ice advancing north from the Icefield Ranges initially entered the Shakwak trench through the Slims valley depositing outwash and tills and damming an extensive lake in which lacustrine sediments were deposited.

Later ice from the Jarvis River valley flowed northwest, covering old sediments and till. Jarvis and Slims ice merged and the combined ice mass flowed northwest along the Shakwak trench (Denton & Stuiver, 1966). These authors estimate that the ice thickness in the study area ranged from 2900 to 3530 feet. In the Shakwak trench, Kluane drift, 20 to 120 feet thick, is revealed in cross sections in exposures along most creeks as well as along the shore of Kluane Lake. Several exposures can be observed at the base of Sheep Mountain at its east side, where cuts had to be made to construct the Alaska Highway. A blanket of loess forms the youngest unit of Kluane drift at altitudes below 4500 feet; covering all drift and most bedrock at lower elevations. Kluane loess consists of well-sorted silt with some fine sand. Its particles are composed of a wide range of mineral types, reflecting the complex lithology of source rocks of glacial sediments in the region (Denton & Stuiver, 1966). Loess deposits in the study area vary from 14 to 40 inches, depending on altitude, aspect and slope. Denton & Stuiver (1966) inferred that several scattered outwash bodies, the Slims valley train being one of the largest, were the predominant source for loess during the retreat of the Kluane ice. Both, Denton & Stuiver (1966, 1967) as well as Muller (1967), assume that the Kluane Glaciation (St. Elias Glacial Advance) was synchronous with the classical "Wisconsin" Glaciation.

The Slims non-glacial interval was named by Denton & Stuiver (1966) after the Slims Soil, a weathering product of the Kluane loess, which is particularly well developed in the Slims River valley. Denton & Stuiver (1966) as well as Johnson & Raup (1964) have worked out in great detail the stratigraphy and chronology of these aeolian deposits. A representative cross section, as found at the base of Sheep Mountain, is given in

# FIGURE 3

## Generalized soil profile of Kluane Lake basin




Soil profile modified from Johnson and Raup (1964 ).

Fig. 3.

The top layer of gray, unweathered loess is up to 10 inches thick. This is neoglacial loess, which is still being deposited at present. Near its base is a thin layer of volcanic ash, which in the study area is often only found in traces. This ash has been dated by Stuiver, Borns & Denton (1964), using the C-14 technique, at 1425± 50 years B.P., and by Capps (1915) at 1400 B.P., using the rate of peat deposition. Bostock (1952) constructed an isopach map, indicating that the source of this ash was a volcanic eruption near the Yukon - Alaskan boundary, 10 miles south of the White River.

A thin layer of unweathered gray loess below the ash indicates that the neoglacial advance had begun before the volcanic eruption. A thick layer of silt, which is weathered in the upper half, and ranges in thickness from 14 to 40 inches, referred to as Kluane Silt by Johnson & Raup (1964) and as Slims Soil by Denton & Stuiver (1966), underlies the gray, unweathered loess. Denton & Stuiver (1966) describe it as follows: "... The uppermost horizon, 8 inches thick, is intensely oxidized, is moderate brown (5YR 4/4) and grades into a less intensely oxidized moderate yellow (5Y 7/6) horizon, 4 inches thick, which in turn grades down into a light gray (N 7) unoxidized horizon, 10 or more inches thick. The moderate brown horizon is completely leached of calcium carbonate; the moderate yellow horizon is partially leached, and the gray horizon is unleached." This silt layer overlies gravel, till, outwash, and in some places bedrock.

This profile is encountered to an elevation of 4500 feet in the study area, even though the thickness decreases with altitude and is affected

by aspect and slope as well as by exposure to wind. Particularly at sub-alpine elevations considerable modification has occurred through erosion, animal activity, vertical soil movement, and incorporation of organic as well as colluvial material.

The Slims non-glacial interval includes the "Hypsithermal interval" as defined by Deevey and Flint (1957). During this rather warm period the Kaskawulsh Glacier retreated 13.7 miles above the present location of its terminus (Denton & Stuiver, 1966). The Slims River valley train, the most important source of loess for the area, became deactivated and covered by vegetation. Loess deposited on the surrounding landscape had time to weather and the "Slims Soil", as described above, evolved.

The Neoglaciation resulted in the advance of the Kaskawulsh Glacier slightly beyond the present location of its terminus. The Slims River valley train became again activated, causing renewed loess deposition. Shortly after this reactivation the volcanic eruption occurred and a layer of ash was incorporated into the loess. Lack of any indication of weathering in this top loess layer indicates that the Slims valley train has been active ever since, as it is at present. Denton & Stuiver (1966) state that the neoglacial maximum of the Kaskawulsh Glacier was reached sometime before 1865 A.D. and that there have been fluctuating retreats since then.

Neoglacial advances of the Lowell Glacier with the subsequent damming of the Alsek River have resulted in the establishment of glacial lakes in the Dezadeash valley, some 50 miles south of the study area. Kindle (1953) and Johnson & Raup (1964) describe Glacial Lake Champagne, Kloo, and several stages of Lake Alsek, of which the last one only drained in

historic times. A connection of Glacial Lake Kloo to a glacial lake in the Shakwak trench, via Jarvis valley and Cultus Creek valley, may have existed with a water level at the 3000 feet contour (Muller, 1967). However, it is generally assumed that the drainage northwest along the Shakwak trench into the Yukon River system had not been blocked (Johnson & Raup, 1964). As has already been pointed out, a neoglacial advance of the Lowell Glacier and the subsequent damming of the Alsek River, may have caused a reversal of the drainage of the Slims River - Kluane Lake system, as proposed by Bostock (1952, 1969).

No soil survey has been done in the study area. Day (1962) did a reconnaissance in the Takhini and Dezadeash valleys. His map sheet terminated around Haines Junction, some 40 miles southeast of Sheep Mountain. Day (1962) states that because of the youth of the soil material and the dry, cool climate, most soil profiles are weakly developed. This applies even more to the study area where continuous loess deposition does not allow leaching and profile development. The soils can therefore be described as juvenile and azonal, and they would be classified in the Regosolic order. Within the Slims River flood plain some soils show mottling and some develope a white crust at their surface during very dry summers. Whether these characteristics are developed far enough to classify these soils as Gleysols only chemical and physical analyses will show.

In the boreal and sub-alpine zones of Sheep Mountain, the profile described earlier, with the modifications mentioned, is usually encountered. Soils below active scree slops or eroding cliffs have a high percentage of colluvial material incorporated into the loess. Alpine soils developed

on bedrock weathered in place or on thin drift deposits left in depressions. Even at this elevation some loess is being deposited during strong winds. Vertical soil movement (creep, solifluction, mudflow) is important during spring run-off. The entire study area is alkaline. P.H. values taken in a number of soil types ranged from a low of 7.2 in forest to a high of over 8.4 in flood plain sites.

## Weather and Climate

The description given here is based primarily on the reports by Taylor - Barge (1969) and Kendrew & Kerr (1955), supplemented by data obtained from temporary weather stations on Sheep Mountain during this study.

### Regional climate:

In spite of the short distance of only eighty miles from the Pacific Ocean, the climate of the Kluane area is definitely continental. The St. Elias Mountains and the Coast Mountains serve as an effective barrier against the penetration of moist, warm air from the Pacific. Winters are cold and clear, while summers are pleasant but short. The area lies in the rain shadow of the St. Elias Mountains and it has been classified as approaching semi-arid.

Records of mean monthly temperatures and total monthly precipitation of stations relevant to the study area are listed in Table 1. These data were made available by the Whitehorse weather office, Canada Department of Transport. Burwash Landing is located forty miles north, Aishihik sixty miles east, and Haines Junction fifty miles southeast of the study area. The Kluane Lake station of the Arctic Institute of North America,

TABLE 1:

CLIMATOLOGICAL DATA FOR STATIONS IN THE KLUANE AREA

| Locations | Records | Jan. | Feb. | Mar. | Apr. | May | Jun. | July | Aug. | Sept. | Oct. | Nov. | Dec. | | Climate after Köppen-Trewartha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Burwash Ldg | Temp. (1) | -19.9 | 0.2 | 10.3 | 26.0 | 42.4 | 51.2 | 53.1 | 49.5 | 40.8 | 25.0 | 7.2 | -6.5 | x̄23.3 (3) | Dfcx |
| 61 - 22' N | Prec. (2) | 0.87 | 0.33 | 0.58 | 0.93 | 0.89 | 1.44 | 2.64 | 1.22 | 1.21 | 0.63 | 0.87 | 0.56 | 12.17 (4) | |
| 139 - 3' W | Years of | | | | | | | | | | | | | | |
| + 2628 feet | Record | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 6 | 6 | 6 | | |
| Aishihik | Temp. | -1.0 | -1.0 | 14.0 | 23.0 | 41.0 | 50.0 | 53.0 | 49.0 | 41.0 | 28.0 | 6.0 | -4.0 | x̄25.0 | Dfcx |
| 61 - 37' N | Prec. | 0.50 | 0.40 | 0.50 | 0.50 | 0.90 | 1.70 | 1.80 | 1.40 | 0.90 | 0.60 | 0.50 | 0.40 | 10.10 | |
| 137 - 31'W | Years of | | | | | | | | | | | | | | |
| + 3170 feet | Record | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | | |
| Haines Jct | Temp. | -7.7 | 3.2 | 14.0 | 29.7 | 41.9 | 50.7 | 54.0 | 50.7 | 42.7 | 28.8 | 9.7 | -4.0 | x̄26.1 | Dsc |
| 60 - 46' N | Prec. | 0.80 | 0.49 | 0.36 | 0.30 | 0.55 | 1.06 | 1.34 | 1.06 | 1.16 | 1.16 | 1.16 | 1.16 | 10.60 | |
| 137 - 35'W | Years of | | | | | | | | | | | | | | |
| + 1965 feet | Record | 28 | 28 | 28 | 28 | 28 | 28 | 27 | 28 | 28 | 28 | 28 | 28 | | |
| Kluane Lake | Temp. | -19.4 | 9.1 | 6.0 | 27.0 | 41.6 | 50.2 | 53.3 | 51.2 | 39.8 | 25.1 | 15.0 | -5.4 | x̄24.5 | Dsc |
| 61 - 03' N | Prec. | 0.12 | 0.13 | 0.02 | 0.55 | 0.50 | 0.70 | 1.70 | 1.24 | 0.70 | 0.42 | 0.92 | 0.10 | 7.10 | |
| 138 - 22'W | Years of | | | | | | | | | | | | | | |
| + 2580 feet | Record | 1 | 1 | 1 | 1 | 2 | 7 | 7 | 4 | 1 | 1 | 1 | 1 | 1 | |
| Sheep Mtn | Temp. | -17.9 | 15.2 | 10.4 | 26.9 | 34.4 | 51.0 | 53.9 | 51.8 | 39.8 | 24.3 | 16.5 | -2.4 | x25.3 | Dsc |
| 61 - 02' N | Prec. | 0.12 | 0.12 | 0.02 | 0.55 | 1.39 | 1.01 | 0.84 | 1.01 | 0.81 | 1.25 | 0.90 | 0.10 | 8.12 | |
| 138 - 30'W | Years of | | | | | | | | | | | | | | |
| + 2800 feet | Record | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | | |
| Sheep Mtn | Temp. | -8.8 | 11.2 | 4.5 | 19.6 | 26.6 | 39.5 | 45.9 | 44.7 | 31.1 | 20.0 | 11.9 | -3.5 | x20.8 | ET |
| 61 - 02' N | Prec. | 0.12 | 0.15 | 0.02 | 0.60 | 1.24 | 1.34 | 1.15 | 1.43 | 1.18 | 0.87 | 1.40 | 0.10 | 9.60 | |
| 138 - 31'W | Years of | | | | | | | | | | | | | | |
| + 5380 feet | Record | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | | |

(1) mean monthly temperature (°F)
(2) total monthly precipitation (inches)
(3) mean annual temperature (°F)
(4) total annual precipitation (inches)

located five miles to the east, is usually in operation only during the summer. Two weather stations on Sheep Mountain, one at the foot in the boreal zone at 2800 feet elevation and one in the alpine zone at 5380 feet elevation, were maintained by the writer during two summers (1970 and 1971) and one winter (1970/71).

The mean annual temperature of the area is around 25°F. and the total annual precipitation is around 10 inches or less. Only during June, July and August do the mean monthly temperatures read 50°F. or slightly more. Maximum temperatures of 80°F. have been recorded at Kluane in July; on the other hand, freezing temperatures of around 30°F. can be expected at night in mid-summer. Characteristic for this latitude are long summer days and long winter nights. Tables in Smith & Thomson (1958) indicate that day length on June 30th is 19 hours 11 minutes (02:28 a.m. to 21:39 p.m.), compared to 5 hours 42 minutes (09:12 a.m. to 14:54 p.m.) for January 1st. This phenomenon results in reduced diurnal temperature ranges and intensified annual temperature ranges. During the summer months diurnal temperature ranges are 15°F. to 20°F., and during the winter 5°F. to 10°F. During the 1970/71 period, when the Kluane Lake station was maintained year-round, the annual range between the highest and lowest temperatures recorded was 136°F. (+ 80°F. in July, -56°F. in January). Very cold conditions in winter are associated with stability and temperature inversions.

Most precipitation falls during the summer months. Snow may occur in every month, except in July. Snow depths in winter are one foot to two feet, and drifting is prevalent. In winter the precipitation results from air movement across the St. Elias Mountains from the Gulf of Alaska.

Summer rainstorms, usually generated in interior Alaska or continental Canada, tend to track westward or southwestward and spend their moisture against the eastern flank of the St. Elias Mountains (Neilson, 1972).

Greatest wind speeds occur in late winter and spring and are associated with systems moving in from the Pacific Ocean. In winter these are often of Chinook (Foehn) type, which bring with them warmer temperatures.

The continentality of the area is reflected by the relative low cloud amounts (5.8/10 in summer), a predominance of middle and high clouds, and the presence of convective type cloud after mid-day.

In spite of the short growing season, the average number of days without frost is only twenty-one (Porsild, 1966), hardy field crops have been successfully grown at the former Experimental Farm at Haines Junction, and according to Kindle (1953) former trading posts used to grow cabbage, potatoes, turnips and beans in surrounding areas.

Local Modifications:

The local climatic conditions around Sheep Mountain are considerably modified from the general outline given above, because of its geographical orientation to the sun and its proximity to Kluane Lake and the Slims River valley.

Kluane Lake, largest lake in the Yukon and near the study area up to 270 feet deep, has a moderating effect on the local temperatures, when it is not frozen. It does not freeze over until late November or early December; therefore the mean November temperatures at the base of Sheep Mountain (16.5°F.) and at the Kluane Lake station (15.0°F.) were significantly higher than that temperature at Burwash (7.2°F.), located

only forty miles farther north on the northern, shallow end of the lake, which freezes over in late October. Kluane Lake is not ice-free until late June and even then has a temperature far below that of adjacent land and air. It was noted that coldest temperatures during the summer months occurred when it was calm or with a wind blowing off Kluane Lake from the north.

The orientation of the long axis of Sheep Mountain is southwest to northeast, exposing its large "broadside" to the sun. Most mountain ranges in the area are aligned southeast to northwest.

This orientation and its proximity to the Slims River valley is significant with the regard to the local climate in two respects.

Firstly, the Slims River valley is about two miles wide near Sheep Mountain and Kluane Lake about three miles wide. The adjacent mountain to the west, between Sheep Creek and Bullion Creek is low. Therefore, with the exception of Mt. Wallace (+ 7800 feet) north of Sheep Mountain and thus insignificant with respect to sunshine, Sheep Mountain is surrounded by areas of low relief, allowing it to "catch" almost all the available insolation, even when the sun is at a lower angle in the spring, fall and late winter. This factor results in snow melting and disappearing from Sheep Mountain's east, south and west slopes earlier in spring and permanently remaining on the mountain later in fall than on any of the surrounding mountains. During the height of the summer this factor adds to the dryness.

Secondly, the Slims River valley serves as an effective funnel for down-glacier wind, coming from the southwest down the Kaskawulsh glacier.

These winds are particularly strong in late winter, spring and early summer. They are warmed by a combination of heat gained from strongly radiatively warmed rocks and heat extracted during quasi - adiabatic descent. Together with the direct sunshine mentioned above, they result in great evapotranspiration rates on the exposed slopes of Sheep Mountain and are the reason for the predominance of grassland vegetation here. As already pointed out, these winds are also responsible for the continuing loess deposition.

Mean monthly wind speeds, measured at the base of Sheep Mountain, were highest in February (7.1 miles/hour), April (8.6 miles/hour) and May (11.0 miles/hour), and lowest in mid-winter (November - 2.6 miles/hour, December 1.6 miles/hour, January 4.9 miles/hour). During winter these "down-glacier" winds are chinook (Föhn) types, which reached melting temperatures (38°F.) even in January. They remove the scanty snow cover from exposed slopes, which are occupied by grassland vegetation, and deposit it in depressions or on eastern aspects, which are occupied by forest or shrub communities. Snowdrifts of three to four feet have been measured here.

In spite of only a short time of climatic records for the area, the effects of higher altitudes appear to be the following: The mean summer temperatures are significantly lower in the alpine station at 5380 feet compared to the boreal station at 2800 feet. As can be seen on Table I, the mean June temperatures vary by 10.5°F (51.0°F. and 39.5°F.). Because of the longer insolation periods diurnal ranges are slightly smaller at alpine elevations. However, these temperature differences are less pronounced in spring and fall, and they even become revereed

at the height of winter. The mean monthly temperature during January was - 8.8°F. at 5380 feet, but - 17.9°F. at 2800 feet elevation. This reversal is caused by temperature inversions, which accompany very stable, calm conditions during very cold weather. At such times the alpine station was often 20°F. warmer than the boreal station.

Wind speeds increased greatly with increasing altitudes, possibly because of lack of friction in the form of trees and tall shrubs at higher elevations. During February, for instance, the average monthly wind speed was 34 miles/hour at 5380 feet compared to only 7.1 miles/hour at 2800 feet elevation.

Cloud cover and humidity also increase with altitude and our data indicate (Table 1) that precipitation does. During the observation period the total annual precipitation at the alpine station was 9.6 inches compared to only 8.1 inches at boreal elevations. Whether this difference is significant, only long-term measurements will show.

Our limited data suggest that Sheep Mountain is drier than any of the other stations listed in Table I; except for the coastal flats along the Arctic Ocean, it may be the driest area in the Yukon.

Under the Köppen classification of climates the boreal zone of Kluane would fall into the Dfc or Dsc (sub-Arctic) category (Trewartha, 1943), while the alpine zone would be ET (tundra) climate. Since the alpine station at 5380 feet had a mean July temperature of 45.9°F., it is resonable to assume (through interpolation) that a station at 4500 feet to 5000 feet would have a mean July temperature of around 50°F. This station would therefore be at the borderline between Dfc or Dsc and ET

climates. It was found during this investigation that the borderline between the sub-alpine shrub zone and the "true" alpine zone is also around the 4500 to 5000 feet contour line. It therefore appears that the upper limit of tall shrubs coincides with the upper limit of Dfc climate, and therefore both, the boreal as well as the sub-alpine vegetation, are within the Dfc or Dsc climatic zone.

Previous Botanical Work in the Kluane Area

In spite of its northern location the Kluane area is fairly well-known botanically - better than any other area in the Yukon and northern British Columbia. This is accounted for by the construction of the Alaska and Haines Highways in the mid 1940's, which brought the area into reach of a number of scientists. But more important in this connection was the establishment of a field station at Kluane Lake by the Arctic Institute of North America in 1961, which was utilized by many investigators during the past decade.

As this review will show, however, most botanical work consisted of collections. Therefore, even though the flora may be well known, the vegetation is not. A number of investigators gave good description of the habitat plants were collected in or briefly described major vegetation units (Murray, 1965, 1971?; Johnson & Raup, 1964; Drury, 1953), but plant ecological work as such was limited to investigations of geographers and geologists who correlated vegetation cover with physiographic phenomena (Price, 1971; Rampton, 1971; Scott, 1968). No phytosociological work had so far been done in the area.

In an excellent review paper, Hulten (1940) gives the history of botanical

explorations in Alaska and the Yukon from the time of their discovery to 1940. In the following account the first set of references is extracted from Hulten's (1940) work.

The first published collection relevant to Kluane National Park was made by Arthur KRAUSE of the Bremen Geographical Society in 1881-82. Krause collected mainly the Lynn Canal, Chilkoot Pass and Chilkat Pass areas and only reached the southernmost portion of the Park, where he collected the Tatschenshini River area (tributary to the Alsek River) on June 25, 26, 28, 1881. The collections were published by Kurtz in Engler's Bot. Jahrb. 19, 1895. A report of the journey was published by Krause in Zeitschrift der Gesellschaft fur Erdkunde, Band 18, 1883 (Hulten, 1940).

Albert J. RUDKIN in 1883 collected 31 species about Mt. St. Elias, which are preserved in the New York Bot. Garden. A list of the species was published by Britton (Bull. Torr. Club II, 1884) (Hulten 1940).

Willard C. HAYES, of U.S. Geological Survey, accompanied Lieutenant F. Schwatka on a military reconnaissance of the Yukon River via the White River in 1883. A few cryptogamic plants were collected and are listed by M. Cummings in an article on the Expedition in Nat. Geogr. Mag. 4, 1892 (Hulten, 1940).

David W. EATON, of the Alaskan Boundary Commission, engaged in surveying the 141st Meridian, 1909 to 1912, obtained a collection in the White River valley near the boundary in 1909 and in 1912 on the 141st Meridian north of Mt. St. Elias. The collection, about two hundred fifty (250) specimens, is preserved in the Nat. Herb., Washington (Hulten, 1940).

The Japanese scientist INOUYE took part in a trip arranged by the 12th

International meeting of Soil Invest. at Toronto and obtained a small collection between August 14th and October 15th, 1913, in S.E. Alaska and adjacent Yukon. A list of the plants was published by Koidzumi (Bot. Mag. Tokyo, 30:68-69, 1916) (Hulten, 1940).

H.F. LAMBERT collected a few specimens at Klutlan Glacier at the head of the White River in August 1913 (Hulten, 1940).

Adolf MULLER collected a series of plants in August 1920 at the following localities: Donjek River, Kluane Lake, Bear Creek and Dezadeash Lake. Collections are in Philadelphia, duplicates in the Nat. Herb., Washington (Hulten, 1940).

Hamilton M. LAING, Member of the first Mt. Logan expedition, obtained a collection of two hundred forty-three (243) specimens at the head of the Chitina River and Chitina Glacier, S.E. Alaska, in May to July 1925. Laing's collection is included in Porsild (1939).

During the period of 1935 to 1941 four expeditions under the leadership of Walter A. WOOD have entered the St. Elias Range. A. Bakewell accompanied the 1939 and 1941 expeditions, during which botanical collections were made. The specimens were identified by H. Raup, Harvard University, and published by Bakewell (1943).

H.M. RAUP and associates of Harvard University made expeditions into the area in 1944 and 1948. The complete set of species are deposited in the Gray Herbarium, Harvard University. Even though reference to the 1944 expedition is made in Raup (1944) and the major vegetation types are briefly described in Johnson & Raup (1964), the complete species list has so far not been published. One of Raup's collection sites was the

south end of Kluane Lake.

W.H. DRURY accompanied Raup during the 1948 expedition and published a detailed account on the birds observed (Drury, 1953). In this paper Drury goes into considerable detail in outlining the plant associations the local birds are found in.

H.J. LUTZ studied the ecological effects of forest fires in the interior of Alaska from 1949 to 1952. Some of the forests sampled were close to the Alaska - Yukon boundary and are therefore relevant to the Kluane area. Lutz collected over five hundred (500) species of vascular plants, mosses and lichens and described in detail the major forest types and successional trends after fires. His publication (Lutz, 1956) contains the species lists.

N.J. FREEDMAN collected one hundred fifty-three (153) taxa of vascular plants while employed with Hudson Bay Exploration in summer 1953. His specimens came from the Quill Creek and Tatamagouche Creek areas. The collection was identified by D. Love, University of Manitoba, who named several new Papaver spp. These were later, however, considered as synonymous with already described taxa by Hulten (1968). This collection was published by Love & Freedman (1956).

H.P. HANSEN (1953) described the post glacial forests in the Yukon Territory and Alaska. His publication is based on field work done during the summer of 1950. Some of his peat sections taken for pollen analyses came from the Kluane area. Hansen did not collect plants and only describes the present forests in general terms.

During the summer of 1957 H.A. CRUM of the National Museum in Ottawa, assisted by W.B. SCHOFIELD, made extensive collections of bryophytes and

vascular plants particularly in the valleys of the Alsek and Dezadeash Rivers. While their bryophyte list has so far not been published, the vascular plants are included in Porsild (1966).

A.E. PORSILD and R.T. PORSILD collected plants along the Haines Highway in summer of 1960. The species list is included in Porsild (1966).

Lloyd A. SPETZMAN, Military Geology Branch of the U.S. Geological Survey, made general plant collections along the Alaska Highway between Snag, near the Alaska boundary, and Champagne, while mapping the vegetation in relation to a planned winter army manouvre in June 1962. The Spetzman collection, totalling 370 odd numbers, is deposited in the National Museum in Ottawa and is included in Porsild's (1966) publication.

As part of his grizzly bear study, A. PEARSON, Canadian Wildlife Service, collected vascular plants during the summer of 1965. Pearson's main collection sites were the terminus of the Dusky Glacier, the upper Alsek River, the summit of Sudgen Creek Pass, and Amphitheatre Mountain near Burwash. The plants are deposited in the National Museum in Ottawa, and the more important species are published as a supplement to Porsild's (1966) contribution.

J.A. NEILSON collected vascular plants in the Shakwak Trench and adjacent Kluane - Ruby Ranges while associated with the Arctic Institute of North America for two seasons (1966 and 1967). His collection is deposited at the University of Alaska Herbarium, and a duplicate collection at the National Museum in Ottawa. His important findings were published in Neilson (1968), and the complete list, supplemented by Porsild's (1966) contribution as well as collections made by D. Murray, University of

Alaska, in Neilson (1972).

R.W. SCOTT collected vascular plants in the Chitistone Pass area, southeast Alaska, while involved in a physiography study with the University of Michigan in summer 1967. The collection is deposited at the University of Michigan Herbarium and has been published by the Arctic Institute of North America (Scott, 1968).

O.K. MILLER, Jr., collected fungi while associated with the Arctic Institute of North America during the summer 1967. Other collections were made by him in the area since 1962. The collections were published by Miller (1968, 1969) and Miller & Gilbertson (1969).

V. RAMPTON conducted field investigations on the Quarternary history of the Snag - Klutlan area during the summers 1965 to 1967 and the spring of 1968. In a paper (Rampton, 1971), a paleobotanical record from the area and the vegetational and climatic interpretations of it are presented.

L.W. PRICE studied vegetation, microtopography and depth of active layer on four slopes with different exposures in alpine tundras of the Ruby Range during the summers of 1967 and 1968. His plant species were identified by D. Murray and J. Neilson; they are kept in the investigator's private collection. The study has been published by Price (1971).

D.F. MURRAY has been involved in plant - ecological work and collections in the St. Elias Mountains and adjacent Wrangell Mountains with interruptions from 1965 to the present, largely in association with the Arctic Institute of North America. No other single investigator contributed as much to the knowledge of the alpine flora of the area. Murray has collected in many alpine areas and has gone into great detail in the following three

localities: Kaskawulsh Nunatak, Steele Glacier and Slim's Tundra, located between Sheep and Bullion Creeks. Some of his work has been published (Murray, 1965, 1968, 1971a, 1971b).

The writer worked in the Kluane area during the summers 1969 to 1972. In 1970 to 1971 he was associated with the Arctic Institute of North America. Plant collections were made every season, and an additional collection was made by V. KRAJINA, University of British Columbia, in summer 1970. The collections are deposited at the U.B.C. Herbarium, with a small duplicate collection at the University of Alaska Herbarium and the Yukon Game Branch. A number of willow specimens are with the National Museum in Ottawa. The collections amounted to four hundred twenty-three (423) taxa of vascular plants, fifty-eight (58) lichens and forty-five (45) mosses and hepaticae. Complete lists are attached as an appendix to this work.

## Methods and Materials

An important objective of this study was to describe the vegetation of Sheep Mountain for the purpose of constructing a vegetation map. The methods used were those of the European and Scandinavian schools of phytosociology, which have during the past two decades been employed in various areas of North America (Becking 1954, 1956; Krajina 1960, 1969; Brooke, Peterson & Krajina 1970). The philosophy and methodology of these schools are discussed in detail by Poore (1955, 1956, 1962) and Dahl (1956).

The study area -- Sheep Mountain -- covers an area of approximately 11 square miles in area and includes three major vegetation zones; boreal-

montane, sub-alpine and alpine. The vegetation cover changes accordingly in floristic composition, structure and coverage. Field work started in July 1970. Most plots were analysed between mid June and mid September 1971. Some additional plots had to be established during the summer of 1972.

Analyses of Vegetation:

More than 300 sample plots were located in what appeared to be homogeneous portions of the vegetation cover. In the analyses only 225 plots were used; the others described transitional stages. Plot size was kept uniform at 10 meters by 10 meters, except along creeks or narrow ridges where it was changed to 5 meters by 20 meters, thereby maintaining the total area per plot. For each large community type 10 replicate plots were established and for each small or rare community type 5 replicate plots were located. To be able to come up with the required number of replicates, it was, on occasion, necessary to go beyond the outlined boundaries of Sheep Mountain. Some plots were analysed on the south side of Mount Wallace and some on the "Bullion Plateau", between Sheep Creek and Bullion Creek to the west; but both these areas are within two to three miles of Sheep Mountain and have comparable ecological conditions.

The vegetation of each plot was analysed according to techniques of the Zürich - Montpellier School as modified by Krajina (1933). The analyses included the listing of all species (vascular plants, bryophytes, lichens) according to strata (A - trees, B - schrubs, C - herbaceous vegetation, D - lichens and bryophytes). Each species was rated as to its species significance, sociability and vigor according to the following scales developed by Krajina (1933) from Braun-Blanquet (1932) methods.

Species significance:

| | |
|---|---|
| + | quite solitary |
| 1 | seldom |
| 2 | very scattered |
| 3 | scattered |
| 4 | 5 to 10% cover |
| 5 | 10 to 20% cover |
| 6 | 20 to 30% cover |
| 7 | 30 to 50% cover |
| 8 | 50 to 75% cover |
| 9 | 75 to 95% cover |
| 10 | 95 to 100% cover |

Sociability:

| | |
|---|---|
| + | sporadic |
| 1 | 4 x 4 $cm^2$ |
| 2 | 25 x 25 $cm^2$ |
| 3 | 50 x 50 $cm^2$ |
| 4 | 1/3 to 3/4 $m^2$ |
| 5 | 1 to 2 $m^2$ |
| 6 | 5 $m^2$ |
| 7 | 25 to 50 $m^2$ |
| 8 | 100 $m^2$ |
| 9 | 200 to 250 $m^2$ |
| 10 | 500 $m^2$ |

Vigor:

| | |
|---|---|
| 0 | dead |
| + | dying |
| 1 | very poor |
| 2 | healthy, but not well developed |
| 3 | best, with complete life cycle |

(+) and (-) may be used for intermediate conditions

In addition notes were made on life form and the phenological stage of the various species in a plot.

Analyses of Environmental Factors:

Time restrictions did not permit detailed analyses of the soil and the micro climate of the different vegetation units, but a number of physical parameters were determined which helped to explain the various vegetation - environmental relationships.

For each plot we determined altitude; exposure; slope gradient; land type; land form; history (fire, grazing, other disturbance); rockiness and stoniness of the surface; depth of soil; parent material; percent of humus, mineral soil, decaying wood or stones in the surface horizon; and the soil moisture regimes according to the following hygrotope units:

1 - very dry to dry (xeric conditions); rock outcrops

2 - moderately dry (well drained soils; dry by mid summer)

3 - mesic (well drained soil, seepage during spring run-off)

4 - hygric (moderate to imperfectly drained soils)

5 - hydric (imperfectly to very poorly drained soils, often saturated or inundated throughout the year)

Intermediate conditions were indicated by (+) or (-), and evaluations were made at the height of the growing season in July. A number of associations are considerably moister during spring run-off.

Snow duration in months as well as maximum depths were determined during the 1970/71 winter through the establishment of 160 permanent snow posts, which were distributed over the three altitudinal zones and included sampling of all associations. These measurements were supplemented by frequent sampling of the snow depths with a ruler. Measurements were taken at least at weekly intervals, plus immediately after every heavy snow fall or major removal period (chinooks).

Standard forms for all environmental and vegetational measurements were filled in for each plot, samples of these are attached as an appendix to this thesis. Not all of the factors listed in Table II, which deals with the analyses of soils, could be investigated.

Nomenclature and authorities for vascular plants, with very few exceptions, follow Hulten (1968), for mosses and hepatics Schofield (1969 a, b), and for lichens Otto & Ahti (1967). Voucher specimens of vascular plants and mosses are deposited at the University of British Columbia herbarium, and of lichens at the University of Wisconsin herbarium.

Vegetation Tables:

Using the synthesizing method referred to by Poore (1955, 1962) as "successive approximation", lists of "assumed" vegetational units were compared for similarities and differences and for conformity to a certain scheme of interrelationships. A number of plots with transitional vegetation were discarded which required additional sampling in the summer of 1972 to incorporate the desired number of replicates. In the delineation of units the following order of priority was followed: 1) species significance (dominance and abundance), 2) constancy or presence, 3) fidelity, 4) vigor, and 5) ecological factors (altitude, aspect, hygrotope, snow cover).

Synthesis of the floristic data, supplemented by environmental variables, revealed consistencies of 32 groups of plots; of these vegetational units were developed at three levels of classifications: orders, alliances and associations. Nomenclature of these units follows standard practices of the Zürich - Montpellier School (Drees 1953; Neuhäusl 1968).

| | | |
|---|---|---|
| Order: | - | etalia |
| Alliance: | - | ion |
| Association: | - | etum |
| Sub-association: | - | etosum |

For constancy or presence values the following scale was applied:

| | |
|---|---|
| Species present in 1% to 20% of the plots, | Class I |
| 21% to 40% | Class II |
| 41% to 60% | Class III |
| 61% to 80% | Class IV |
| 81% to 100% | Class V |

Tables of associations list the plots arranged with increasing altitude, and the species within each plot arranged firstly according to strata (trees, shrubs, herbs, lichens and bryophytes) and within each stratum according to decreasing species significance and constancy. For each species the species significance value is followed by the sociability value; these two values are separated by a full stop. At the end of each column the constancy value of the different species is listed for that group of plots, the most frequently observed value for vigor and the average species significance. The latter was computed because it was later used in an overall synthesis table for all vegetation units.

A second set of tables (attached in the appendix) was constructed for each order and the lower units (alliances and associations) within it. Here the species are arranged according to their importance as order-- alliance-- and association character species, and companion species. Within each of these categories, species are arranged firstly according to strata (trees, shrubs, herbs, bryophytes and lichens); and within each stratum they are arranged alphabetically.

Lastly, a condensed table of the floristic structure of all plant associations and their higher unit was constructed (attached in the appendix). Here the species are arranged according to order--

alliance -- and association character species, under each of these headings according to strata, and within each stratum alphabetically. Only character species are listed in this overall synthesis table. For each species its average species significance value is given as well as the constancy value in the respective associations.

Vegetation Map:

A number of schools of phytosociology have come into being, but two have become dominant and their methods and philosophies are followed by the majority of synecologists today. The first school is known as the "Zürich - Montpellier School", often also referred to as the "European School", and was developed under the leadership of Braun - Blanquet in Switzerland. In its basic philosophy is the assumption that the vegetation cover of the earth can be classified into a hierarchy of systematic units. The basic unit is the association, which in many respects is comparable to a plant community, and which is analogous to the level of the species in the hierarchy of taxonomic units. A number of closely related associations can be grouped into an alliance, and a number of closely related alliances can be grouped into orders, in a similar manner in which several species make up a genus and several genera make up a family. Still higher systematic units are classes and zones. The important point is that this school recognized distinct vegetation units in the mosaic of a landscape and boundaries between them.

The other school, which has a great number of followers particularly on the American continent, is the "Wisconsin School" which developed under the leadership of John Curtis, and which is also referred to as the "Ordination School". Its basic philosophy denies the presence of distinct

units in the vegetation cover and it developed the idea of the continuum.

Since the basic objective of this study was to construct a vegetation map, the phytosociological methods of the Zürich - Montpellier School were applied, since the idea of the continuum of the Wisconsin School, implies in many instances a denial of the existence of vegetational boundaries. It is not possible to draw up a map without showing boundaries.

The procedure of constructing the vegetation map followed very closely "Küchler's Comprehensive Method" (Küchler, 1967). The baseline map was a blow-up of aerial photographs (RCA A15434 - 108) to a scale of about 1:6200, giving a size of the study area on the map of about 3 x 4 feet. The mosaic of vegetation cover on this photograph was then delineated and classified into similar units on the basis of colour, texture, altitude and aspect. Duplicates of portions of this photograph were taken into the field and representative plots were analyzed in each of the units. A number of additional units (associations), which were not discernible from the photograph, were located in the field and transferred to the map. This applied particularly to the alpine vegetation whose associations are often of similar height and coverage, and on the photographs similar in texture and colour. It also applied to flood-plain and grassland associations. Additional colored aerial photgraphs were taken in early fall at the time when the leaves begin to change colour (mid September). These colour changes are species - specific; poplar and aspen change colour before willows; all three turn yellow in contrast to dwarf birch which turns red. Colored photographs were very useful in delineating boundaries between willows and poplar - aspen stands in the boreal and sub-alpine zones, and between grasslands (yellow)

and other associations (brownish) in alpine zone.

In addition to airphotos (RCA A15434 - 108) the topographic map sheet of Destruction Bay (Department of National Defense, Canada, Sheet 115 G/2) served for base line information. From it were obtained such physical variables as altitude, contour, longitude and latitude. The vegetation map was further divided into 45 sections, each of which contained 100 quadrats, in order to precisely describe the distribution of plant associations as well as the utilization patterns of sheep over the study area.

Other details of the map as far as symbols or patterns of various associations go, types of physiographic phenomena and degree of accuracy of boundaries, are described in the legend. The map is attached as an appendix of this work.

## CLASSIFICATION OF VEGETATION ON SHEEP MOUNTAIN

Three biogeoclimatic zones are distinquished in the area of this study.

(1) The boreal (montane) spruce biogeoclimatic zone from the lowest elevations (around 2570' or 770 m elevation above sea) up to about 3800' or 1100 m, in which the mesic (zonal) vegetation on calcareous soils is the white spruce forest.

(2) The subalpine willow - birch biogeoclimatic zone as described by Krajina (1974), extends between 3800' or 1100 m up to about 5000' or 1500 m in which the mesic (zonal) vegetation is characterized by willow and birch shrubs.

(3) The alpine tundra biogeoclimatic zone, developed above 5000' or 1500 m, in which the mesic (zonal) vegetation on calcareous soils

is characterized by plant communities where Dryas integrifolia is predominant.

32 plant associations were found and grouped into 23 alliances and 17 orders. Table 2 shows a synopsis of all these systematic units and Table 3 lists the approximate acreages each association occupies on the mapped area. As it should be expected, some synecological orders cross the borders of the biogeoclimatic zones, because the plant associations, belonging to them, find their suitable habitats even in the areas where the general macroclimates are distinctly different. This becomes obvious especially in the grassland (steppe) vegetation occurring in both the boreal (montane) spruce as well as the subalpine willow - birch biogeoclimatic zones. Another such case is the alpine tundra vegetation, occurring mainly in the alpine tundra biogeoclimatic zone, but occassionally descending also into the subalpine willow - birch biogeoclimatic zone where the large accumulation of snow by drift shortens the vegetation season of the subalpine zone. This will become obvious from the discussion of different synecological units of the whole classification of the vegetation.

Order 1. PUCCINELLIO - SALICORNIETALIA Braun-Blanquet & de Leeuw, 1936.
In our study area it occurs only in the boreal (montane) zone in the Slims River flood-plain (mapping sections: E3, E4, E5, F3, F4, F5) on saline and alkaline soils, in the spring temporarily inundated, poorly drained, gleyed and becoming slightly solonetzic by summer desiccation. The total area occupied by this order is approximately 426 acres.

Alliance 1. Puccinellion deschampsioidis Hoefs & Krajina

The characteristic combination of species (for the order and the

Table 2. SYNOPSIS OF THE SYNSYSTEMATIC UNITS IN THE AREA OF THE STUDY

| ORDER | ALLIANCE | ASSOCIATION |
|---|---|---|
| 1. PUCCINELLIO - SALICORNIETALIA | 1. Puccinellion deschampsioidis | 1. Puccinellio (deschampsioidis) - Taraxacetum laceri |
| | | 2. Astero (yukonensis) - Hordeo (jubati) - Puccinellietum deschampsioidis |
| | | 3. Hordeo (jubati) - Asteretum yukonensis |
| | 2. Deschampsion caespitosae | 4. Astero (yukonensis) - Deschampsietum caespitosae |
| 2. CARICETALIA AQUATILIS | 3. Triglochinion palustris | 5. Triglochino (palustris) - Juncetum arctici |
| | | 6. Triglochino (palustris) - Caricetum aquatilis |
| 3. SALICETALIA PLANIFOLIAE | 4. Salicion brachycarpae | 7. Astero (yukonensis) - Junco (arctici) - Salicetum brachycarpae |
| | 5. Salicion planifoliae | 8. Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae |
| 4. DRYADETALIA DRUMMONDII | 6. Dryadion drummondii | 9. Dryadetum drummondii |
| 5. POPULETALIA BALSAMIFERAE | 7. Junipero (communis & horizontalis) - Shepherdio (canadensis) - Populion tremuloidis | 10. Poso (acicularis) - Shepherdio (canadensis) - Populetum tremuloidis |
| 6. CALAMAGROSTIDO (PURPURASCENTIS) - ARCTOSTAPHYLETALIA UVAE-URSI | 8. Calamagrostido (purpurascentis) - Arctostaphylion uvae-ursi | 11. Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi |
| 7. PICEETALIA GLAUCAE - MARIANAE | 9. Hypno (procerrimi) - Abietinello (abietinae) - Piceion glaucae | 12. Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae |
| 8. ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS | 10. Artemisio (frigidae) - Agropyrion yukonensis | 13. Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis |
| | | 14. Artemisio (frigidae) - Agropyro (yukonensis) - Eurotietum lanatae |
| | | 15. Pentstemono (gormanii) - Artemisietum frigidae |
| | | 16. Agropyro (yukonensis) - Artemisietum frigidae - rupestris |
| | | 17. Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum filifoliae |
| 9. BETULI ?ALI? GLANDULOSAE | 11. Potentillo (fruticosae) - Salicion glaucae | 18. Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae |
| | | 19. Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - lanatae - glaucae |
| 10. ARTEMISIETALIA ALASKANAE | 12. Artemision alaskanae | 20. Artemisietum alaskanae |
| | 13. Artemisio (hyperboreae - alaskanae) - Salicion myrtillifoliae | 21. Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae |
| 11. DRYADETALIA INTEGRIFOLIAE | 14. Carico (scirpoideae) - Dryadion integrifoliae | 22. Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae |
| | 15. Dryado (integrifoliae) - Cassiopion tetragonae | 23. Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae |
| 12. OXYTROPO (VISCIDAE) - ARTEMISIO (HYPERBOREAE) - FESTUCO (BRACHYPHYLLAE) - TRISETETALIA SPICATI | 16. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetion spicati | 24. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati |
| | | 25. Oxytropo (huddelsonii) - Salicetum dodgeanae |
| 13. AGROPYRETALIA VIOLACEI | 17. Agropyrion violacei | 26. Agropyretum violacei |
| 14. FESTUCETALIA ALTAICAE | 18. Festucion altaicae | 27. Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae |
| 15. SALICETALIA BARRATTIANAE | 19. Salicion barrattianae | 28. Salicetum barrattianae |
| 16. SALICETALIA POLARIS | 20. Saxifraga (oppositifoliae) - Oxyrio (digynae) - Salicion polaris | 29. Saxifraga (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris |
| | 21. Senecione (lugentis) - Salicion polaris - reticulatae | 30. Senecione (lugentis) - Salicetum polaris - reticulatae |
| 17. PETASITETALIA FRIGIDI | 22. Oxyrio (digynae) - Artemision arcticae - tilesii | 31. Oxyrio (digynae) - Artemisietum arcticae - tilesii |
| | 23. Saxifraga (hirculi) - Caricion membranaceae | 32. Saxifraga (hirculi) - Caricetum membranaceae |

SIZES OF ASSOCIATIONS OF THE MAP AREA IN ACRES

Numbers of Associations[1]

| (2) Sect. No. | 1;2 3;4 | 5;6; | 7;8; | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Scree | 27 | 28 | 29 | 30 | 31 | 32 | Cliffs | Boulder Fields | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A 1 | | | | | 2.5 | 0.5 | 1.5 | | | | | | 16.0 | | | | 6.0 | 4.0 | | | | 3.5 | | | | | | | 7.5 | | 31.5 |
| A 2 | | | | | 1.0 | 0.5 | | | | | | | 74.0 | | | | 8.0 | 2.5 | | | | 4.5 | | | | | | | 4.0 | | 90.0 |
| A 3 | | | | | | | | | | | | | | | | | 1.0 | | | | | 0.5 | 0.5 | | | 1.5 | 0.5 | | | | 14.5 |
| A 4 | | | | | | | | | | | | | | | | | 4.5 | | | 0.5 | | | | | 2.5 | 3.0 | 0.5 | 12.5 | | | 4.5 |
| A 5 | | | | | | | | | | | | | | | | | 6.5 | | 0.5 | | | 47.0 | | | 4.0 | | | | 52.0 | | 22.5 |
| A 6 | | | | | | | | | | | | | | | | | 7.0 | 1.0 | | | | | | | | | | | 55.5 | | 110.0 |
| A 7 | | | | | 1.0 | | 25.0 | | | | | | | 29.0 | | | | | | | | | | | | | | | | | 118.5 |
| A 8 | | | | | | | 33.0 | | | | | | | | | | | | | | | | | | | | | | | | 33.0 |
| B 1 | | | | | 1.0 | 5.5 | 46.5 | | | | | | 14.0 | | | | | | | | | 9.0 | | | | | | | 3.0 | | 79.0 |
| B 2 | | | | | | 1.0 | | 5.5 | | | | 4.0 | 139.0 | | | | 12.5 | | | | | 32.5 | | | | | | | 10.0 | | 204.5 |
| B 3 | | | | | | | | | | | | 5.0 | 1.0 | | | | 51.0 | | 6.5 | 0.5 | | 35.5 | | | 0.5 | | | | 86.0 | | 186.0 |
| B 4 | | | | | | | | | | | | | | | | | 149.0 | | 1.0 | 2.0 | | 6.0 | 2.0 | | 17.0 | 5.5 | 0.5 | | 4.5 | | 187.5 |
| B 5 | | | | | | | | | | | | | | | | | 129.0 | | 3.5 | 3.5 | 20.0 | 5.5 | 3.0 | 7.5 | 4.5 | 0.5 | | | 28.0 | | 205.0 |
| B 6 | | | | | | | | 1.5 | | | | 8.0 | | | | | 82.0 | 2.0 | 14.5 | 1.0 | 10.0 | 52.5 | | | 0.5 | | | | 32.5 | | 204.5 |
| B 7 | | | | | | 1.0 | 34.5 | 15.0 | | | | 3.0 | | 75.0 | | | 39.5 | | | | | | | | | | | | 37.0 | | 205.0 |
| B 8 | | | | | | | 173.5 | | | | | | | | | | | | | | | | | | | | | | | | 173.5 |
| C 1 | | | | | | 3.0 | 122.5 | | | | | | 7.5 | | | | | | | | | | | | | | | | 4.5 | | 141.0 |
| C 2 | | | | | | | 8.5 | 13.5 | | | | 4.0 | 141.0 | | | | 8.0 | 1.0 | | | | 15.5 | | | | | | | 13.5 | | 205.0 |
| C 3 | | | | | | | | | | | | 5.0 | 16.5 | | | | 31.5 | | 14.5 | 0.5 | | 36.0 | | | | | | | 100.0 | | 204.0 |
| C 4 | | | | | | | | | | | | | 0.5 | | 3.0 | 2.5 | 24.0 | | 8.5 | | 50.0 | 44.0 | | | | 0.5 | | | 71.5 | | 204.5 |
| C 5 | | | | | | | | | | | | | 1.0 | | | 0.5 | | | | | 30.0 | 48.0 | | | | | | | 124.0 | | 204.5 |
| C 6 | | | | | | | | 28.0 | | | | 5.0 | 20.0 | | | | 34.0 | 0.5 | | | 20.0 | 47.5 | | | | | | | 49.5 | | 204.5 |
| C 7 | | | | | | 5.0 | 87.5 | 17.5 | | | 5.0 | | | 60.5 | | | 6.0 | | | | | 2.5 | | | | | | | 20.5 | | 204.5 |
| C 8 | | | | | | 1.0 | 62.0 | 0.5 | | | | | | | | | | | | | | | | | | | | | | | 63.5 |
| D 1 | | | | 0.5 | 2.5 | 9.5 | 37.5 | 10.0 | | | | | 6.0 | | | | | | | | | | | | | | | | 26.5 | | 92.5 |
| D 2 | | | | | 6.0 | 3.0 | 15.0 | 135.0 | | | | | 34.5 | | | | 1.5 | | | | | | | | | | | | 9.5 | | 204.5 |
| D 3 | | | | | 18.5 | 3.0 | 10.5 | 63.0 | | | 40.0 | | 39.0 | | | | | | | | | 8.0 | | | | | | | 21.5 | | 203.5 |
| D 4 | | | | | 21.5 | 16.5 | 6.0 | 37.5 | 2.0 | | 60.0 | | 35.0 | | 0.5 | 0.5 | | | | | | 24.5 | | | | | | | | | 204.0 |
| D 5 | | | | | 6.0 | 12.5 | 20.0 | 53.0 | 1.0 | | 40.0 | | 14.5 | | | | | | | | | 21.5 | | | | | | | 37.0 | | 204.5 |
| D 6 | | | | | 2.5 | 10.5 | 30.0 | 61.0 | | | 40.0 | | 13.0 | | | | | | | | | 23.5 | | | | | | | 25.0 | | 205.5 |
| D 7 | | | | | 3.0 | 18.5 | 100.0 | 41.0 | | | | | | 0.5 | | | | | | | | 6.0 | | | | | | | 14.5 | 15.5 | 199.0 |
| D 8 | | | | | | 0.5 | 21.5 | 0.5 | | | | | | | | | | | | | | | | | | | | | | | 22.5 |
| E 1 | | | | 3.5 | | 13.5 | 49.5 | 25.0 | | | | | | | | | | | | | | | | | | | | | 6.0 | | 97.5 |
| E 2 | | 1.0 | | | 1.0 | 16.0 | 160.0 | 25.0 | | | | | | | | | | | | | | | | | | | | | 1.0 | | 204.0 |
| E 3 | 28.5 | 9.5 | 0.5 | | 0.5 | 20.0 | 109.0 | 30.0 | | 1.0 | | | | | | | | | | | | | | | | | | | 0.5 | | 200.5 |
| E 4 | 102.5 | 2.5 | | | 8.0 | 14.5 | 54.5 | 19.0 | | 2.5 | | | | | | | | | | | | | | | | | | | | | 203.5 |
| E 5 | 51.5 | | | | 10.0 | 15.5 | 12.5 | 52.0 | | | | | | | | | | | | | | | | | | | | | | | 141.5 |
| E 6 | | | | | 2.0 | 17.5 | 60.0 | 26.5 | | | | | | | | | | | | | | | | | | | | | | | 106.0 |
| E 7 | | | | | | 3.0 | 2.5 | 2.5 | | | | | | | | | | | | | | | | | | | | | | 25.0 | 33.0 |
| F 1 | | | | | | | 1.0 | | | | | | | | | | | | | | | | | | | | | | | | 1.0 |
| F 2 | | 3.0 | 27.5 | | 1.0 | 3.5 | 25.0 | 5.0 | | | | | | | | | | | | | | | | | | | | | 0.5 | | 65.5 |
| F 3 | 43.5 | | 39.0 | | | 3.0 | 5.0 | 3.0 | | | | | | | | | | | | | | | | | | | | | 2.5 | | 96.0 |
| F 4 | 100.0 | | 0.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 100.5 |
| F 5 | 100.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 100.0 |
| Sum | (3) 426.0 | (4) 16.0 | (5) 67.5 | 4.0 | 88.0 | 198.0 | 1314.0 | 675.0 | 3.0 | 3.5 | 185.0 | 34.0 | 572.5 | 165.0 | (6) 3.5 | 3.5 | 601.0 | (7) 11.0 | 49.0 | 8.0 | (8) 130.0 | 473.5 | (9) 5.5 | (10) 7.5 | (11) 29.0 | (12) 11.0 | 1.5 | 12.5 | 848.5 | 40.5 | 5986.0 |

(about 9.3 square miles)

TABLE 3: (cont'd)

EXPLANATIONS:

(1) For names of associations corresponding to these numbers see Table 2.

(2) For pattern of numbering of sections and quadrats see vegetation map.

(3) These four associations are lumped, since they cannot be separated from air photographs. Field work indicates that Puccinellio - Taraxacetum laceri is the smallest (perhaps 5 acres), followed by Hordeo - Asteretum yukonensis (perhaps 50 acres), followed by Astero - Hordeo - Puccinellietum deschampsioidis and Astero - Deschampsietum caespitosae which are both very common (150 to 200 acres each).

(4) These two associations are lumped, since they cannot be separated from air photographs. Field work revealed that Triglochino - Juncetum arctici is more common than Triglochino - Caricetum aquatilis.

(5) These two associations are lumped, since they cannot be separated from air photographs. Field work revealed that Astero - Junco - Salicetum brachycarpae is more common than Eriophoro - Carico - Salicetum planifoliae.

(6) Artemisietum alaskanae is probably more widespread than indicated here, since large tracts of scree slopes could not be investigated.

(7) Salico - Cassiopo - Dryadetum integrifoliae, even though of limited extent in the mapping area, is much more common around Mount Wallace north of the study area.

(8) Agropyretum violacei is probably more widespread than indicated

TABLE 3: (cont'd)

here, since large tracts of scree slopes could not be investigated.

(9,10) Artemisio - Salico - Festucetum altaicae and Salicetum barrattianae, even though of limited extent in the mapping area, are very common on "Bullion Plateau" about 2 to 3 miles west of the study area.

(11) This acreage only refers to typical "snow bed sites". Less typical "stands" of Saxifrago - Oxyrio - Salicetum polaris, particularly transition zones to Salico - Sileno - Carico - Dryadetum integrifoliae and to Seneciono - Salicetum polaris - reticulatae are common and widespread.

(12) "Typical" sites of Seneciono - Salicetum polaris - reticulatae are limited in extent, but transitional stages to Saxifrago - Oxyrio - Salicetum polaris, to Salico - Sileno - Carico - Dryadetum integrifoliae and to Artemisio - Salico - Festucetum altaicae are more common.

alliance) is:

Aster yukonensis
Hordeum jubatum
Puccinellia deschampsioides
Taraxacum lacerum

Association 1. Puccinellio (deschampsioidis - Taraxacetum laceri

Association 2. Astero (yukonensis) - Hordeo (jubati) - Puccinellietum deschampsioidis

Association 3. Hordeo (jubati) - Asteretum yukonensis

There are three plant associations in this alliance which are distinguishable mainly by distinctly different degrees of average species significance values and constance of otherwise the same plants belonging to the same alliance and order (as is obvious from Tables 4,5 and 6).

Alliance 2. Deschampsion caespitosae Hoefs & Krajina

Only one plant association belongs to this alliance, the soils of which are evidently less saline than those of the previous three plant associations.

Association 4. Astero (yukonensis) - Deschampsietum caespitosae

The characteristic combination of species (alliance and association) is:

Deschampsia caespitosa var. glauca
Ranunculus cymbalaria

The soils of all four associations in this order are saturated and often inundated during run-off in early summer. In late summer, however, they show different degrees of desiccation and the distribution of vegetation on them can be correlated to a moisture gradient, as will be discussed.

FIGURE 4: Puccinellio (deschampsioidis) - Taraxacetum laceri occupying the driest locations on the Slims River flood plain.

FIGURE 5: Zonation along a fairly steep moisture gradient between Astero (yukonensis) - Hordeo (jubati) - Puccinellietum deschampsioidis at the left in photograph, Hordeo (jubati) - Asteretum yukonensis (dark strip in centre), and Astero (yukonensis) - Deschampsietum caespitosae on the right of the photograph.

Table 4.

Order: 1. PUCCINELLIO - SALICORNIETALIA

Alliance: 1. Puccinellion deschampsioidis

Association: 1. Puccinellio (deschampsioidis) - Taraxacetum laceri

| Number of plots | 1 | 2 | 3 | 4 | 5 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|
| Plot number | 85 | 86 | 90 | 401 | 402 | | | |
| Date | 13.8. 71 | 13.8. 71 | 13.8. 71 | 17.9. 72 | 17.9. 72 | | | |
| Elevation (feet) | 2575 | 2575 | 2575 | 2575 | 2575 | | | |
| Exposure | flat | | | | | | | |
| Slope | flat | | | | | | | |
| Hygrotope | 3- | 3- | 3/4 | 3- | 3- | | | |
| *Taraxacum lacerum* | 3.1 | 3.1 | 3.1 | 3.2 | 3.1 | V | 3.0 | 3 |
| *Puccinellia deschampsioides* | +.+ | +.1 | +.1 | +.1 | . | IV | 0.8 | 2+ |
| *Aster yukonensis* | +.1 | +.+ | . | . | +.1 | III | 0.6 | 2 |

Table 5.

Order: 1. PUCCINELLIO - SALICORNIETALIA

Alliance: 1. Puccinellion deschampsioidis

Association: 2. Astero (yukonensis) - Hordeo (jubati) - Puccinellietum deschampsioidis

| Number of plots | 1 | 2 | 3 | 4 | 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Plot number | 88 | 89 | 94 | 97 | 98 | | | |
| Date | 13.8. 71 | 13.8. 71 | 13.8. 71 | 13.8. 71 | 13.8. 71 | | | |
| Elevation (feet) | 2570 | 2570 | 2570 | 2570 | 2570 | (+) | | |
| Exposure | flat | | | | | | | |
| Slope | flat | | | | | | | |
| Hygrotope | 4+ | 4+ | 3/4 | 3/4 | 4+ | | | |
| | | | | | | Constancy | Average species significance | Vigor |
| *Puccinellia deschampsioides* | 6.2 | 5.1 | 7.2 | 5.2 | 2.2 | V | 5.0 | 3 |
| *Aster yukonensis* | 2.1 | 3.1 | 1.1 | 1.1 | 5.2 | V | 2.4 | 2+ |
| *Hordeum jubatum* | 2.1 | 2.1 | 3.1 | 2.1 | 1.1 | V | 2.0 | 3 |
| *Taraxacum lacerum* | +.1 | +.1 | . | . | +.1 | III | 0.6 | 2+ |
| *Deschampsia caespitosa* | +.1 | . | . | . | . | I | 0.2 | 2 |

Table 6.

Order: 1. PUCCINELLIO - SALICORNIETALIA

Alliance: 1. Puccinellion deschampsioidis

Association: 3. Hordeo (jubati) - Asteretum yukonensis

| Number of plots | 1 | 2 | 3 | 4 | 5 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|
| Plot number | 82 | 84 | 87 | 102 | 400 | | | |
| Date | 13.8. 71 | 13.8. 71 | 13.8. 71 | 13.8. 71 | 17.9. 72 | | | |
| Elevation (feet) | 2570 | 2570 | 2570 | 2570 | 2570 | | | |
| Exposure | flat | | | | | | | |
| Slope | flat | | | | | | | |
| Hygrotope | 4+ | 4+ | 4+ | 4+ | 4+ | | | |
| *Aster yukonensis* | 5.1 | 4.1 | 6.2 | 4.2 | 4.2 | V | 4.6 | 3 |
| *Hordeum jubatum* | 2.1 | 1.1 | 1.1 | 1.1 | 1.1 | V | 1.2 | 2+ |
| *Puccinellia deschampsioides* | +.1 | . | 2.1 | +.1 | 1.1 | IV | 1.0 | 2 |
| *Deschampsia caespitosa* | +.1 | 1.1 | 2.1 | . | 1.1 | IV | 1.0 | 2 |
| *Taraxacum lacerum* | . | . | +.1 | . | . | I | 0.2 | 2 |

Table 7.

Order: 1. PUCCINELLIO - SALICORNIETALIA

Alliance: 2. Deschampsion caespitosae

Association: 4. Astero (yukonensis) - Deschampsietum caespitosae

| Number of plots | 1 | 2 | 3 | 4 | 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Plot number | 81 | 83 | 93 | 95 | 99 | | | |
| Date | 13.8. 71 | 13.8. 71 | 13.8. 71 | 13.8. 71 | 13.8. 71 | | | |
| Elevation (feet) | 2570 | 2570 | 2570 | 2570 | 2570 | (-) | | |
| Exposure | flat | | | | | | | |
| Slope | flat | | | | | | | |
| Hygrotope | 4 | 4+ | 4 | 4 | 4 | Constancy | Average species significance | Vigor |
| *Deschampsia caespitosa* | 4.1 | 5.1 | 6.2 | 5.1 | 5.2 | V | 5.0 | 3 |
| *Aster yukonensis* | 1.1 | 2.+ | 3.1 | 2.1 | 2.1 | V | 2.0 | 2 |
| *Ranunculus cymbalaria* | +.+ | . | 2.1 | . | +.+ | III | 0.8 | 2 |
| *Triglochin palustre* | . | . | . | 2.+ | +.+ | II | 0.6 | 2+ |
| *Hordeum jubatum* | . | . | 2.1 | . | . | I | 0.4 | 2 |
| *Puccinellia deschampsioides* | . | . | 1.1 | . | . | I | 0.2 | 2 |
| *Juncus arcticus* | . | . | . | 1.1 | . | I | 0.2 | 2 |
| *Equisetum variegatum* | . | . | . | . | 1.+ | I | 0.2 | 2 |

FIGURE 6:

Triglochino (palustris) - Juncetum arctici

Note the salt crust forming at the soil surface in late summer. Subsurface is moist throughout the season.

FIGURE 7:

Triglochino (palustris) - Caricetum aquatilis

Photograph shows Carex aquatilis in bloom during June.

Soils of this association are water saturated throughout the season and often flooded.

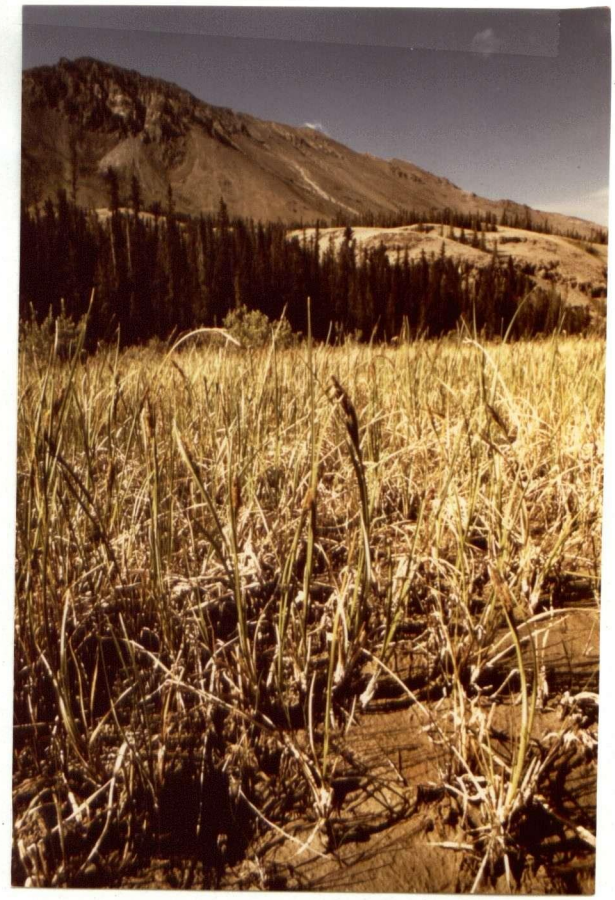


Figure 4 shows the sparse vegetation cover of Puccinellio (deschampsioidis) - Taraxacetum laceri, which occupies the driest, portions of the Slims River flood-plain. This association is small in extent, probably not exceeding 5 acres in the study area. Figure 5 shows a transition zone between the other three associations in this order. Hordeo (jubati) - Asteretum yukonensis occupies a rather narrow belt between the other two - much larger - associations. Tables 4, 5, 6, 7, 33 and 53 give details on these associations and their higher synsystematic units.

Order 2. CARICETALIA AQUATILIS Hoefs & Krajina

These are wetlands with gleysols with continuous water supply and some effective (even if slow) drainage. They are restricted to the boreal (montane) zone in this area, even if they theoretically could develop also in the subalpine zone.

This order is related to the European Caricetalia fuscae the name of which was originally applied either by Lambert & Krajina (1968) or by Barrett & Krajina (1972) for the North American wetlands. However, it is considered now as necessary to separate these Caricetalia aquatilis from Caricetalia fuscae. They include Caricion aquatilis and Eriophorion angustifolii, both alliances described by Lambert and Krajina (1968), originally assigned to Caricetalia fuscae. The third alliance of the Caricetalia aquatilis is described here as follows:

Alliance 3. Triglochinion palustris Hoefs & Krajina

The characteristic combination of species (order and alliance) is:

Calamagrostis neglecta
Carex aquatilis
(Juncus arcticus)*
Triglochin palustre

Evidently the two plant communities, included into this alliance,

* Species in brackets are less characteristic than those without brackets.

are characterized by their floristic structures containing several characteristic plants for Puccinellio - Salicornietalia (Aster yukonensis, Puccinellia deschampsioides, Hordeum jubatum and Deschampsia caespitosa). Thus, this new alliance of Caricetalia aquatilis stands relatively close to the order of Puccinellio - Salicornietalia.

The Triglochinion palustris is represented here by two plant associations:

Association 5. Triglochino (palustris) - Juncetum arctici

The characteristic combination of species (plant association) is:

Castilleja yukonis
Lomatogonium rotatum
Primula stricta

Figure 6 shows a photograph of this association.

Assocation 6. Triglochino (palustris) - Caricetum aquatilis

The characteristic species are:

(Eriophorum angustifolium)*
(Eriophorum brachyantherum)*

Figure 7 shows a photograph of this association.

The two associations in this order cover an area of approximately 16 acres. Tables 8, 9, 37 and 53 in the appendix give details on the analyses and synthesis of these associations and their higher systematic units.

Order 3. SALICETALIA PLANIFOLIAE Hoefs & Krajina

These are willow communities on gleysols in the boreal (montane) zone. Their herbaceous layer is related either to Puccinellio - Salicornietalia or to Caricetalia aquatilis.

The characteristic combination of species (order) is:

* Species in brackets are less characteristic than those without brackets.

Table 8.

Order: 2. CARICETALIA AQUATILIS

Alliance: 3. Triglochinion palustris

Association: 5. Triglochino (palustris) - Juncetum arctici

| Number of plots | 1 | 2 | 3 | 4 | 5 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|
| Plot number | 70 | 71 | 75 | 76 | 100 | | | |
| Date | 12.8. 71 | 12.8. 71 | 12.8. 71 | 12.8. 71 | 14.8. 71 | | | |
| Elevation (feet) | 2570 | 2570 | 2570 | 2570 | 2570 | | | |
| Exposure | flat | | | | | | | |
| Slope | flat | | | | | | | |
| Hygrotope | 4- | 4- | 4- | 4/5 | 4/5 | | | |
| *Salix brachycarpa* | . | . | +.+ | +.2 | . | II | 0.4 | 2 |
| *Juncus arcticus* | 7.5 | 7.5 | 6.5 | 6.3 | 5.1 | V | 6.2 | 3 |
| *Triglochin palustre* | 3.1 | +.+ | +.+ | 2.+ | 5.1 | V | 2.4 | 3 |
| *Carex aquatilis* | 1.+ | +.+ | +.1 | +.+ | 1.+ | V | 1.0 | 2 |
| *Aster yukonensis* | +.1 | 1.1 | +.+ | 3.1 | . | IV | 1.2 | 3 |
| *Deschampsia caespitosa* | 2.+ | +.+ | . | 2.+ | 1.+ | IV | 1.2 | 2 |
| *Calamagrostis neglecta* | 2.1 | 3.1 | 3.+ | . | . | III | 1.6 | 3 |
| *Hordeum jubatum* | 3.1 | 2.1 | 2.1 | . | . | III | 1.4 | 2 |
| *Lomatogonium rotatum* | 2.+ | 2.+ | 1.+ | . | . | III | 1.0 | 3 |
| *Ranunculus cymbalaria* | +.1 | 1.1 | +.1 | . | . | III | 0.6 | 2 |
| *Parnassia palustris* | . | . | 3.+ | 3.1 | . | II | 1.2 | 3 |
| *Carex parryana* | . | . | . | +.+ | . | I | 0.2 | 3 |
| *Primula stricta* | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Elymus glaucus* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Castilleja yukonis* | . | . | . | +.+ | . | I | 0.2 | 2 |
| *Pedicularis sudetica* | +.1 | . | . | . | . | I | 0.2 | 2 |

Table 9.

Order: 2. CARICETALIA AQUATILIS

Alliance: 3. Triglochinion palustris

Association: 6. Triglochino (palustris) - Caricetum aquatilis

| Number of plots | 1 | 2 | 3 | 4 | 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Plot number | 74 | 77 | 91 | 101 | 403 | | | |
| Date | 12.8. 71 | 12.8. 71 | 13.8. 71 | 14.8. 71 | 17.9. 72 | | | |
| Elevation (feet) | 2565 | 2565 | 2565 | 2565 | 2565 | | | |
| Exposure | flat | | | | | | | |
| Slope | flat | | | | | | | |
| Hygrotope | 4/5 | 4/5 | 4- | 4- | 4/5 | Constancy | Average species significance | Vigor |
| *Carex aquatilis* | 7.6 | 7.4 | 7.3 | 6.6 | 7.4 | V | 6.8 | 3 |
| *Triglochin palustre* | 4.1 | +.+ | +.+ | +.+ | +.1 | V | 1.6 | 3 |
| *Eriophorum angustifolium* | 2.+ | . | . | +.+ | +.1 | III | 0.8 | 3 |
| *Calamagrostis neglecta* | +.+ | . | +.+ | . | +.1 | III | 0.6 | 3 |
| *Aster yukonensis* | . | 3.1 | . | . | . | I | 0.6 | 2 |
| *Parnassia palustris* | . | 2.1 | . | . | . | I | 0.4 | 3 |
| *Deschampsia caespitosa* | . | 2.+ | . | . | . | I | 0.4 | 2- |
| *Juncus arcticus* | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Hordeum jubatum* | +.+ | . | . | . | . | I | 0.2 | 2- |
| *Eriophorum brachyantherum* | . | . | +.+ | . | . | I | 0.2 | 3 |
| *Carex parryana* | . | +.+ | . | . | . | I | 0.2 | 2- |

(B) Shrub layer: Salix brachycarpa
Salix planifolia

(C) Herb layer: Carex hassei
Equisetum palustre
Juncus arcticus
(Parnassia palustris)*

(D) Moss layer: Catoscopium nigritum
Cinclidium stygium

Salicetalia planifoliae are divided here into two alliances:

Alliance 4. Salicion brachycarpae Hoefs & Krajina

is somehow related to Puccinellio - Salicornietalia.

Only one plant association is described in this alliance:

Association 7. Astero (yukonensis) - Junco (arctici) - Salicetum brachycarpae

The characteristic combination of species (alliance and plant association) is:

(C) Herb layer: (Aster yukonensis)*
(Calamagrostis neglecta)*
Carex microglochin
Carex parryana
(Lomatogonium rotatum)*
Pedicularis sudetica
Spiranthes romanzoffiana

Figure 8 shows a photograph of this association.

Alliance 5. Salicion planifoliae Hoefs & Krajina

is more closely related to the Caricetalia aquatilis than to the Puccinellio - Salicornietalia.

It is represented by only one plant association.

Association 8. Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae

The characteristic combination of species (alliance and plant association) is:

* Species in brackets are less characteristic than those without brackets.

FIGURE 8:

Astero (yukonensis) - Junco (arctici) - Salicetum brachycarpae

Soils moist throughout the season.

FIGURE 9:

Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae

Soil saturated and often inundated throughout the season.

(C) Herb layer: (Carex aquatilis)*
(Eriophorum angustifolium)*
Eriophorum brachyantherum
Juncus alpinus

(D) Moss layer: (Campylium stellatum)*
Marchantia polymorpha
Meesea uliginosa

Figure 9 shows a photograph of this association.

The two associations in this order cover an area of approximately 67.5 acres in the study area. Tables 10 and 11 in the text and Tables 38 and 53 in the appendix give details on the analyses and synthesis of these associations and their higher synsystematic units.

The three orders, five alliances, and eight associations discussed so far make up the vegetation cover of the Slims River flood-plain. They all developed on fine - textured (water and wind deposited) soil and they all are subject to periodic inundations.

The characteristic faunal component of these flood-plain associations consists primarily of birds. On the flats in herbaceous vegetation Anas platyrhynchos (Mallards), Anas carolinensis (Green-winged Teal), Circus cyaneus (Marsh Hawk), Totanus flavipes (Lesser Yellowlegs), Charadrius semipalmatus (Semipalmated Plover), Sterna paradisaea (Arctic Tern) and Asio flammeus (Short-eared Owl) have been observed, while willow stands provide habitat for Colaptes auratus (Yellow-shafted Flicker), Dendroica coronata (Myrtle Warbler), Passerculus sandwichensis (Savannah Sparrow) and Zonotrichia leucophrys (White-crowned Sparrow).

Order 4. DRYADETALIA DRUMMONDII Hoefs & Krajina

grow on alluvial gravel beds (of calcium rich rocks) in the boreal (montane) spruce biogeoclimatic zone.

* Species in brackets are less characteristic than those without brackets.

Table 10.

Order: 3. SALICETALIA PLANIFOLIAE

Alliance: 4. Salicion brachycarpae

Association: 7. Astero (yukonensis) - Junco (arctici) - Salicetum brachycarpae

| Number of plots | 1 | 2 | 3 | 4 | 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Plot number | 79 | 80 | 105 | 108 | 113 | | | |
| Date | 12.8. 71 | 12.8. 71 | 14.8. 71 | 16.8. 71 | 16.8. 71 | | | |
| Elevation (feet) | 2570 | 2570 | 2570 | 2570 | 2570 | | | |
| Exposure | flat | | | | | | | |
| Slope | flat | | | | | | | |
| Hygrotope | 4 | 4- | 4- | 4- | 4 | Constancy | Average species significance | Vigor |
| *Salix brachycarpa* | 6.5 | 5.4 | 5.3 | 5.4 | 7.4 | V | 5.6 | 3 |
| *Salix planifolia* | . | 1.2 | 1.2 | . | +.2 | III | 0.6 | 2 |
| *Salix myrtillifolia* | . | +.2 | . | . | . | I | 0.2 | 2 |
| *Salix novae-angliae* | . | . | . | . | +.2 | I | 0.2 | 2 |
| *Picea glauca* | . | . | . | . | +.1 | I | 0.2 | 2- |
| *Juncus arcticus* | 6.5 | 6.5 | 6.6 | 6.6 | 7.5 | V | 6.2 | 3 |
| *Aster yukonensis* | 3.1 | 1.+ | 1.+ | 2.+ | 2.+ | V | 1.8 | 2+ |
| *Carex parryana* | 2.+ | 1.+ | 3.+ | +.+ | 1.+ | V | 1.6 | 3 |
| *Pedicularis sudetica* | +.+ | +.+ | 1.+ | +.1 | 2.+ | V | 1.2 | 3 |
| *Parnassia palustris* | 1.+ | . | 3.+ | +.1 | 2.+ | IV | 1.4 | 2+ |
| *Equisetum palustre* | 2.1 | 2.1 | 1.+ | +.1 | . | IV | 1.2 | 2 |
| *Carex microglochin* | 1.+ | . | 1.+ | +.+ | 1.+ | IV | 0.8 | 2 |
| *Spiranthes romanzoffiana* | +.+ | +.+ | +.1 | . | . | III | 0.6 | 3 |
| *Calamagrostis neglecta* | 1.+ | 1.+ | +.+ | . | . | III | 0.6 | 3 |
| *Lomatogonium rotatum* | +.+ | . | +.+ | . | +.+ | III | 0.6 | 2+ |
| *Triglochin palustre* | +.+ | . | 1.+ | +.+ | . | III | 0.6 | 2 |
| *Carex aquatilis* | +.+ | . | 1.1 | . | . | II | 0.4 | 2- |
| *Pyrola asarifolia* | . | +.1 | . | . | +.+ | II | 0.4 | 2 |
| *Carex hassei* | . | 1.+ | +.+ | . | . | II | 0.4 | 2 |
| *Deschampsia caespitosa* | . | . | +.+ | 1.+ | . | II | 0.4 | 2 |
| *Hordeum jubatum* | . | . | . | 1.+ | . | I | 0.2 | 2 |
| *Tofieldia pusilla* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Carex maritima* | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Trichophorum pumilum* | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Equisetum variegatum* | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Ranunculus cymbalaria* | . | . | . | +.+ | . | I | 0.2 | 2 |
| *Catoscopium nigritum* | 2.1 | . | 1.1 | . | 3.1 | III | 1.2 | 2 |
| *Cinclidium stygium* | . | . | 2.1 | . | +.+ | II | 0.6 | 2 |

Table 11.

Order: 3. SALICETALIA PLANIFOLIAE

Alliance: 5. Salicion planifoliae

Association: 8. Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae

| Number of plots | 1 | 2 | 3 | 4 | 5 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|
| Plot number | 73 | 78 | 104 | 109 | 115 | | | |
| Date | 12.8. 71 | 12.8. 71 | 14.8. 71 | 16.8. 71 | 26.8. 71 | | | |
| Elevation (feet) | 2565 | 2565 | 2565 | 2565 | 2565 | | | |
| Exposure | flat | | | | | | | |
| Slope | flat | | | | | | | |
| Hygrotope | 5+ | 5+ | 4/5 | 4/5 | 5+ | | | |
| *Salix planifolia* | 7.5 | 5.4 | 7.7 | 7.5 | 7.5 | V | 6.6 | 3 |
| *Salix brachycarpa* | . | 4.2 | 2.2 | . | . | II | 1.2 | 2 |
| *Salix novae-angliae* | . | 1.2 | . | +.2 | . | II | 0.4 | 2 |
| *Picea glauca* | +.2 | . | . | . | | I | 0.2 | 2- |
| *Carex aquatilis* | 5.2 | 6.5 | 7.6 | 7.6 | 2.1 | V | 5.4 | 3 |
| *Eriophorum angustifolium* | +.1 | 1.1 | 2.+ | 1.1 | +.1 | V | 1.2 | 3 |
| *Juncus arcticus* | 4.2 | . | +.+ | +.+ | +.1 | IV | 1.4 | 2 |
| *Parnassia palustris* | 2.+ | 2.+ | 1.+ | . | +.1 | IV | 1.2 | 2+ |
| *Equisetum palustre* | . | . | 2.1 | 3.1 | 6.4 | III | 2.2 | 3 |
| *Eriophorum brachyantherum* | . | 1.+ | . | +.+ | . | II | 0.4 | 2+ |
| *Juncus alpinus* | . | . | 2.+ | . | . | I | 0.4 | 2 |
| *Lomatogonium rotatum* | 2.+ | . | . | . | . | I | 0.4 | 2 |
| *Aster yukonensis* | +.+ | . | . | . | . | I | 0.2 | 2- |
| *Pyrola asarifolia* | 1.+ | . | . | . | . | I | 0.2 | 2 |
| *Carex hassei* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Spiranthes romanzoffiana* | +.1 | . | . | . | . | I | 0.2 | 2 |
| *Catoscopium nigritum* | . | +.1 | . | 2.1 | +.1 | III | 0.8 | 2 |
| *Campylium stellatum* | +.1 | +.1 | +.1 | . | . | III | 0.6 | 2 |
| *Cinclidium stygium* | . | . | +.1 | +.1 | . | II | 0.4 | 2 |
| *Marchantia polymorpha* | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Meesea uliginosa* | . | +.1 | . | . | . | I | 0.2 | 2 |

They are represented by only one alliance:

Alliance 6. Dryadion drummondii Hoefs & Krajina

and by one plant association:

Association 9. Dryadetum drummondii

The characteristic combination of species (order, alliance, plant association) is:

(B) Shrub layer: Elaeagnus commutata
(Populus balsamifera)*

(C) Herb layer: Crepis elegans
Dryas drummondii
(Epilobium latifolium)*
Lupinus arcticus
Oxytropis campestris

Figure 10 shows a photgraph of this association. It is very limited in extent in the study area making up less than 4 acres in Sections D 1 and E 1 of the map. Since it occupies creek beds it is periodically covered by thick sheets of ice which build up over the winter as the creek "glaciates". It is not uncommon to find ice as thick as 10 feet by the end of winter. This mass of ice melts very slowly and greatly reduces the potential length of the growing season of the vegetation under it. Not all plots are covered by ice, nor is this "glaciating" of creeks experienced every winter. Tables 12 in the text and 39 and 53 in the appendix reveal details on the analyses and synthesis of this association and its higher systematic units.

Order 5. POPULETALIA BALSAMIFERAE Krajina, 1969

These are plant communities on either alluvial flood-plains or more recent terraces (such habitats were not studied) and on colluvial deposits

* Species in brackets are less characteristic than those without brackets.

FIGURE 10:

Dryadetum drummondii

Photograph taken in early June, when Dryas drummondii and Lupinus arcticus are in bloom.

Note the creek bed substrate consisting of rocks, gravel and sand.

FIGURE 11:

Roso (acicularis) - Shepherdio (canadensis) - Populetum tremuloidis

This association often forms narrow fringe between dry grasslands and mesic white spruce forest.

Note the dense understory of Viburnum edule.

Table 12.

Order: 4. DRYADETALIA DRUMMONDII

Alliance: 6. Dryadion drummondii

Association: 9. Dryadetum drummondii

| Number of plots | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Plot number | 372 | 373 | 374 | 375 | 376 |
| Date | 31.8. 72 | 31.8. 72 | 31.8. 72 | 31.8. 72 | 31.8. 72 |
| Elevation (feet) | 2590 | 2590 | 2590 | 2600 | 2600 |
| Exposure | flat | | | | |
| Slope | flat | | | | |
| Hygrotope | 2- much moister | 2/3 (5+) | 2 during | 2 spring | 2- run-off |

| | | | | | | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|
| *Populus balsamifera* | . | +.1 | 2.2 | . | . | II | 0.6 | 2 |
| *Elaeagnus commutata* | +.1 | . | . | . | . | I | 0.2 | 3 |
| *Dryas drummondii* | 6.5 | 5.5 | 7.6 | 6.5 | 6.5 | V | 6.0 | 3 |
| *Crepis elegans* | 1.1 | 1.1 | 1.1 | 2.1 | +.1 | V | 1.2 | 2+ |
| *Epilobium latifolium* | 2.1 | +.1 | +.1 | 1.1 | +.1 | V | 1.2 | 2 |
| *Oxytropis campestris* | +.1 | . | 2.1 | +.1 | . | III | 0.8 | 2+ |
| *Lupinus arcticus* | +.2 | 1.2 | . | +.2 | . | III | 0.6 | 3 |
| *Artemisia alaskana* | . | . | . | . | +.2 | I | 0.2 | 2 |
| *Potentilla multifida* | . | . | +.1 | . | . | I | 0.2 | 2 |

with temporary seepage effects (such habitats were studied here). In this study they are represented by only one alliance:

Alliance 7. Juniperc (communis & horizontalis) - Shepherdio (canadensis) - Populion tremuloidis Hoefs & Krajina

with only one association:

Association 10. Roso (acicularis) - Shepherdio (canadensis) - Populetum balsamiferae

The characteristic combination of species (order, alliance, plant association) is :

(A) Tree layer: Populus balsamifera
Populus tremuloides

(B) Shrub layer: Juniperus communis
Rosa acicularis
Shepherdia canadensis
Viburnum edule

(C) Herb layer: (Arctostaphylos uva-ursi)*
Epilobium angustifolium
(Geocaulon lividum)*
Juniperus horizontalis

(D) Moss layer: (Hypnum procerrimum)*

Figure 11 shows a photograph of this association. This association is poorly developed in the study area. It serves primarily as a successional stage between white spruce climax forest and grasslands as well as spruce forest and flood-plain vegetation. It also serves as a pioneer association occupying recently disturbed sites as along road cuts. Its total acreage in the study area is estimated at 88. Tables 13, 40 and 53 reveal details on the analyses and synthesis of this association and its higher units.

Characteristic birds in poplar stands include Accipiter gentilis (Goshawk), Bonasa umbellus (Ruffed Grouse), Contopus sordidulus

* Species in brackets are less characteristic than those without brackets.

Table 13.

Order: 5. POPULETALIA BALSAMIFERAE

Alliance: 7. Junipero (communis & horizontalis) - Shepherdio (canadensis) - Populion tremuloidis

Association: 10. Roso (acicularis) - Shepherdio (canadensis) - Populetum balsamiferae

| Number of plots | 1 | 2 | 3 | 4 | 5 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|
| Plot number | 395 | 397 | 359 | 155 | 166 | | | |
| Date | 17.9. 72 | 17.9. 72 | 28.8. 72 | 9.9. 71 | 14.9. 71 | | | |
| Elevation (feet) | 2620 | 2680 | 3370 | 3680 | 3750 | | | |
| Exposure (degree) | 170 | 160 | 170 | 160 | 150 | | | |
| Slope (degree) | -31 | -22 | -20 | -24 | -40 | | | |
| Hygrotope | 3+ | 3+ | 3+ | 3+ | 2/3 | | | |
| *Populus balsamifera* | 7.6 | 7.7 | 7.7 | 7.6 | 6.5 | V | 6.8 | 3 |
| *Populus tremuloides* | 7.6 | 7.7 | 4.5 | 4.5 | . | IV | 4.4 | 2+ |
| *Juniperus communis* | 7.5 | 7.6 | 7.7 | 5.5 | +.2 | V | 5.4 | 3 |
| *Shepherdia canadensis* | 4.3 | 6.6 | 7.6 | +.1 | 3.4 | V | 4.2 | 3 |
| *Rosa acicularis* | 5.2 | 3.2 | 3.1 | 3.3 | 2.1 | V | 3.2 | 3 |
| *Viburnum edule* | 4.2 | 5.4 | . | 5.6 | . | III | 2.8 | 3 |
| *Populus balsamifera* | . | +.2 | . | . | 2.2 | II | 0.6 | 2 |
| *Picea glauca* | +.2 | +.2 | . | . | . | II | 0.4 | 2 |
| *Salix glauca* | . | . | 1.5 | . | +.2 | II | 0.4 | 2 |
| *Arctostaphylos uva-ursi* | +.1 | 1.2 | 4.5 | 6.6 | 5.5 | V | 3.4 | 3 |
| *Juniperus horizontalis* | +.2 | +.1 | +.3 | 2.3 | 8.7 | V | 2.6 | 3 |
| *Epilobium angustifolium* | +.1 | 3.1 | 2.1 | . | 1.+ | IV | 1.4 | 3 |
| *Geocaulon lividum* | 1.1 | +.1 | 1.4 | . | . | III | 0.6 | 2 |
| *Linnaea borealis* | +.1 | . | +.2 | . | . | II | 0.4 | 2 |
| *Smilacina stellata* | . | . | . | . | 2.+ | I | 0.4 | 2 |
| *Mertensia paniculata* | . | . | . | 2.1 | . | I | 0.4 | 2 |
| *Achillea borealis* | . | . | . | . | 1.+ | I | 0.2 | 2 |
| *Artemisia rupestris* | . | . | . | . | +.1 | I | 0.2 | 1+ |
| *Artemisia frigida* | . | . | . | . | +.+ | I | 0.2 | 1+ |
| *Pyrola secunda* | +.1 | . | . | . | . | I | 0.2 | 2 |
| *Hypnum procerrimum* | +.1 | +.2 | +.1 | . | . | III | 0.6 | 2 |
| *Tortula ruralis* | . | . | +.1 | . | . | I | 0.2 | 2 |

(Western Wood Pewee), Perisoreus canadensis (Gray Jay), Pica Pica (Black-billed Magpie), Turdus migratorius (Robin), Hylocichla ustulata (Swainson's Thrush), Sialia currucoides (Mountain Bluebird) and Spizella passerina (Chipping Sparrow).

Order 6. CALAMAGROSTIDO (PURPURASCENTIS) - ARCTOSTAPHYLETALIA UVAE-URSI Hoefs & Krajina

occur on less active aeolian deposits (loess) which successionally could develop into the spruce forest. It is represented by only one alliance:

Alliance 8. Calamagrostido (purpurascentis) - Arctostaphylion uvae-ursi Hoefs & Krajina

and by the only plant association:

Association 11. Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi

The characteristic combination of species (order, alliance, plant association) is:

(B) Shrub layer: (Juniperus communis)*
(Rosa acicularis)*
(Shepherdia canadensis)*

(C) Herb layer: Achillea lanulosa
Anemone multifida
Arctostaphylos uva-ursi
Astragalus williamsii
Bromus pumpellianus
Calamagrostis purpurascens
Comandra umbellata
Galium boreale
(Hedysarum mackenzii)*
(Juniperus horizontalis)*
(Linum perenne)*
Pulsatilla patens
Smilacina stellata
Solidago decumbens

It may become evident that the floristic structure of this plant association has some close relation to the order of PICEETALIA GLAUCAE-MARIANAE, a plant association which may

* Species in brackets are less characteristic than those without brackets.

successionally develop from this plant community. It is also closely related to Roso (acicularis) - Shepherdio (canadensis) - Populetum balsamiferae and often forms transitional communities with the latter.

This association is very common in the boreal zone of the study area and is found almost always as an intermediate stage between dry grassland vegetation at one side and spruce or poplar forest at the other. Figure 12 shows a photograph of this association during spring. It is estimated that it covers 198 acres of the study area. Tables 14, 41 and 53 give details on this association and its classification into higher synsystematic units. The characteristic animal in this association is the Eutamias minimus caniceps (chipmunk). In late winter and spring Ovis dalli dalli (Dall Sheep) utilize a number of species in this association, in particular Calamagrostis purpurascens, Pulsatilla patens, Bromus pumpellianus and Achillea lanulosa.

Order 7. PICEETALIA GLAUCAE - MARIANAE Krajina, 1969

These are coniferous forests of the boreal (montane) biogeoclimatic zone. The characteristic combination of species for this order is as follows:

(A) Tree layer: Picea glauca

(B) Shrub layer: (Rosa acicularis)*

(C) Herb layer: (Anemone multifida)*
Carex concinna
Geocaulon lividum
Linnaea borealis
Pyrola secunda

This order is represented here (on strongly calcareous soils) by only one alliance:

* Species in brackets are less characteristic than those without brackets.

FIGURE 12: Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi

Photograph taken during spring aspect in late May.

FIGURE 13: Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae

Note the lack of shrubby or herbaceous understory vegetation.

Table 14.

Order: 6. CALAMAGROSTIDO (PURPURASCENTIS) - ARCTOSTAPHYLETALIA UVAE-URSI

Alliance: 8. Calamagrostido (purpurascentis) - Arctostaphylion uvae-ursi

Association: 11. Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 11 | 2 | 373 | 13 | 201 | 7/70 | 374 | 17 | 372 | 6/70 | | | |
| Date | 16.7. 71 | 11.7. 71 | 1.9. 72 | 15.7. 71 | 25.9. 71 | 31.7. 70 | 1.9. 72 | 16.7. 71 | 1.9. 72 | 29.7. 70 | | | |
| Elevation (feet) | 2640 | 2670 | 2700 | 2790 | 2820 | 2850 | 2860 | 2880 | 2950 | 2960 | | | |
| Exposure (degree) | 210 | 145 | 140 | 120 | 120 | 110 | 110 | 260 | 190 | 165 | | | |
| Slope (degree) | -15 | -10 | -8 | -17 | -32 | -26 | -32 | -13 | -12 | -17 | | | |
| Hygrotope | 2/3 | 2/3 | 3+ | 2/3 | 2/3 | 3 | 3+ | 3 | 2/3 | 3 | | | |
| *Rosa acicularis* | 4.2 | +.2 | +.2 | 3.2 | 5.3 | 2.1 | 3.2 | +.1 | 3.1 | +.2 | V | 2.4 | 3 |
| *Shepherdia canadensis* | 3.4 | 3.4 | +.3 | 1.2 | . | . | . | +.2 | +.4 | +.4 | IV | 1.1 | 2 |
| *Juniperus communis* | . | 4.5 | +.4 | 1.3 | . | . | +.2 | . | 1.4 | . | III | 0.8 | 3 |
| *Populus balsamifera* | . | . | . | +.2 | . | . | . | . | . | +.2 | I | 0.2 | 2 |
| *Salix glauca* | . | . | . | +.2 | . | +.3 | . | . | . | . | I | 0.2 | 2 |
| *Picea glauca* | . | . | . | . | . | . | . | +.2 | . | . | I | 0.1 | 2 |
| *Arctostaphylos uva-ursi* | 6.4 | 8.6 | 7.6 | 5.3 | 7.6 | 8.5 | 8.5 | 7.5 | 7.5 | 7.4 | V | 7.0 | 3 |
| *Calamagrostis purpurascens* | 5.2 | 5.2 | 8.4 | 5.2 | 3.2 | 7.5 | 6.3 | 6.2 | 7.4 | 6.5 | V | 5.8 | 3 |
| *Pulsatilla patens* | 3.1 | 3.1 | 3.1 | 2.1 | 2.+ | 3.2 | 2.1 | . | 2.+ | 2.2 | V | 2.2 | 3 |
| *Astragalus williamsii* | 4.3 | . | 2.2 | 4.2 | . | 2.2 | 1.2 | 6.2 | 4.2 | 3.3 | IV | 2.6 | 3 |
| *Achillea lanulosa* | 2.+ | 1.+ | 3.1 | . | 1.+ | +.1 | 1.1 | . | 2.1 | 1.1 | IV | 1.2 | 2+ |
| *Anemone multifida* | 3.1 | 3.1 | +.1 | 2.+ | . | . | . | +.1 | +.1 | +.1 | IV | 1.2 | 2+ |
| *Solidago decumbens* | . | 1.+ | 2.1 | 1.1 | . | 1.1 | +.1 | . | 3.1 | 1.1 | IV | 1.0 | 2+ |
| *Bromus pumpellianus* | 5.1 | 1.1 | +.1 | 1.1 | 3.1 | . | . | . | 1.1 | . | III | 1.2 | 3 |
| *Artemisia frigida* | +.1 | . | . | +.1 | 2.1 | 2.2 | +.1 | . | . | 2.1 | III | 0.9 | 2 |
| *Erigeron caespitosus* | . | +.1 | 1.+ | . | . | 1.+ | . | +.1 | +.1 | 1.+ | III | 0.6 | 2- |
| *Linum perenne* | +.+ | +.+ | . | . | +.+ | +.+ | . | . | . | +.+ | III | 0.5 | 2- |
| *Juniperus horizontalis* | . | 2.3 | . | +.3 | . | . | 5.5 | 4.4 | . | . | II | 1.2 | 3 |
| *Hedysarum mackenzii* | 5.3 | . | . | . | . | . | . | 1.2 | +.2 | . | II | 0.7 | 2 |
| *Smilacina stellata* | . | . | . | . | . | 1.1 | 3.1 | . | . | 3.2 | II | 0.7 | 3 |
| *Agropyron yukonense* | . | +.1 | . | . | 2.1 | . | . | . | . | +.+ | II | 0.4 | 2- |
| *Galium boreale* | 1.1 | 1.+ | . | 1.+ | 1.+ | . | . | . | . | . | II | 0.4 | 3 |
| *Pentstemon gormanii* | . | . | . | +.1 | +.+ | 1.1 | . | . | . | 1.1 | II | 0.4 | 2- |
| *Aster alpinus* | +.1 | . | . | +.1 | . | . | +.1 | . | . | . | II | 0.3 | 2 |
| *Artemisia dracunculus* | . | . | +.1 | . | . | . | +.1 | . | . | . | I | 0.2 | 3 |
| *Carex filifolia* | . | +.1 | . | . | . | . | . | . | . | +.1 | I | 0.2 | 2- |
| *Comandra umbellata* | . | +.+ | . | +.+ | . | . | . | . | . | . | I | 0.2 | 2 |
| *Agropyron subsecundum* | . | . | . | +.+ | . | . | . | . | . | . | I | 0.1 | 2 |
| *Antennaria media* | . | +.1 | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Erysimum angustatum* | . | . | . | +.1 | . | . | . | . | . | . | I | 0.1 | 2 |
| *Mertensia paniculata* | 1.1 | . | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Poa glauca* | . | . | . | +.+ | . | . | . | . | . | . | I | 0.1 | 2- |
| *Potentilla hookeriana* | . | +.1 | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Lecidea rubiformis* | . | . | +.1 | . | 2.2 | +.1 | . | . | +.1 | +.1 | III | 0.6 | 2 |
| *Dermatocarpon hepaticum* | . | . | . | . | 2.2 | 1.1 | . | . | 1.1 | +.1 | II | 0.5 | 2 |
| *Buellia epigaea* | . | . | . | . | 2.1 | +.+ | . | . | +.1 | . | II | 0.4 | 2 |
| *Caloplaca cirrochroa* | . | . | . | . | +.1 | +.+ | . | . | +.+ | +.+ | II | 0.4 | 2 |
| *Lecidea decipiens* | . | . | . | . | +.1 | . | . | . | . | . | I | 0.1 | 2 |
| *Hypnum vaucheri* | . | . | . | 1.1 | . | 2.1 | . | . | 1.1 | 2.1 | II | 0.6 | 2 |
| *Tortula ruralis* | . | +.+ | . | . | . | . | . | . | . | +.+ | I | 0.2 | 2 |

Alliance 9. Hypno (procerrimi) - Abietinello (abietinae) - Piceion glaucae Hoefs & Krajina

developed on stabilized aeolian (loess) deposits in the montane zone (mainly between 2570' and 3500' above the sea level in the Sheep Mountain area). Only one plant association was distinguished during this study. It is:

Association 12. Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae

The characteristic combination of species (alliance and plant association) is:

(B) Shrub layer: (Juniperus communis)*
(Salix glauca)*
(Shepherdia canadensis)*

(C) Herb layer: (Arctostaphylos uva-ursi)*
Cypripedium passerinum
Hedysarum mackenzii
(Mertensia paniculata)*

(D) Moss layer: Abietinella abietina
(Distichium capillaceum)*
Hypnum procerrimum
Peltigera canina
(Stereocaulon glareosum)*

Figure 13 shows a photograph of this association. It is the dominant vegetation type in the boreal zone of the study area, covering approximately 1314 acres. Remains of charcoal in the soil and on dead trees indicate that fires have been of frequent occurrence in the past in this association. From the point of view of commercial forestry, white spruce stands in the study area are of little importance. Mature trees are on the average not more than 40 to 50 feet in height and 8 to 10 inches (d. b. h.) thick. Only in a few exceptional sites have trees with diameter of 12 to 16 inches (d. b. h.) been observed. Tables

* Species in brackets are less characteristic than those without brackets.

15, 42 and 53 reveal details on the analyses and synthesis of this association and its higher units. Characteristic animals of white spruce stands are: Tamiasciurus hudsonicus (Red Squirrel), Accipiter striatus (Sharp-shinned Hawk), Canachites canadensis (Spruce Grouse), Strix nebulosa (Great Gray Owl), Dendrocopos villosus (Hairy Woodpecker), Picoides arcticus (Black-backed Three-toed Woodpecker), Parus hudsonicus (Boreal Chickadee), Regulus calendula (Ruby-crowned Kinglet), Acanthis flammea (Common Redpoll), Loxia leucoptera (White-winged Crossbill) and Junco hyemalis (Slate-colored Junco).

Order 8. ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS Hoefs & Krajina

These are grassland communities developed mostly on very fine loess aeolian (frequently still active) Regosols, either in the boreal (montane) or in the sub-alpine biogeoclimatic zone. They are the main winter pastures for the sheep population here.

In the study area, this order contains only the following one alliance:

Alliance 10. Artemisio (frigidae) - Agropyrion yukonensis Hoefs & Krajina

The characteristic combination of species (order and alliance) is:

(C) Herb layer:
- Agropyron yukonense
- Artemisia frigida
- Aster alpinus
- (Calamagrostis purpurascens)*
- Carex filifolia
- Erigeron caespitosus
- Linum perenne
- (Oxytropis viscida)*
- Pentstemon gormanii
- (Poa glauca)*
- (Pulsatilla patens)*

*Species in brackets are less characteristic than those without brackets.

Table 15.

Order: 7. PICEETALIA GLAUCAE - MARIANAE

Alliance: 9. Hypno (procerrimi) - Abietinello (abietinae) - Piceion glaucae

Association: 12. Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 393 | 396 | 391 | 392 | 6 | 390 | 394 | 361 | 360 | 154 | | | |
| Date | 17.9. 72 | 17.9. 72 | 17.9. 72 | 17.9. 72 | 13.7. 71 | 17.9. 72 | 17.9. 72 | 28.8. 72 | 28.8. 72 | 9.9. 71 | | | |
| Elevation (feet) | 2600 | 2640 | 2660 | 2670 | 2670 | 2730 | 2750 | 2970 | 3100 | 3810 | | | |
| Exposure (degree) | 70 | 180 | 60 | 50 | 180 | 70 | 30 | 140 | 140 | 180 | | | |
| Slope (degree) | -11 | -5 | -24 | -10 | -7 | -20 | -25 | -12 | -20 | -18 | | | |
| Hygrotope | 3 | 3 | 3 | 3- | 2/3 | 3 | 3- | 3 | 3+ | 2/3 | Constancy | Average species significance | Vigor |
| *Picea glauca* | 8.7 | 8.7 | 7.7 | 7.7 | 7.5 | 7.7 | 7.7 | 7.7 | 7.7 | 7.6 | V | 7.2 | 3 |
| *Picea glauca* | +.3 | 4.4 | 4.4 | +.3 | 5.4 | 2.4 | 3.4 | 2.4 | 3.5 | 3.3 | V | 2.8 | 2+ |
| *Salix glauca* | . | . | +.5 | . | 3.4 | . | 1.3 | . | . | 3.4 | II | 0.8 | 2 |
| *Juniperus communis* | . | . | . | . | . | . | . | 1.2 | +.3 | 3.4 | II | 0.5 | 2- |
| *Rosa acicularis* | . | . | . | . | . | . | . | . | +.1 | +.+ | I | 0.2 | 1+ |
| *Shepherdia canadensis* | . | . | . | . | . | . | . | . | . | 2.3 | I | 0.2 | 1+ |
| *Ledum palustre* | . | . | . | . | +.1 | . | . | . | . | . | I | 0.1 | 2 |
| *Linnaea borealis* | 1.1 | +.+ | +.1 | 4.3 | 5.4 | . | 6.6 | 7.6 | 5.6 | 4.4 | V | 3.4 | 2+ |
| *Pyrola secunda* | +.1 | . | +.+ | +.1 | +.+ | . | +.1 | 2.+ | +.1 | 2.1 | IV | 1.0 | 3 |
| *Carex concinna* | +.+ | 1.1 | . | 1.1 | 1.2 | . | 2.1 | +.1 | +.1 | +.+ | IV | 0.9 | 2+ |
| *Anemone multifida* | . | 1.1 | 1.1 | +.1 | . | 1.1 | 1.1 | 1.1 | . | 1.+ | IV | 0.7 | 2 |
| *Geocaulon lividum* | . | . | . | 2.1 | 3.3 | . | 4.3 | 3.5 | 4.5 | 2.4 | III | 1.8 | 3 |
| *Arctostaphylos uva-ursi* | . | . | . | . | 3.4 | . | +.2 | +.1 | +.2 | 2.4 | III | 0.8 | 2 |
| *Hedysarum mackenzii* | . | +.2 | +.1 | +.1 | 3.2 | +.1 | . | . | . | . | III | 0.7 | 1+ |
| *Mertensia paniculata* | . | . | +.1 | +.1 | . | +.1 | . | +.1 | +.1 | . | III | 0.5 | 1+ |
| *Arctostaphylos rubra* | . | . | . | 3.3 | 4.3 | . | 3.3 | . | . | 3.4 | II | 1.3 | 2 |
| *Equisetum scirpoides* | . | . | . | 3.2 | . | . | 3.1 | . | . | 1.1 | II | 0.7 | 2 |
| *Cypripedium passerinum* | . | . | . | +.1 | . | . | 1.1 | . | . | . | I | 0.2 | 3 |
| *Gentiana propinqua* | . | . | . | . | . | . | . | +.+ | . | 1.+ | I | 0.2 | 2 |
| *Astragalus williamsii* | . | . | . | . | 2.2 | . | . | . | . | . | I | 0.2 | 1+ |
| *Senecio lugens* | . | . | . | . | +.1 | . | . | . | . | . | I | 0.1 | 2 |
| *Zygadenus elegans* | . | . | . | . | +.1 | . | . | . | . | . | I | 0.1 | 2 |
| *Peltigera canina* | 3.2 | 3.2 | 2.2 | 2.2 | 1.1 | 2.3 | +.1 | 4.3 | 2.1 | 2.2 | V | 2.2 | 3 |
| *Cladonia pocillum* | +.1 | . | . | . | . | +.1 | . | . | +.1 | 2.2 | II | 0.5 | 2+ |
| *Stereocaulon glareosum* | +.1 | . | . | . | . | . | +.1 | +.1 | . | +.1 | II | 0.4 | 3 |
| *Lecanora epibryon* | . | . | . | . | +.1 | +.1 | +.1 | . | . | . | II | 0.3 | 2+ |
| *Stereocaulon rivulorum* | . | . | . | . | . | +.1 | . | . | . | +.1 | I | 0.2 | 2 |
| *Cetraria tilesii* | . | . | . | . | +.1 | +.1 | . | . | . | . | I | 0.2 | 2 |
| *Solorina saccata* | . | . | . | . | . | . | +.1 | . | . | . | I | 0.1 | 2 |
| *Hypnum procerrimum* | 4.4 | 7.6 | 6.6 | 6.5 | 4.3 | 7.6 | 6.5 | 4.3 | 4.3 | 3.5 | V | 5.1 | 3 |
| *Abietinella abietina* | 7.6 | 7.5 | 7.7 | 4.4 | 3.3 | 6.6 | 5.5 | 3.3 | 2.2 | 2.4 | V | 4.6 | 3 |
| *Distichium capillaceum* | 1.2 | 2.1 | 2.2 | +.1 | +.1 | +.2 | +.2 | +.2 | . | 1.2 | V | 1.1 | 3 |
| *Tomentypnum nitens* | . | +.1 | . | . | +.1 | . | . | . | . | +.1 | II | 0.3 | 2 |
| *Tortula ruralis* | 1.2 | . | +.2 | . | . | . | . | 1.2 | . | . | II | 0.3 | 2 |
| *Ditrichum flexicaule* | . | +.1 | . | . | . | +.1 | . | . | . | . | I | 0.2 | 2 |
| *Ceratodon purpureus* | . | . | . | +.1 | +.1 | . | . | . | . | . | I | 0.2 | 2 |

(D) Moss layer: Caloplaca cirrochroa
Dermatocarpon hepaticum
Hypnum vaucheri
Lecidea decipiens
Lecidea rubiformis
(Tortula ruralis)*

Association 13. Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis

Its distribution is in the boreal (montane) spruce biogeoclimatic zone in map sections D 2, D 3, D 4, D 5, D 6, D 7, E 1, E 3, E 4, E 5 and E 6.

The characteristic combination of species is:

(C) Herb layer: Arabis holboellii
Astragalus aboriginum
(Solidago decumbens)*

(D) Moss layer: Lecanora lentigera
Parmelia taractica

The total acreage occupied by this association is estimated to be 675.0 acres.

Association 14. Artemisio (frigidae) - Agropyro (yukonensis) Eurotietum lanatae

The characteristic combination of species (plant association) is:

(Artemisia rupestris)*
Chamaerhodos erecta
Eurotia lanata

Characteristic is also the absence of many species occurring in the preceding plant association. Its occurrence is in both the boreal (montane) as well as in the sub-alpine willow - birch biogeoclimatic zones.

This association is of very limited extent in the study area,

* Species in brackets are less characteristic than those without brackets.

being restricted to mapping sections D 4.35, D 4.45 and D 5.91. Its total size in the study area does not exceed 3 acres.

Association 15. Pentstemono (gormanii) - Artemisietum frigidae

This plant association, occurring in the boreal (montane) zone is very limited in extent, occupying only about 3.5 acres in sections E 3.69, E 4.53 and E 4.34. It occupies very steep, south-facing slopes, at the base of Sheep Mountain. The substrate consists of a very thick (2 to 3 feet) deposition of loess. No grazing of sheep takes place in this association since it is far removed from any escape terrain. Characteristic is the almost complete crustose lichen cover which stabilizes the loess.

Figure 15 shows an ecotone between this association and Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi above it on flatter ground.

Its only characteristic species is a lichen, Buellia epigaea.

Association 16. Agropyro (yukonensis) - Artemisietum frigidae - rupestris

It occurs on colluvial material at the bottom of a scree mixed with aeolian loess deposits in both the boreal (montane) as well as the sub-alpine biogeoclimatic zones.

The characteristic combination of species (plant association) is:

Artemisia dracunculus
Artemisia rupestris

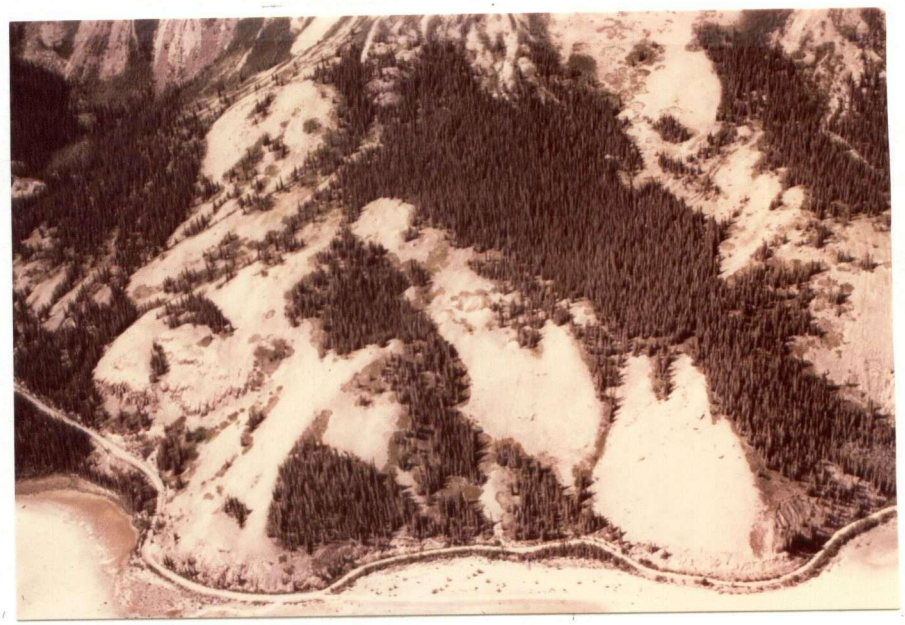


FIGURE 14: Grasslands occupy southern and western aspects on fairly steep slopes. White spruce is found on flat areas and eastern aspects. Transitional zones are occupied by Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi.

FIGURE 15: Photograph shows ecotone between Pentstemono (gormanii) - Artemisietum frigidae and Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi.

(Chamaerhodos erecta)*
(Eurotia lanata)*

This plant association has two variations: var. agropyro (yukonensis) - artemisiosum frigidae - rupestris which is the type of the association, and var. caricosum filifoliae differentiated by the occurrence of Carex filifolia, Minuartia rossii, Oxytropis viscida, Plantago canescens and Potentilla hookeriana. The latter variety occupies less steep areas with a lower percentage of coarse material making up the substrate.

This association occupies about 185.0 acres in map sections C 7, D 2, D 3, D 4, D 5 and D 6. It is best developed between the 3500 and 4500 feet elevations, where it is the dominant grassland association.

Association 17. Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum filifoliae

This plant association occurs already in the sub-alpine bio-geoclimatic zone and it has a number of similarities to the alpine grassland association Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati in particular the occurrence of Artemisia hyperborea, Carex scirpoidea, Potentilla hookeriana and Potentilla virgulata.

The characteristic combination of species is:

(Artemisia hyperborea)*
(Artemisia rupestris)*
(Carex scirpoidea)*
Minuartia rossii
Potentilla hookeriana
Potentilla virgulata
(Senecio conterminus)*

* Species in brackets are less characteristic than those without brackets.

Some plants, occurring in the previous as well as in this plant association, show that these subalpine grassland communities, in their floristic structure, have such elements which otherwise grow much more commonly in the alpine tundra biogeoclimatic zone. In other words, the rather rare occurrence of these plants in the subalpine zone does not constitute a substantiation for a consideration that they characterize the subalpine biogeoclimatic zone.

Such characteristically alpine plants are:

Agropyron boreale
Agropyron violaceum
Artemisia hyperborea
Carex rupestris
Minuartia rossii
Oxytropis huddelsonii
Potentilla hookeriana
Potentilla virgulata
Senecio conterminus
Cetraria cucullata
Cetraria tilesii
Thamnolia subuliformis

This association occupies an area of about 34 acres along ridge tops in map sections B 3, B 6, B 7, C 3, C 6 and C 7. These grassland associations with the exception of #15 [Pentstemono (gormannii) - Artemisietum frigidae] are the important winter range of Dall sheep as well as some Oreamus americanus (Mountain goat) in neighbouring areas. Sheep utilize these areas from September to the following late May. Figure 14 shows the typical distribution pattern of plant associations in the boreal zone.

Grasslands -- in this particular case mainly Pentstemono

(gormanii) - Artemisietum frigidae -- occupy south and west facing, rather steep slopes; level areas as well as east facing slopes are covered by White Spruce forests. There is almost always a transitional zone between grasslands and spruce usually made up by Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi. Tables 16, 17, 18, 19, 20, 43 and 53 reveal details on the analyses and synthesis of these grasslands. The characteristic animal of these grasslands (besides sheep) is the Spermophilus parryii (Arctic ground squirrel). Common birds include Falco sparverius (sparrow hawk), Sayornis saya (Say's phoebe) and Myadestes townsendi (Townsend's solitaire).

Order 9. BETULETALIA GLANDULOSAE Lambert & Krajina, 1968

This order is the major vegetation unit of the subalpine willow - birch biogeoclimatic zone of Sheep Mountain. It contains the following alliance:

Alliance 11. Potentillo (fruticosae) - Salicion glaucae Hoefs & Krajina

and occurs mainly on stabilized aeolian loess deposits of the subalpine biogeoclimatic zone.

The characteristic combination of species (order and alliance) is:

(B) Shrub layer: Betula glandulosa
(Juniperus communis)*
Picea glauca (in "Krummholz" form)
Potentilla fruticosa
Salix alaxensis
(Salix brachycarpa)*
Salix glauca
Salix lanata
(Shepherdia canadensis)*
(Viburnum edule)*

(C) Herb layer: (Anemone parviflora)*
Arctostaphylos rubra
(Carex scirpoidea)*

* Species in brackets are less characteristic than those without brackets.

Table 16.

Order: 8. ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS

Alliance: 10. Artemisio (frigidae) - Agropyrion yukonensis

Association: 13. Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 10 | 4 | 4/70 | 1/70 | 8/70 | 8 | 2/70 | 151 | 1 | 193 | | | |
| Date | 15.7. 71 | 13.7. 71 | 24.7. 70 | 23.7. 70 | 31.7. 70 | 13.7. 71 | 23.7. 70 | 9.9. 71 | 12.7. 71 | 18.9. 71 | | | |
| Elevation (feet) | 2650 | 2720 | 2720 | 2750 | 2770 | 2770 | 2800 | 2820 | 2900 | 2910 | | | |
| Exposure (degree) | 190 | 230 | 210 | 210 | 210 | 190 | 165 | 190 | 120 | 130 | | | |
| Slope (degree) | -22 | -23 | -10 | -10 | -15 | -27 | -26 | -30 | -14 | -15 | | | |
| Hygrotope | 2 | 2 | 2 | 2 | 2 | 2- | 2 | 2 | 2+ | 2/3 | Constancy | Average species significance | Vigor |
| *Artemisia frigida* | 6.2 | 4.2 | 7.2 | 7.3 | 6.3 | 4.2 | 7.2 | 5.2 | 4.2 | 5.3 | V | 5.5 | 3 |
| *Agropyron yukonense* | 4.1 | 4.1 | 3.2 | 4.+ | 6.2 | 2.1 | 5.1 | 6.2 | 3.1 | 7.3 | V | 4.4 | 2+ |
| *Carex filifolia* | 4.3 | 4.1 | 1.2 | . | 2.2 | 4.2 | 5.3 | 1.1 | 5.2 | +.2 | V | 2.7 | 3 |
| *Erigeron caespitosus* | 2.1 | 2.1 | 3.1 | 3.+ | 2.1 | 2.1 | 5.1 | 2.1 | 3.1 | 3.1 | V | 2.7 | 3 |
| *Pentstemon gormanii* | 3.1 | 4.1 | 2.1 | 1.+ | 2.1 | 3.1 | 3.1 | 1.1 | 2.1 | 1.+ | V | 2.2 | 2+ |
| *Linum perenne* | 1.+ | 1.+ | . | . | 2.+ | . | 2.+ | 2.+ | +.+ | 1.+ | IV | 1.0 | 3 |
| *Calamagrostis purpurascens* | 2.1 | 2.+ | . | +.1 | . | +.+ | 2.2 | . | 3.1 | . | III | 1.1 | 2 |
| *Aster alpinus* | . | 1.1 | . | 1.+ | . | . | . | 1.1 | +.1 | 2.+ | III | 0.6 | 3 |
| *Pulsatilla patens* | 2.1 | +.1 | . | +.+ | . | . | +.+ | . | +.+ | . | III | 0.6 | 2 |
| *Anemone multifida* | +.1 | 2.1 | . | . | . | . | . | . | 3.+ | . | II | 0.6 | 2 |
| *Oxytropis viscida* | . | . | 3.1 | . | . | . | . | +.+ | 2.1 | . | II | 0.6 | 2 |
| *Poa glauca* | +.1 | . | . | . | . | 1.+ | . | . | 1.+ | . | II | 0.3 | 2 |
| *Solidago decumbens* | . | +.1 | . | . | . | . | +.+ | . | 1.+ | . | II | 0.3 | 2 |
| *Arabis holboellii* | . | . | . | . | 1.+ | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Astragalus aboriginum* | . | . | . | +.+ | . | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Potentilla hookeriana* | . | +.1 | . | . | . | . | . | . | 1.1 | . | I | 0.2 | 3 |
| *Rosa acicularis* | 1.1 | 1.1 | . | . | . | . | . | . | . | . | I | 0.2 | 2 |
| *Senecio conterminus* | . | . | . | 1.+ | . | . | . | +.+ | . | . | I | 0.2 | 2 |
| *Townsendia hookeri* | . | . | . | . | +.+ | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Antennaria media* | . | . | . | . | . | . | . | . | +.2 | . | I | 0.1 | 2+ |
| *Antennaria rosea* | . | . | . | . | . | +.1 | . | . | . | . | I | 0.1 | 2 |
| *Artemisia rupestris* | . | . | . | . | . | . | . | . | +.2 | . | I | 0.1 | 2 |
| *Comandra umbellata* | . | . | . | . | . | . | . | . | +.+ | . | I | 0.1 | 2 |
| *Eurotia lanata* | . | . | +.+ | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Orobanche fasciculata* | . | . | . | . | +.+ | . | . | . | . | . | I | 0.1 | 2- |
| *Oxytropis splendens* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Dermatocarpon hepaticum* | 5.2 | 4.2 | 7.3 | 5.2 | 4.1 | 4.1 | 6.2 | 5.2 | 4.2 | 4.2 | V | 4.8 | 3 |
| *Lecidea rubiformis* | 3.2 | +.1 | 4.2 | 1.1 | 3.2 | 4.2 | 4.2 | 4.2 | 2.1 | 2.2 | V | 2.8 | 3 |
| *Lecanora lentigera* | 5.1 | 3.1 | 1.1 | +.1 | +.1 | 3.1 | . | 4.1 | 4.1 | 1.2 | V | 2.3 | 3 |
| *Caloplaca cirrochroa* | . | 1.+ | 2.+ | 1.+ | +.+ | . | . | 1.+ | 1.+ | +.+ | IV | 0.8 | 3 |
| *Lecidea decipiens* | 1.1 | 2.1 | +.1 | 1.1 | . | . | . | +.1 | 1.+ | 1.+ | IV | 0.8 | 3 |
| *Parmelia taractica* | 2.1 | 2.+ | . | . | . | . | . | . | 4.1 | 1.+ | II | 0.9 | 2 |
| *Physcia muscigena* | +.+ | . | . | +.+ | . | . | . | . | . | +.+ | II | 0.3 | 2 |
| *Buellia epigaea* | . | . | . | . | . | . | . | 2.1 | . | . | I | 0.2 | 2 |
| *Collema coccophorum* | . | . | . | +.+ | . | . | . | +.+ | . | . | I | 0.2 | 2 |
| *Fulgensia bracteata* | . | . | +.+ | . | . | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Tortula ruralis* | 3.2 | +.1 | . | 1.1 | . | . | . | 1.1 | 1.1 | 1.2 | III | 0.8 | 2 |
| *Hypnum vaucheri* | +.1 | . | . | 3.1 | . | . | . | +.1 | +.1 | . | II | 0.6 | 2 |
| *Barbula icmadophila* | . | . | . | +.1 | . | . | . | . | . | +.+ | I | 0.2 | 2 |

Table 17.

Order: 8. ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS

Alliance: 10. Artemisio (frigidae) - Agropyrion yukonensis

Association: 14. Artemisio (frigidae) - Agropyro (yukonensis) - Eurotietum lanatae

| Number of plots | 1 | 2 | 3 | 4 | 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Plot number | 16 | 157 | 178 | 179 | 170 | | | |
| Date | 16.7. 71 | 9.9. 71 | 15.9. 71 | 15.9. 71 | 14.9. 71 | | | |
| Elevation (feet) | 2880 | 3300 | 3980 | 4010 | 4210 | | | |
| Exposure (degree) | 260 | 140 | 160 | 145 | 150 | | | |
| Slope (degree) | -10 | -39 | -37 | -38 | -38 | | | |
| Hygrotope | 2 | 2- | 2 | 2 | 2 | Constancy | Average species significance | Vigor |
| *Artemisia frigida* | 6.3 | 6.3 | 5.2 | 5.2 | 6.3 | V | 5.6 | 2+ |
| *Eurotia lanata* | 4.2 | 6.3 | 6.3 | 5.3 | 5.2 | V | 5.2 | 3 |
| *Agropyron yukonense* | 3.1 | 2.1 | 3.+ | 3.2 | 3.1 | V | 2.8 | 2- |
| *Chamaerhodos erecta* | . | 2.1 | +.+ | . | 1.+ | III | 0.8 | 2+ |
| *Pentstemon gormanii* | +.1 | 1.1 | +.1 | . | . | III | 0.6 | 1+ |
| *Carex filifolia* | 2.1 | . | +.1 | . | . | II | 0.6 | 2 |
| *Artemisia rupestris* | . | +.2 | +.2 | . | . | II | 0.4 | 2+ |
| *Artemisia dracunculus* | . | . | +.1 | . | 1.1 | II | 0.4 | 2 |
| *Calamagrostis purpurascens* | 2.1 | . | . | . | . | I | 0.4 | 2 |
| *Oxytropis viscida* | 1.1 | . | . | . | . | I | 0.2 | 2 |
| *Potentilla hookeriana* | . | . | . | +.+ | . | I | 0.2 | 2 |
| *Lappula myosotis* | . | . | . | . | +.+ | I | 0.2 | 2+ |
| *Linum perenne* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Erigeron caespitosus* | +.1 | . | . | . | . | I | 0.2 | 2 |
| *Dermatocarpon hepaticum* | 3.1 | . | . | . | . | I | 0.6 | 2 |
| *Lecidea rubiformis* | 1.1 | . | . | . | . | I | 0.2 | 2 |
| *Caloplaca cirrochroa* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Buellia epigaea* | 1.1 | . | . | . | . | I | 0.2 | 2 |
| *Lecidea decipiens* | +.1 | . | . | . | . | I | 0.2 | 2 |
| *Tortula ruralis* | 3.1 | . | . | . | . | I | 0.6 | 2 |
| *Hypnum vaucheri* | 1.1 | . | . | . | . | I | 0.2 | 2 |

Table 18.

Order: 8. ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS

Alliance: 10. Artemisio (frigidae) - Agropyrion yukonensis

Association: 15. Pentstemono (gormanii) - Artemisietum frigidae

| Number of plots | 1 | 2 | 3 | 4 | 5 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|
| Plot number | 21 | 381 | 12 | 152 | 382 | | | |
| Date | 17.7. 71 | 12.9. 72 | 15.7. 71 | 9.9. 71 | 12.9. 72 | | | |
| Elevation (feet) | 2730 | 2770 | 2790 | 2840 | 2870 | | | |
| Exposure (degree) | 170 | 110 | 135 | 180 | 130 | | | |
| Slope (degree) | -40 | -45 | -28 | -42 | -38 | | | |
| Hygrotope | 2+ | 2+ | 1/2 | 2+ | 2+ | | | |
| *Artemisia frigida* | 5.2 | 6.3 | 5.1 | 5.2 | 5.2 | V | 5.2 | 2+ |
| *Pentstemon gormanii* | 4.2 | 4.1 | 5.1 | 4.1 | 4.1 | V | 4.2 | 3 |
| *Linum perenne* | 3.1 | +.+ | . | 1.+ | . | III | 1.0 | 2+ |
| *Carex filifolia* | 1.1 | . | 2.1 | . | . | II | 0.6 | 2 |
| *Agropyron yukonense* | . | . | 2.+ | . | . | I | 0.4 | 2 |
| *Oxytropis viscida* | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Townsendia hookeri* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Erigeron caespitosus* | . | . | 1.+ | . | . | I | 0.2 | 2 |
| *Lecidea rubiformis* | 5.2 | 6.2 | 4.2 | 6.3 | 6.3 | V | 5.4 | 3 |
| *Dermatocarpon hepaticum* | 5.2 | 4.2 | 5.2 | 3.2 | 5.2 | V | 4.4 | 3 |
| *Buellia epigaea* | 5.2 | 2.1 | 3.+ | 2.1 | 3.1 | V | 3.0 | 3 |
| *Lecidea decipiens* | 3.1 | 2.1 | +.+ | +.+ | 1.1 | V | 1.6 | 3 |
| *Caloplaca cirrochroa* | +.+ | 2.+ | . | +.+ | +.+ | IV | 1.0 | 2 |
| *Lecanora lentigera* | . | 1.1 | . | 1.1 | +.+ | III | 0.6 | 2 |
| *Collema coccophorum* | . | +.+ | . | +.+ | +.+ | III | 0.6 | 2 |
| *Parmelia taractica* | . | . | 2.+ | . | . | I | 0.4 | 2 |
| *Fulgensia bracteata* | . | . | . | . | 1.+ | I | 0.2 | 2 |
| *Hypnum vaucheri* | 3.1 | +.1 | 1.1 | . | +.1 | IV | 1.2 | 2 |
| *Tortula ruralis* | . | +.1 | 1.1 | 1.1 | . | III | 0.6 | 2 |

Table 19.

Order: 8. ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS

Alliance: 10. Artemisio (frigidae) - Agropyrion yukonensis

Association: 16. Agropyro (yukonensis) - Artemisietum frigidae - rupestris

Variation: agropyro - artemisiosum frigidae - rupestris | caricosum filifoliae

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Constancy | Average species significance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 176 | 177 | 168 | 169 | 199 | 15 | 202 | 161 | 204 | 160 | | |
| Date | 15.9. 71 | 15.9. 71 | 14.9. 71 | 14.9. 71 | 18.9. 71 | 16.7. 71 | 25.9. 71 | 10.9. 71 | 25.9. 71 | 13.9. 71 | | |
| Elevation (feet) | 3290 | 3680 | 3770 | 3970 | 4260 | 2870 | 3460 | 3970 | 4310 | 4560 | | |
| Exposure (degree) | 145 | 130 | 150 | 140 | 140 | 260 | 110 | 140 | 110 | 110 | | |
| Slope (degree) | -34 | -39 | -36 | -37 | -38 | -25 | -33 | -24 | -22 | -33 | | |
| Hygrotope | 2 | 2 | 2 | 2- | 2- | 2 | 2- | 2 | 2- | 2- | | |
| *Artemisia rupestris* | 6.4 | 6.4 | 5.2 | 6.4 | 5.3 | 6.3 | 5.2 | 4.3 | 5.2 | 5.3 | V | 5.3 |
| *Artemisia frigida* | 5.3 | 4.2 | 4.2 | 1.1 | 3.2 | +.2 | 3.1 | 5.2 | 4.1 | 3.1 | V | 3.3 |
| *Agropyron yukonense* | 3.1 | 4.1 | 3.1 | 4.1 | 2.1 | 1.+ | 1.+ | 2.+ | . | 2.+ | V | 2.2 |
| *Calamagrostis purpurascens* | . | +.1 | 3.2 | 1.1 | 3.1 | 1.1 | 2.1 | 2.1 | 4.1 | +.1 | V | 1.8 |
| *Pentstemon gormanii* | 2.1 | 3.1 | 1.1 | 1.1 | +.+ | +.1 | 2.+ | . | . | 3.1 | IV | 1.4 |
| *Erigeron caespitosus* | +.+ | . | . | 1.1 | 1.+ | 2.1 | 2.+ | 1.+ | +.+ | +.+ | IV | 1.0 |
| *Carex filifolia* | . | . | . | . | . | 4.1 | 6.2 | 6.2 | 6.2 | 5.2 | III | 2.7 |
| *Oxytropis viscida* | . | . | . | . | . | 3.1 | . | 4.1 | 1.+ | 4.1 | II | 1.2 |
| *Eurotia lanata* | 2.1 | 2.1 | 2.1 | . | . | . | . | . | . | . | II | 0.6 |
| *Artemisia dracunculus* | 1.2 | +.1 | 2.1 | +.1 | . | . | . | . | . | . | II | 0.5 |
| *Aster alpinus* | . | +.1 | +.1 | . | . | . | 1.+ | . | 1.+ | . | II | 0.4 |
| *Chamaerhodos erecta* | . | +.+ | 1.+ | . | . | . | . | . | . | 1.+ | II | 0.3 |
| *Linum perenne* | . | . | 1.+ | . | +.+ | +.+ | . | . | . | . | II | 0.3 |
| *Plantago canescens* | . | . | . | . | . | . | 4.1 | . | 1.1 | . | I | 0.5 |
| *Minuartia rossii* | . | . | . | . | . | . | . | 3.1 | +.1 | . | I | 0.4 |
| *Potentilla hookeriana* | . | . | . | . | . | . | . | 2.1 | 1.1 | . | I | 0.3 |
| *Bromus pumpellianus* | . | . | . | . | . | . | . | . | 2.+ | . | I | 0.2 |
| *Pulsatilla patens* | . | . | . | . | . | . | . | +.+ | +.+ | . | I | 0.2 |
| *Solidago decumbens* | . | . | . | +.1 | +.+ | . | . | . | . | . | I | 0.2 |
| *Antennaria rosea* | +.+ | . | . | . | . | . | . | . | . | . | I | 0.1 |
| *Artemisia hyperborea* | . | . | . | . | . | . | . | . | 1.1 | . | I | 0.1 |
| *Astragalus williamsii* | . | . | . | . | . | +.1 | . | . | . | . | I | 0.1 |
| *Poa glauca* | . | . | . | . | . | . | . | 1.1 | . | . | I | 0.1 |
| *Potentilla virgulata* | . | . | 1.+ | . | . | . | . | . | . | . | I | 0.1 |
| *Senecio conterminus* | . | . | . | . | . | . | . | +.+ | . | . | I | 0.1 |
| *Dermatocarpon hepaticum* | +.1 | +.1 | . | . | . | +.+ | 2.1 | +.1 | . | . | III | 0.6 |
| *Lecidea rubiformis* | . | +.1 | . | +.+ | . | . | 1.1 | 2.1 | . | +.+ | III | 0.6 |
| *Caloplaca cirrochroa* | +.+ | +.+ | . | . | . | +.+ | +.+ | +.1 | . | . | III | 0.5 |
| *Buellia epigaea* | . | +.+ | . | . | . | . | 2.1 | . | . | . | I | 0.3 |
| *Lecanora lentigera* | . | +.1 | . | . | . | . | 1.1 | . | . | . | I | 0.2 |
| *Lecidea decipiens* | . | . | . | . | . | . | 1.1 | 1.1 | . | . | I | 0.2 |
| *Cetraria tilesii* | . | . | . | . | . | . | . | . | . | +.+ | I | 0.1 |
| *Thamnolia subuliformis* | . | . | . | . | . | . | . | . | +.+ | . | I | 0.1 |
| *Tortula ruralis* | +.1 | . | . | . | . | . | 2.1 | . | +.+ | . | II | 0.4 |
| *Hypnum vaucheri* | . | . | . | . | . | +.+ | . | +.+ | . | . | I | 0.2 |

Table 20.

Order: 8. ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS

Alliance: 10. Artemisio (frigidae) - Agropyrion yukonensis

Association: 17. Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum filifoliae

| Number of plots | 1 | 2 | 3 | 4 | 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Plot number | 162 | 163 | 159 | 25 | 158 | | | |
| Date | 13.9. 71 | 13.9. 71 | 10.9. 71 | 18.7. 71 | 10.9. 71 | | | |
| Elevation (feet) | 4190 | 4820 | 4960 | 5140 | 5770 | | | |
| Exposure (degree) | 90 | 160 | 130 | 120 | 110 | | | |
| Slope (degree) | -14 | -31 | -28 | -18 | -14 | | | |
| Hygrotope | 2/3 | 2- | 2- | 2- | 2/3 | Constancy | Average species significance | Vigor |
| *Carex filifolia* | 6.3 | 5.2 | 5.2 | 6.2 | 4.2 | V | 5.2 | 3 |
| *Artemisia hyperborea* | 4.2 | 2.1 | 4.2 | 5.2 | 6.3 | V | 4.2 | 2+ |
| *Artemisia frigida* | 3.1 | 2.2 | 4.2 | 5.2 | 5.2 | V | 3.8 | 2+ |
| *Oxytropis viscida* | 4.1 | 4.1 | 3.1 | 4.1 | 4.1 | V | 3.8 | 3 |
| *Calamagrostis purpurascens* | 5.1 | 3.1 | 3.1 | 4.1 | 3.1 | V | 3.6 | 2+ |
| *Potentilla hookeriana* | 2.1 | 4.1 | 4.1 | +.1 | 1.+ | V | 2.4 | 3 |
| *Poa glauca* | +.+ | 1.+ | 1.1 | 4.1 | 1.1 | V | 1.6 | 3 |
| *Erigeron caespitosus* | 1.+ | +.+ | +.+ | 1.+ | +.+ | V | 1.0 | 2 |
| *Minuartia rossii* | 2.1 | 2.1 | 4.2 | . | +.+ | IV | 1.8 | 2+ |
| *Senecio conterminus* | +.1 | +.+ | +.+ | . | . | III | 0.6 | 2 |
| *Carex scirpoidea* | 2.+ | . | +.+ | . | . | II | 0.6 | 2 |
| *Castilleja hyperborea* | . | +.+ | 2.1 | . | . | II | 0.6 | 2 |
| *Potentilla virgulata* | . | . | . | +.1 | 2.2 | II | 0.6 | 2+ |
| *Anemone multifida* | 1.+ | +.+ | . | . | . | II | 0.4 | 2 |
| *Artemisia rupestris* | +.1 | . | 1.2 | . | . | II | 0.4 | 2 |
| *Agropyron yukonense* | 2.+ | . | . | . | . | I | 0.4 | 2- |
| *Pulsatilla patens* | . | . | 1.+ | . | . | I | 0.2 | 2 |
| *Agropyron violaceum* | . | . | 1.1 | . | . | I | 0.2 | 2 |
| *Antennaria media* | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Solidago multiradiata* | +.1 | . | . | . | . | I | 0.2 | 2 |
| *Aster alpinus* | +.1 | . | . | . | . | I | 0.2 | 2 |
| *Agropyron boreale* | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Antennaria stolonifera* | . | . | +.+ | . | . | I | 0.2 | 2 |
| *Lappula myosotis* | . | . | . | +.+ | . | I | 0.2 | 2 |
| *Oxytropis huddelsonii* | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Carex rupestris* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Caloplaca cirrochroa* | +.+ | +.+ | +.+ | +.+ | +.+ | V | 1.0 | 2+ |
| *Lecidea rubiformis* | 1.1 | 1.1 | +.1 | 1.1 | . | IV | 0.8 | 2 |
| *Dermatocarpon hepaticum* | 2.1 | 1.1 | . | . | . | II | 0.6 | 2 |
| *Lecidea decipiens* | 2.1 | . | . | +.1 | . | II | 0.6 | 2 |
| *Thamnolia subuliformis* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Cetraria tilesii* | 1.+ | . | . | . | . | I | 0.2 | 2 |
| *Cetraria cucullata* | 1.1 | . | . | . | . | I | 0.2 | 2 |
| *Lecanora lentigera* | +.1 | . | . | . | . | I | 0.2 | 2 |
| *Hypnum vaucheri* | 2.1 | 1.1 | . | +.1 | +.1 | IV | 1.0 | 2 |
| *Tortula ruralis* | . | 1.1 | +.1 | 1.1 | +.1 | IV | 0.8 | 2 |

(Dryas integrifolia)*
(Epilobium latifolium)*
(Equisetum arvense)*
Equisetum scirpoides
(Festuca altaica)*
(Gentiana propinqua)*
(Hedysarum alpinum)*
(Linnaea borealis)*
(Mertensia paniculata
Parnassia palustris
Pedicularis capitata
(Petasites frigidus)*
(Pyrola secunda)*
(Salix reticulata)*
(Valeriana capitata)*

(D) Moss layer: (Abietinella abietina)*
Campylium stellatum
Ceratodon purpureus
(Peltigera canina)*

There are two plant associations belonging to this alliance and order as follows:

Association 18. Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae

It represents the zonal (mesic) plant association of the subalpine willow - birch biogeoclimatic zone.

The characteristic combination of species (plant association) is:

(B) Shrub layer: (Salix myrtillifolia)*

(C) Herb layer: (Achillea lanulosa)*
(Aconitum delphinifolium)*
(Arctostaphylos uva-ursi)*
(Artemisia arctica)*
(Astragalus alpinus)*
(Carex filifolia)*
(Epilobium angustifolium)*
(Salix arctica)*
(Senecio lugens)*
(Solidago decumbens)*
Zygadenus elegans

* Species in brackets are less characteristic than those without brackets.

Figure 16 shows a photograph of this association. It occupies an area of approximately 572.5 acres of Sheep Mountain in map sections A 2, B 3, C 2, D 2, D 3, D 4, D 5 and D 6. It is best developed in the subalpine zone (4000 to 5000 feet) of Sheep Mountain's west slope.

Association 19. Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - lanatae - glaucae

Its soils are hygric with longer snow duration than in the preceding plant association.

The characteristic combination of species (plant association) is:

| | | |
|---|---|---|
| (B) | Shrub layer: | Ledum palustre<br>Rhododendron lapponicum<br>Vaccinium uliginosum |
| (C) | Herb layer: | Arctagrostis latifolia<br>(Cassiope tetragona)*<br>Empetrum nigrum<br>(Kobresia myosuroides)*<br>Pyrola asarifolia<br>Saussurea angustifolia |
| (D) | Moss layer: | (Cetraria tilesii)*<br>(Cladonia pocillum)*<br>(Dactylina arctica)*<br>Orthothecium chryseum |

Figure 17 shows a photograph of this association. It is best developed on Sheep Mountain's east face (map sections A 7, B 7 and C 7), where it occupies an area of about 165 acres. It may also be found on flat, moister sites within the previous association (No. 18).

Tables 21, 22, 44 and 53 reveal details on the analyses and

* Species in brackets are less characteristic than those without brackets.

FIGURE 16: Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae

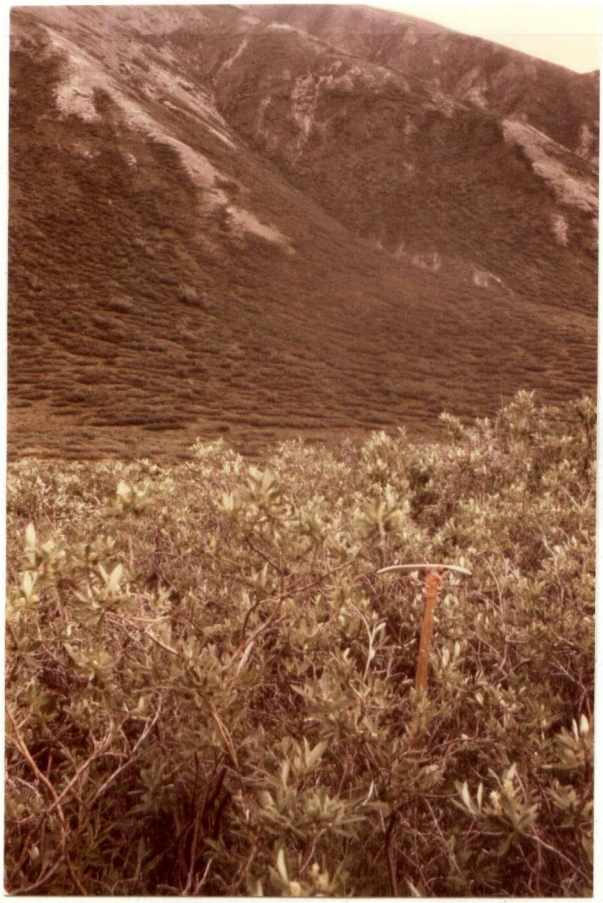


FIGURE 17:

Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - lanatae - glaucae

Table 21

Order: 9. BETULETALIA GLANDULOSAE

Alliance: 11. Potentillo (fruticosae) - Salicion glaucae

Association: 18. Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 358 | 355 | 356 | 54 | 354 | 353 | 53 | 357 | 351 | 352 | | | |
| Date | 28.8. 72 | 26.8. 72 | 28.8. 72 | 1.8. 71 | 26.8. 72 | 26.8. 72 | 1.8. 71 | 28.8. 72 | 26.8. 72 | 26.8. 72 | | | |
| Elevation (feet) | 4130 | 4200 | 4390 | 4410 | 4430 | 4470 | 4520 | 4540 | 4620 | 4670 | | | |
| Exposure (degree) | 230 | 130 | 150 | 210 | 150 | 170 | 80 | 270 | 140 | 230 | | | |
| Slope (degree) | -7 | -14 | -14 | -17 | -18 | -11 | -14 | -24 | -12 | -15 | | | |
| Hygrotope | 3 | 3 | 3+ | 3+ | 3 | 3 | 3 | 3 | 3+ | 3 | Constancy | Average species significance | Vigor |
| *Salix glauca* | 8.7 | 8.7 | 8.7 | 6.6 | 8.7 | 8.7 | 8.7 | 7.6 | 8.7 | 8.6 | V | 7.7 | 3 |
| *Salix myrtillifolia* | +.3 | 2.3 | 3.4 | . | +.3 | 1.3 | . | 6.5 | 1.3 | 3.4 | IV | 1.8 | 2 |
| *Salix lanata* | . | 2.4 | +.4 | 2.5 | . | +.4 | +.4 | 1.5 | 2.4 | 3.5 | IV | 1.3 | 2 |
| *Salix alaxensis* | 1.5 | . | . | 4.5 | . | . | . | . | . | . | I | 0.5 | 2 |
| *Salix brachycarpa* | . | . | . | . | . | +.3 | . | . | . | . | I | 0.1 | 2- |
| *Betula glandulosa* | . | 3.3 | 5.4 | 5.4 | 3.3 | 4.3 | 4.4 | 5.4 | 3.3 | 4.4 | V | 3.6 | 2+ |
| *Potentilla fruticosa* | 1.3 | 4.3 | 4.4 | 2.3 | 3.4 | 4.4 | +.3 | 4.4 | 4.4 | 4.3 | V | 3.1 | 3 |
| *Juniperus communis* | . | +.3 | +.3 | . | . | +.3 | 4.3 | +.2 | . | . | III | 0.8 | 2 |
| *Shepherdia canadensis* | +.2 | +.2 | . | . | +.2 | +.2 | . | 1.3 | . | . | III | 0.5 | 2 |
| *Picea glauca* | +.2 | +.2 | +.5 | +.3 | . | . | . | +.2 | . | . | III | 0.5 | 1 |
| *Viburnum edule* | . | 2.1 | . | . | . | . | . | . | . | . | I | 0.2 | 2 |
| *Salix reticulata* | 2.3 | 6.4 | 3.3 | 3.3 | 5.3 | 5.4 | 5.4 | 3.3 | 5.4 | 5.3 | V | 4.2 | 2+ |
| *Arctostaphylos rubra* | 4.4 | 5.4 | 5.4 | 3.4 | 4.4 | 4.3 | 5.4 | 4.3 | 4.4 | 3.3 | V | 4.1 | 2+ |
| *Arctostaphylos uva-ursi* | 4.5 | 3.3 | 6.5 | 3.3 | 1.3 | 3.3 | +.2 | 3.3 | 2.3 | 3.3 | V | 2.9 | 2+ |
| *Carex filifolia* | 4.3 | +.1 | 4.2 | 2.1 | 3.1 | 5.2 | +.1 | +.1 | 4.1 | 4.1 | V | 2.9 | 2 |
| *Festuca altaica* | 2.2 | 1.2 | 4.2 | 3.2 | 4.2 | 3.2 | 2.2 | 3.2 | 3.2 | 3.2 | V | 2.8 | 2 |
| *Carex scirpoidea* | 1.+ | 1.+ | 3.1 | 1.1 | 2.1 | 2.1 | 3.1 | 3.1 | 2.1 | 3.1 | V | 2.1 | 2+ |
| *Hedysarum alpinum* | 1.1 | 3.1 | 2.1 | 2.1 | 3.1 | 3.1 | 1.1 | 3.1 | 1.1 | 2.1 | V | 2.1 | 2 |
| *Anemone parviflora* | 1.+ | 2.1 | 2.+ | 1.+ | 2.+ | 2.+ | 5.1 | 2.+ | 1.+ | 2.+ | V | 2.0 | 2 |
| *Zygadenus elegans* | +.1 | 3.1 | 3.+ | 1.1 | 2.1 | 2.1 | 3.1 | 1.+ | +.1 | 3.1 | V | 2.0 | 2 |
| *Mertensia paniculata* | 2.1 | 2.1 | 2.+ | 2.1 | 2.1 | 3.1 | 1.1 | +.1 | 2.1 | 2.1 | V | 1.9 | 2 |
| *Linnaea borealis* | +.2 | 3.1 | 1.2 | +.2 | 1.2 | 2.1 | 3.1 | 3.3 | +.1 | +.1 | V | 1.7 | 2 |
| *Equisetum scirpoides* | 3.+ | 2.+ | +.+ | . | 2.+ | 3.+ | +.+ | +.+ | +.+ | 2.+ | V | 1.6 | 2 |
| *Gentiana propinqua* | 2.+ | 1.+ | +.+ | 1.+ | 1.+ | 1.+ | 1.+ | +.+ | +.+ | 1.+ | V | 1.1 | 2 |
| *Parnassia palustris* | 1.+ | 2.+ | . | . | 2.+ | 3.+ | 1.+ | . | +.+ | 3.+ | IV | 1.3 | 2 |
| *Pedicularis capitata* | +.+ | +.+ | . | . | 2.1 | +.+ | 2.1 | +.1 | +.+ | +.+ | IV | 1.0 | 2 |
| *Aconitum delphinifolium* | +.1 | +.1 | +.1 | . | 1.1 | +.1 | 1.1 | . | +.1 | +.1 | IV | 0.8 | 2+ |
| *Senecio lugens* | +.1 | . | +.+ | +.+ | +.1 | +.1 | 1.+ | . | +.1 | +.1 | IV | 0.8 | 2 |
| *Solidago decumbens* | . | . | . | +.1 | +.1 | +.1 | 1.1 | +.1 | +.1 | +.1 | IV | 0.7 | 2+ |
| *Artemisia arctica* | . | 1.+ | . | . | 2.1 | 2.1 | . | . | +.1 | 1.1 | III | 0.7 | 2 |
| *Achillea lanulosa* | . | +.+ | +.1 | . | . | . | . | +.+ | . | +.1 | II | 0.4 | 2+ |
| *Astragalus alpinus* | . | +.+ | . | . | +.1 | +.1 | . | . | . | +.+ | II | 0.4 | 2 |
| *Dryas integrifolia* | . | +.3 | . | +.1 | . | +.2 | . | +.1 | . | . | II | 0.4 | 2- |
| *Epilobium angustifolium* | +.1 | 1.+ | +.1 | . | +.1 | . | . | . | . | . | II | 0.4 | 2 |
| *Equisetum arvense* | . | +.1 | 1.+ | . | . | +.1 | . | . | +.+ | . | II | 0.4 | 2 |
| *Pyrola secunda* | 1.+ | +.+ | +.+ | . | +.1 | . | . | . | . | . | II | 0.4 | 2+ |
| *Salix arctica* | . | . | . | . | . | . | . | +.3 | +.2 | +.2 | II | 0.3 | 2 |
| *Valeriana capitata* | +.+ | +.+ | . | . | . | +.1 | . | . | . | . | II | 0.3 | 2 |
| *Lupinus arcticus* | . | . | . | . | . | . | 2.2 | . | . | . | I | 0.2 | 2+ |
| *Agropyron boreale* | . | . | . | . | . | . | . | +.+ | . | . | I | 0.1 | 2 |
| *Antennaria stolonifera* | . | . | . | . | +.+ | . | . | . | . | . | I | 0.1 | 2 |
| *Carex concinna* | . | . | . | . | . | +.1 | . | . | . | . | I | 0.1 | 2 |
| *Carex petricosa* | . | . | . | . | +.1 | . | . | . | . | . | I | 0.1 | 2 |
| *Elymus innovatus* | . | . | . | . | . | . | . | . | +.1 | . | I | 0.1 | 2+ |
| *Epilobium latifolium* | . | . | . | . | . | . | . | +.1 | . | . | I | 0.1 | 2 |
| *Ledum palustre* | . | . | . | . | . | . | . | +.1 | . | . | I | 0.1 | 2 |
| *Petasites frigidus* | . | . | . | . | . | . | . | . | +.2 | . | I | 0.1 | 2 |
| *Poa alpina* | . | . | . | . | . | . | +.1 | . | . | . | I | 0.1 | 2 |
| *Trisetum spicatum* | . | . | . | . | . | . | . | +.+ | . | . | I | 0.1 | 1 |
| *Peltigera canina* | +.1 | +.1 | +.1 | . | 1.1 | 2.1 | . | +.1 | +.1 | 1.1 | IV | 0.9 | 2 |
| *Cladonia pocillum* | +.1 | . | . | . | . | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Campylium stellatum* | 1.1 | +.1 | 1.1 | . | 1.+ | 2.1 | . | +.+ | +.1 | +.1 | IV | 0.9 | 2 |
| *Ceratodon purpureus* | +.1 | . | . | . | 1.1 | 1.1 | . | . | 2.+ | 2.1 | III | 0.7 | 2 |
| *Abietinella abietina* | +.1 | . | +.1 | . | 1.1 | 1.1 | . | . | 1.+ | . | III | 0.5 | 2 |

Table 22.

Order: 9. BETULETALIA GLANDULOSAE

Alliance: 11. Potentillo (fruticosae) - Salicion glaucae

Association: 19. Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - lanatae - glaucae

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 367 | 368 | 365 | 366 | 369 | 370 | 371 | 364 | 362 | 363 | | | |
| Date | 30.8. 72 | 29.8. 72 | 29.8. 72 | 29.8. 72 | 30.8. 72 | 30.8. 72 | 30.8. 72 | 29.8. 72 | 29.8. 72 | 29.8. 72 | | | |
| Elevation (feet) | 3870 | 4020 | 4090 | 4100 | 4120 | 4120 | 4150 | 4340 | 4370 | 4440 | | | |
| Exposure (degree) | 80 | 30 | 20 | 50 | 30 | 70 | 60 | 30 | 70 | 60 | | | |
| Slope (degree) | -33 | -35 | -32 | -34 | -30 | -26 | -15 | -24 | -29 | -26 | | | |
| Hygrotope | 4 | 4 | 4+ | 4+ | 4 | 4 | 4+ | 4+ | 4 | 3/4 | Constancy | Average species significance | Vigor |
| *Salix glauca* | 7.6 | 7.6 | 6.6 | 7.7 | 7.7 | 7.6 | 8.7 | 7.7 | 7.6 | 8.6 | V | 7.1 | 2+ |
| *Salix lanata* | 6.6 | 7.6 | 7.7 | 5.6 | 8.7 | 7.6 | 7.6 | 5.6 | 6.6 | 7.6 | V | 6.5 | 3 |
| *Salix alaxensis* | . | . | +.4 | . | +.3 | . | . | . | . | . | I | 0.2 | 2 |
| *Salix brachycarpa* | . | . | . | . | . | . | . | . | +.2 | . | I | 0.1 | 2 |
| *Betula glandulosa* | 5.3 | 4.2 | 4.2 | 5.2 | 3.2 | 4.2 | 6.3 | 3.2 | 3.3 | 4.2 | V | 4.1 | 3 |
| *Vaccinium uliginosum* | 3.2 | 3.1 | 4.2 | 2.1 | 2.1 | 5.2 | 4.2 | 2.2 | 5.5 | 4.2 | V | 3.4 | 3 |
| *Ledum palustre* | 4.2 | 3.2 | 3.2 | 3.2 | 3.2 | 4.2 | 5.2 | +.1 | 2.2 | 3.2 | V | 3.1 | 2+ |
| *Potentilla fruticosa* | 1.2 | 2.2 | 4.2 | 3.2 | 1.2 | . | 2.2 | 2.1 | 3.3 | 2.2 | V | 2.0 | 2+ |
| *Rhododendron lapponicum* | +.1 | . | +.2 | +.1 | +.1 | +.1 | 2.2 | . | 2.1 | +.2 | IV | 1.0 | 2+ |
| *Picea glauca* | +.3 | +.2 | . | +.2 | . | +.3 | . | +.2 | +.3 | +.2 | IV | 0.7 | 1 |
| *Shepherdia canadensis* | +.2 | +.2 | +.2 | . | . | +.2 | 1.2 | . | . | . | III | 0.5 | 2 |
| *Juniperus communis* | . | . | +.2 | +.2 | . | +.3 | 2.3 | . | . | . | II | 0.5 | 2 |
| *Viburnum edule* | . | . | +.1 | . | . | . | 1.2 | . | . | . | I | 0.2 | 1 |
| *Arctostaphylos rubra* | 7.5 | 6.5 | 6.5 | 7.5 | 4.5 | 4.5 | 5.3 | 5.5 | 5.5 | 5.3 | V | 5.4 | 3 |
| *Cassiope tetragona* | 7.3 | 5.2 | 3.2 | 4.3 | 4.2 | 5.2 | 3.2 | 4.4 | 3.5 | 2.2 | V | 4.0 | 3 |
| *Salix reticulata* | 4.2 | 5.3 | 4.3 | 3.2 | 5.3 | 4.3 | 3.2 | 5.5 | 3.3 | 4.4 | V | 4.0 | 2 |
| *Equisetum scirpoides* | 4.1 | 3.1 | 3.1 | 3.2 | 3.2 | 2.1 | 2.1 | 4.2 | 3.2 | 3.+ | V | 3.0 | 3 |
| *Dryas integrifolia* | 2.2 | 3.2 | +.2 | 2.2 | 3.2 | +.2 | 2.2 | 5.4 | 4.5 | +.2 | V | 2.4 | 2 |
| *Hedysarum alpinum* | 3.1 | 2.1 | 2.1 | 2.1 | 2.1 | 3.2 | 2.1 | 3.1 | 2.1 | 2.1 | V | 2.3 | 2 |
| *Festuca altaica* | 3.2 | 3.2 | 1.1 | 2.1 | 2.1 | 4.2 | 2.1 | +.1 | +.1 | +.2 | V | 2.0 | 2 |
| *Anemone parviflora* | 2.+ | 2.1 | 2.+ | 1.+ | 2.+ | 1.+ | 3.+ | 1.+ | +.1 | 1.+ | V | 1.6 | 2 |
| *Carex scirpoidea* | 1.1 | 1.1 | 2.1 | 3.1 | 3.+ | 1.+ | +.1 | +.+ | +.+ | +.+ | V | 1.5 | 2 |
| *Mertensia paniculata* | 1.1 | 2.1 | 1.1 | 1.1 | 1.1 | 1.1 | 3.2 | +.1 | 1.1 | 1.1 | V | 1.3 | 2 |
| *Pedicularis capitata* | 2.+ | 1.+ | 1.+ | +.+ | 2.+ | 2.+ | +.1 | 1.+ | 1.+ | 1.+ | V | 1.3 | 2+ |
| *Parnassia palustris* | 2.+ | 3.+ | +.+ | . | 1.+ | 2.+ | 2.+ | . | 1.+ | 1.+ | IV | 1.3 | 2 |
| *Arctagrostis latifolia* | . | . | 1.+ | +.2 | +.1 | . | +.1 | 2.+ | 1.+ | 3.1 | IV | 1.0 | 3 |
| *Gentiana propinqua* | +.+ | +.+ | +.+ | +.+ | . | +.+ | 1.+ | . | +.+ | 1.+ | IV | 0.8 | 2 |
| *Linnaea borealis* | . | . | 3.2 | 2.2 | . | +.2 | 2.2 | . | +.1 | 2.3 | III | 1.1 | 2 |
| *Equisetum arvense* | . | 1.+ | +.+ | . | . | . | +.1 | . | 2.+ | 2.+ | III | 0.7 | 2 |
| *Petasites frigidus* | +.1 | 1.2 | +.1 | . | . | +.1 | 1.1 | +.1 | . | . | III | 0.6 | 2 |
| *Pyrola asarifolia* | . | . | +.1 | 1.1 | +.1 | +.1 | . | 1.1 | . | . | III | 0.5 | 3 |
| *Epilobium latifolium* | . | . | +.1 | . | 1.1 | . | . | +.1 | . | . | II | 0.3 | 2 |
| *Kobresia myosuroides* | . | . | . | . | . | . | . | +.1 | +.+ | 1.1 | II | 0.3 | 2 |
| *Empetrum nigrum* | . | . | . | . | . | 2.2 | 1.2 | . | . | . | I | 0.3 | 2 |
| *Valeriana capitata* | . | +.1 | . | . | . | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Saussurea angustifolia* | . | +.1 | . | . | +.1 | . | . | . | . | . | I | 0.2 | 2 |
| *Zygadenus elegans* | . | . | . | . | . | . | +.1 | . | . | +.+ | I | 0.2 | 2 |
| *Pyrola secunda* | . | . | . | . | +.1 | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Calamagrostis purpurascens* | . | . | . | . | . | . | . | +.1 | . | . | I | 0.1 | 2 |
| *Oxytropis viscida* | . | . | . | . | . | . | . | +.1 | . | . | I | 0.1 | 2 |
| *Trisetum spicatum* | . | . | . | . | . | . | . | . | +.+ | . | I | 0.1 | 2 |
| *Senecio lugens* | . | . | . | . | . | . | . | . | +.+ | . | I | 0.1 | 2 |
| *Solidago decumbens* | . | . | . | . | . | . | . | +.1 | . | . | I | 0.1 | 2 |
| *Polemonium pulcherrimum* | . | . | . | . | . | . | 1.1 | . | . | . | I | 0.1 | 2 |
| *Polygonum viviparum* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Lupinus arcticus* | . | . | . | . | . | +.1 | . | . | . | . | I | 0.1 | 2 |
| *Artemisia arctica* | . | . | . | . | . | . | +.1 | . | . | . | I | 0.1 | 2 |
| *Cladonia pocillum* | +.1 | +.1 | . | +.1 | 1.1 | 1.1 | 1.1 | 1.1 | +.1 | . | IV | 0.8 | 2 |
| *Cetraria tilesii* | +.+ | +.+ | +.1 | . | . | +.+ | . | +.1 | . | . | III | 0.5 | 2 |
| *Peltigera canina* | +.1 | +.1 | +.1 | . | . | +.+ | . | +.1 | . | . | III | 0.5 | 2 |
| *Dactylina arctica* | . | +.+ | . | . | . | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Lecanora epibryon* | . | . | . | +.1 | +.+ | . | . | . | . | . | I | 0.2 | 2 |
| *Cetraria cucullata* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Ceratodon purpureus* | 3.1 | 3.1 | 2.1 | . | 2.1 | 2.1 | 2.1 | 1.1 | 1.2 | +.+ | V | 1.7 | 2 |
| *Campylium stellatum* | 1.1 | 1.1 | 2.1 | 1.1 | 2.1 | 1.1 | 1.1 | 1.2 | +.2 | +.1 | V | 1.2 | 2 |
| *Orthothecium chryseum* | . | +.+ | +.1 | . | . | . | . | +.1 | . | . | II | 0.3 | 2 |
| *Abietinella abietina* | . | . | 1.1 | . | . | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Bryum sp.* | . | . | . | . | . | . | . | 1.1 | . | . | I | 0.1 | 2 |

synthesis of these subalpine shrub associations. Characteristic animals and birds of the subalpine shrub zone include the Alces alces gigas (Moose), Lagopus lagopus (Willow Ptarmigan), Spizella breweri (Brewer's sparrow) and Zonotrichia atricapilla (Golden-crowned sparrow).

Order 10. ARTEMISIETALIA ALASKANAE Hoefs & Krajina

occur mainly in the subalpine willow - birch biogeoclimatic zone and very little in the alpine tundra zone. They are established on colluvial Regosols of the scree slopes. Two plant associations included here are separated in two different alliances.

The characteristic combination of species (order) is:

Artemisia alaskana
(Artemisia frigida)*
(Artemisia hyperborea)*
(Aster sibiricus)*
(Crepis nana)*
(Epilobium latifolium)*
(Oxytropis huddelsonii)*

Alliance 12. Artemision alaskanae Hoefs & Krajina

includes only one plant association:

Association 20. Artemisietum alaskanae

The characteristic combination of species (alliance and plant association) is:

(Anemone drummondii)*
(Astragalus nutzotinenzis)*
Cystopteris fragilis
(Draba alpina)*
(Papaver macounii)*
Ranunculus pedatifidus
(Smelowskia borealis)*
Stellaria monantha

It occurs on scree slopes between the subalpine and the alpine biogeoclimatic zones. It appears to be very limited on Sheep

* Species in brackets are less characteristic than those without brackets.

Mountain, occupying about 3.5 acres in map sections C 4.76; C 4.83; C 4.84; and C 4.94. It is possible that more sites with this association will be located, if all scree slopes in the area are investigated. Figure 18 shows a photograph of this association. Notice the sparse vegetation cover and the "fine grained", relatively stabilized scree substrate.

Alliance 13. Artemisio (hyperboreae - alaskanae) - Salicion myrtillifoliae Hoefs & Krajina

includes only one plant association:

Association 21. Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae

which grows in the lower parts of a scree slope on colluvial Regosols, affected by temporary seepage (especially when snow melts in higher elevations). It belongs to the subalpine willow - birch biogeoclimatic zone.

The characteristic combination of species (alliance and plant association) is:

(B) Shrub layer:
- (Potentilla fruticosa)*
- (Salix glauca)*
- Salix myrtillifolia
- (Shepherdia canadensis)*

(C) Herb layer:
- (Anemone multifida)*
- (Antennaria media)*
- (Artemisia dracunculus)*
- (Calamagrostis purpurascens)*
- (Castilleja hyperborea)*
- (Chamaerhodos erecta)*
- (Erigeron caespitosus)*
- (Gentiana propinqua)*
- (Oxytropis viscida)*
- (Pentstemon gormanii)*
- (Potentilla hookeriana)*
- Saxifraga tricuspidata
- (Solidago decumbens)*

* Species in brackets are less characteristic than those without brackets.

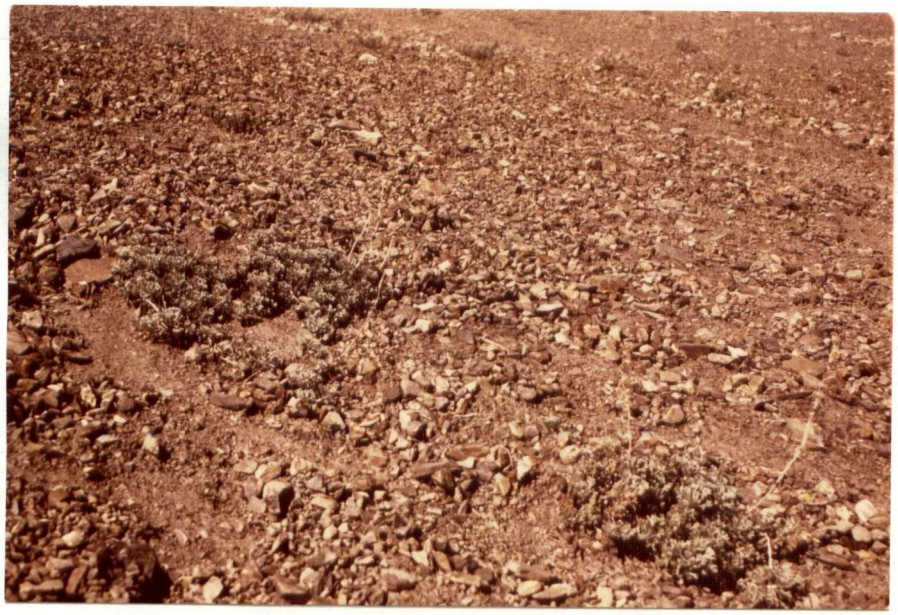


FIGURE 18: Artemisietum alaskanae on fine, relatively stable scree.

FIGURE 19: Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae on coarse, "active" scree.

Figure 19 shows a photograph of this association. It is limited in extent on Sheep Mountain, occupying only 3.5 acres in map sections C 4.83; C 4.85; C 4.80; C 4.88 and C 4.100. This association occupies very coarse scree, which is not stabilized but kept active by eroding cliffs above.

Tables 23, 24, 42 and 53 give details on the analyses and synthesis of the scree slope associations.

Order 11. DRYADETALIA INTEGRIFOLIAE Hoefs and Krajina

It becomes obvious that the North American Dryadetalia should be divided into two separate orders, DRYADETALIA OCTOPETALAE (on acidic or neutral rankers) and DRYADETALIA INTEGRIFOLIAE (on alkaline soils).

They occur on rendzina soils mainly in the alpine tundra biogeoclimatic zone and may descend to the subalpine willow - birch biogeoclimatic zone only rarely.

The characteristic combination of species (order) is:

(C) Herb layer:
- (Anemone parviflora)*
- Arctostaphylos alpina
- Astragalus alpinus
- Carex scirpoidea
- Dryas integrifolia
- (Lloydia serotina)*
- (Parrya nudicaulis)*
- (Pedicularis capitata)*
- (Pedicularis kanei)*
- (Polygonum viviparum)*
- (Salix reticulata)*
- (Saxifraga oppositifolia)*
- (Saussurea viscida)*
- (Silene acaulis)*

(D) Moss layer:
- (Caloplaca cirrochroa)*
- (Cetraria cucullata)*
- (Cetraria tilesii)*
- Cladonia pocillum

* Species in brackets are less characteristic than those without brackets.

Table 23.

Order: 10. ARTEMISIETALIA ALASKANAE

Alliance: 12. Artemision alaskanae

Association: 20. Artemisietum alaskanae

| Number of plots | 1 | 2 | 3 | 4 | 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Plot number | 196 | 171 | 187 | 185 | 174 | | | |
| Date | 18.9. 71 | 14.9. 71 | 15.9. 71 | 15.9. 71 | 14.9. 71 | | | |
| Elevation (feet) | 4300 | 4480 | 4700 | 5000 | 5150 | | | |
| Exposure (degree) | 140 | 145 | 140 | 160 | 130 | | | |
| Slope (degree) | -37 | -38 | -38 | -42 | -34 | | | |
| Hygrotope | 3+ | 2/3 | 2/3 | 3+ | 3 | Constancy | Average species significance | Vigor |
| *Artemisia alaskana* | 2.1 | 3.1 | 2.2 | 4.2 | 3.2 | V | 2.8 | 3 |
| *Oxytropis huddelsonii* | 2.1 | +.1 | 3.1 | 4.1 | . | IV | 2.0 | 2+ |
| *Artemisia hyperborea* | 2.1 | . | 2.1 | 3.1 | . | III | 1.4 | 2 |
| *Anemone drummondii* | +.+ | . | +.+ | . | . | II | 0.4 | 2- |
| *Ranunculus pedatifidus* | +.+ | . | . | +.+ | . | II | 0.4 | 2 |
| *Stellaria monantha* | . | . | . | . | +.1 | I | 0.2 | 2 |
| *Smelowskia borealis* | . | . | . | . | +.1 | I | 0.2 | 2 |
| *Astragalus nutzotinensis* | . | . | . | . | +.1 | I | 0.2 | 2+ |
| *Artemisia frigida* | +.1 | . | . | . | . | I | 0.2 | 2- |
| *Epilobium latifolium* | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Papaver macounii* | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Draba alpina* | . | . | +.+ | . | . | I | 0.2 | 2 |
| *Cystopteris fragilis* | . | . | . | . | +.1 | I | 0.2 | 2 |
| *Crepis nana* | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Calamagrostis purpurascens* | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Aster sibiricus* | . | +.+ | . | . | . | I | 0.2 | 2 |

Table 24.

Order: 10. ARTEMISIETALIA ALASKANAE

Alliance: 13. Artemisio (hyperboreae - alaskanae) - Salicion myrtillifoliae

Association: 21. Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae

| Number of plots | 1 | 2 | 3 | 4 | 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Plot number | 195 | 181 | 173 | 183 | 175 | | | |
| Date | 18.9. 71 | 15.9. 71 | 14.9. 71 | 15.9. 71 | 18.9. 71 | | | |
| Elevation (feet) | 4290 | 4420 | 4880 | 4930 | 4990 | | | |
| Exposure (degree) | 140 | 130 | 160 | 130 | 140 | | | |
| Slope (degree) | -37 | -32 | -25 | -24 | -27 | | | |
| Hygrotope | 3+ | 3+ | 3+ | 3+ | 3+ | Constancy | Average species significance | Vigor |
| *Salix myrtillifolia* | 4.4 | 5.4 | 5.4 | 5.4 | 4.4 | V | 4.6 | 2+ |
| *Salix glauca* | +.3 | +.3 | 1.4 | +.2 | 1.4 | V | 1.0 | 2 |
| *Potentilla fruticosa* | 3.2 | 3.2 | 1.1 | 1.2 | 2.3 | V | 2.0 | 2+ |
| *Shepherdia canadensis* | . | . | 1.3 | . | . | I | 0.2 | 2- |
| *Artemisia hyperborea* | 3.1 | 3.2 | 2.1 | 3.2 | 2.1 | V | 2.6 | 2+ |
| *Calamagrostis purpurascens* | 1.1 | 1.1 | 1.1 | 2.1 | +.1 | V | 1.2 | 2- |
| *Oxytropis huddelsonii* | 3.1 | . | +.1 | 3.1 | 4.1 | IV | 2.2 | 3 |
| *Artemisia alaskana* | 2.1 | +.1 | +.1 | . | +.1 | IV | 1.0 | 2+ |
| *Anemone multifida* | . | 1.+ | +.+ | 1.+ | +.+ | IV | 0.8 | 2 |
| *Artemisia frigida* | +.1 | 3.1 | . | . | +.1 | III | 1.0 | 2- |
| *Oxytropis viscida* | . | . | 2.1 | 1.1 | 2.1 | III | 1.0 | 2 |
| *Erigeron caespitosus* | +.+ | +.+ | . | . | +.+ | III | 0.6 | 2 |
| *Solidago decumbens* | . | +.+ | . | 1.+ | 1.+ | III | 0.6 | 2 |
| *Epilobium latifolium* | +.+ | +.+ | . | . | . | II | 0.4 | 2 |
| *Artemisia dracunculus* | . | +.1 | . | . | 1.1 | II | 0.4 | 3 |
| *Aster sibiricus* | +.+ | . | . | . | +.+ | II | 0.4 | 2 |
| *Castilleja hyperborea* | . | . | +.+ | . | . | I | 0.2 | 1 |
| *Saxifraga tricuspidata* | . | . | 1.1 | . | . | I | 0.2 | 2 |
| *Gentiana propinqua* | . | . | . | . | 1.+ | I | 0.2 | 1 |
| *Antennaria media* | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Potentilla hookeriana* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Crepis nana* | +.+ | . | . | . | . | I | 0.2 | 3 |
| *Pentstemon gormanii* | . | +.1 | . | . | . | I | 0.2 | 1 |
| *Chamaerhodos erecta* | . | +.+ | . | . | . | I | 0.2 | 1 |

(Dactylina arctica)*
(Dermatocarpon hepaticum)*.
Lecanora epibryon
(Peltigera canina)*
Stereocaulon glareosum
(Thamnolia subuliformis)*

DRYADETALIA INTEGRIFOLIAE are divided into two alliances, ecologically and floristically quite distinct.

'Alliance 14. Carico (scirpoideae) - Dryadion integrifoliae Hoefs & Krajina

represented by only one plant association:

Association 22. Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae

In the alpine tundra biogeoclimatic zone it is the zonal (mesic) plant association on calcareous alkaline rendzina soils, strongly influenced by aeolian loess material. It is rarely growing in the subalpine zone (only at its highest elevations).

The characteristic combination of species (alliance and plant association) is:

(C) Herb layer: (Antennaria monocephala)*
(Hedysarum alpinum)*
(Kobresia myosuroides)*
(Oxytropis deflexa)*
Potentilla biflora
(Salix arctica)*
(Salix dodgeana)*
(Trisetum spicatum)*
(Oxytropis viscida)*

(D) Moss layer: (Buellia epigaea)*
(Cetraria nivalis)*
(Cetraria richardsonii)*
(Cornicularia aculeata)*
(Lecanora lentigera)*
(Lecidea decipiens)*
(Physcia muscigena)*
(Solorina spongiosa)*

* Species in brackets are less characteristic than those without brackets.

This is the most common plant association in the alpine biogeoclimatic zone occupying a total acreage of about 601 acres primarily in map sections B 3, B 4, B 5, B 6, B 7, C 3 and C 6. In addition transition zones between this association and Oxytropo (huddelsonii) - Salicetum dodgeanae, Seneciono (lugentis) - Salicetum polaris - reticulatae and particularly Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris are fairly common on gentle slopes. This association is very much affected by solifluction. Figure 20 shows a photograph of this association.

Alliance 15. Dryado (integrifoliae) - Cassiopion tetragonae Hoefs & Krajina

is represented by only one plant association:

Association 23. Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae

It occurs in the alpine tundra as well as in the subalpine willow - birch biogeoclimatic zone.

The characteristic combination of species (alliance and plant association) is:

(C) Herb layer: Carex microchaeta
Cassiope tetragona
(Epilobium latifolium)*
(Oxyria digyna)*
Pyrola grandiflora
(Salix polaris)*
(Vaccinium uliginosum)*

(D) Moss layer: (Distichium capillaceum)*
Lecidea cuprea
Solorina saccata
(Timmia austriaca)*
(Tomentypnum nitens)*

* Species in brackets are less characteristic than those without brackets.

In comparison with the preceding plant association this synecological unit occurs in habitats where snow lies relatively longer, promoting especially Cassiope tetragona, Vaccinium uliginosum and Salix polaris.

It is rare on Sheep Mountain, being restricted to about 11 acres on north and east facing slopes in map sections A 2.90, A 7.54, B 6.66 and C 6.34. It is much more common on Mount Wallace north of the map area. Figure 21 shows a photograph of this association.

Tables 25, 26, 46 and 53 give details on the analyses and synthesis of these two plant associations in this order.

Order 12. OXYTROPO (VISCIDAE) - ARTEMISIO (HYPERBOREAE) - FESTUCO (BRACHYPHYLLAE) - TRISETETALIA SPICATI Hoefs & Krajina

This order occurs on calcareous, dry (strongly drained) soils ( in the case of this study area derived from the very fine loess deposits mixed with coarse fragments of bedrocks weathered in place). It is a counterpart of Triseto (spicati) - Festucetalia brachyphyllae, evolved on similarly well drained habitats on non-calcareous (siliceous) soils in the alpine tundra biogeoclimatic zone which do not occur in the study area. It shows some relationships either with the ARTEMISIETALIA ALASKANAE (Tables 23 and 24), occurring on scree slopes mainly in the subalpine willow - birch biogeoclimatic zone, or with the Agropyro (yukonensis) - Artemisietum frigidae - rupestris, occurring in the boreal (montane) and the subalpine willow - birch zones.

Alliance 16. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetion spicati Hoefs & Krajina

FIGURE 20:

Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae

Sheep Mountain northwest slope.

FIGURE 21:

Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae

Sheep Mountain east slope, overlooking Kluane Lake.

Table 25.

Order: 11. DRYADETALIA INTEGRIFOLIAE

Alliance: 14. Carico (scirpoideae) - Dryadion integrifoliae

Association: 22. Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 67 | 36 | 349 | 48 | 347 | 331 | 332 | 46 | 125 | 135 | | | |
| Date | 4.8. 71 | 21.7. 71 | 16.8. 72 | 23.7. 71 | 15.8. 72 | 7.8. 72 | 7.8. 72 | 22.7. 71 | 18.8. 71 | 20.8. 71 | | | |
| Elevation (feet) | 4740 | 5370 | 5400 | 5600 | 5700 | 5750 | 5800 | 6190 | 6240 | 6320 | | | |
| Exposure (degree) | 30 | 260 | 170 | 90 | 270 | 70 | 45 | 260 | 270 | 230 | | | |
| Slope (degree) | 32 | 21 | 12 | 38 | 15 | 17 | 28 | 22 | 41 | 24 | | | |
| Hygrotope | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | Constancy | Average species significance | Vigor |
| *Dryas integrifolia* | 8.5 | 6.3 | 8.5 | 8.4 | 8.4 | 8.5 | 8.5 | 8.3 | 7.4 | 7.4 | V | 7.6 | 3 |
| *Salix reticulata* | . | 4.2 | 2.1 | 5.3 | 4.2 | 3.2 | 4.2 | 4.2 | 4.2 | 4.1 | V | 3.4 | 2+ |
| *Carex scirpoidea* | 3.1 | 3.2 | 3.2 | 2.1 | 1.+ | 3.1 | 2.1 | 2.1 | 3.1 | 3.1 | V | 2.5 | 3 |
| *Saxifraga oppositifolia* | 3.1 | 3.1 | +.1 | . | 1.1 | 1.1 | 2.1 | 1.1 | 1.1 | +.1 | V | 1.4 | 3 |
| *Silene acaulis* | +.1 | 1.2 | 2.1 | 1.2 | 3.2 | . | 1.1 | 2.2 | 1.1 | +.1 | V | 1.3 | 3 |
| *Hedysarum alpinum* | 3.1 | 2.1 | +.1 | 3.1 | 1.1 | 2.1 | 2.1 | . | . | 2.1 | IV | 1.6 | 3 |
| *Oxytropis deflexa* | +.1 | . | 2.+ | . | 2.1 | 1.+ | +.+ | 3.1 | 2.1 | 2.1 | IV | 1.4 | 2 |
| *Kobresia myosuroides* | 2.1 | 3.1 | +.1 | 3.1 | +.1 | . | . | +.1 | +.1 | 1.1 | IV | 1.3 | 2 |
| *Oxytropis viscida* | 2.1 | . | 1.1 | +.1 | 3.1 | . | . | . | . | +.1 | III | 0.8 | 2 |
| *Saussurea viscida* | . | +.1 | . | . | 2.1 | 1.1 | 2.1 | +.1 | +.1 | . | III | 0.8 | 2 |
| *Anemone parviflora* | +.+ | . | . | . | 1.+ | +.+ | +.+ | 1.+ | 2.+ | . | III | 0.7 | 2 |
| *Antennaria monocephala* | . | +.+ | +.+ | . | +.+ | . | . | +.+ | +.+ | . | III | 0.5 | 2 |
| *Salix arctica* | +.2 | 1.1 | 1.1 | 2.2 | . | . | . | . | . | . | II | 0.5 | 2 |
| *Astragalus alpinus* | . | +.+ | . | . | . | +.+ | +.+ | +.1 | . | . | II | 0.4 | 2 |
| *Parrya nudicaulis* | . | . | . | . | 1.+ | +.1 | 1.1 | . | +.1 | . | II | 0.4 | 2 |
| *Salix dodgeana* | . | . | . | 1.2 | +.1 | . | . | +.1 | . | +.1 | II | 0.4 | 2 |
| *Trisetum spicatum* | . | . | . | 2.1 | +.+ | . | . | . | +.+ | . | II | 0.4 | 2 |
| *Lloydia serotina* | . | . | . | . | +.+ | . | 1.+ | . | +.+ | . | II | 0.3 | 2 |
| *Pedicularis capitata* | . | . | . | . | 1.+ | +.1 | 1.1 | . | . | . | II | 0.3 | 2 |
| *Arctostaphylos alpina* | . | . | +.1 | 3.1 | . | . | . | . | . | . | I | 0.4 | 2- |
| *Epilobium latifolium* | . | +.1 | . | 2.1 | . | . | . | . | . | . | I | 0.3 | 2 |
| *Salix polaris* | . | . | . | . | . | . | 2.2 | . | +.2 | . | I | 0.3 | 2 |
| *Festuca altaica* | . | +.1 | +.1 | . | . | . | . | . | . | . | I | 0.2 | 2 |
| *Festuca brachyphylla* | . | . | . | 2.1 | . | . | . | . | . | . | I | 0.2 | 2 |
| *Myosotis alpestris* | . | . | . | +.+ | . | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Pedicularis kanei* | . | +.1 | . | . | . | . | . | . | 1.1 | . | I | 0.2 | 2 |
| *Poa glauca* | . | . | . | 1.+ | +.+ | . | . | . | . | . | I | 0.2 | 2 |
| *Poa lanata* | . | . | . | +.+ | . | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Potentilla biflora* | +.1 | . | . | . | . | . | +.1 | . | . | . | I | 0.2 | 3 |
| *Draba hirta* | . | . | . | +.+ | . | . | . | . | . | . | I | 0.1 | 2 |
| *Gentiana propinqua* | . | . | . | +.+ | . | . | . | . | . | . | I | 0.1 | 2 |
| *Mertensia paniculata* | . | . | . | 1.1 | . | . | . | . | . | . | I | 0.1 | 2 |
| *Poa alpina* | . | . | . | 1.+ | . | . | . | . | . | . | I | 0.1 | 2 |
| *Polygonum viviparum* | . | . | . | +.+ | . | . | . | . | . | . | I | 0.1 | 2 |
| *Cetraria tilesii* | +.1 | 1.1 | +.+ | +.1 | 2.1 | +.1 | 1.1 | 3.1 | 2.1 | 2.1 | V | 1.5 | 3 |
| *Dermatocarpon hepaticum* | 1.1 | . | +.1 | 1.1 | 1.1 | 1.1 | 1.1 | 2.1 | 2.1 | 4.2 | V | 1.4 | 2 |
| *Lecanora epibryon* | +.1 | +.+ | +.+ | +.+ | +.1 | 1.1 | +.+ | +.+ | 2.1 | 4.1 | V | 1.4 | 3 |
| *Cetraria cucullata* | +.1 | . | 3.1 | +.1 | 1.1 | +.1 | . | +.1 | . | 2.1 | IV | 1.0 | 3 |
| *Thamnolia subuliformis* | +.1 | +.+ | . | +.+ | +.1 | +.+ | +.+ | . | 2.1 | +.+ | IV | 0.9 | 3 |
| *Cladonia pocillum* | +.1 | . | . | . | 2.1 | 2.1 | . | 1.1 | 3.1 | 1.1 | III | 1.0 | 2 |
| *Dactylina arctica* | . | +.1 | . | . | 1.1 | . | +.1 | 3.1 | 1.1 | . | III | 0.7 | 3 |
| *Lecanora lentigera* | +.1 | . | . | . | . | 1.1 | +.1 | . | 2.1 | +.+ | III | 0.6 | 3 |
| *Peltigera canina* | . | . | +.1 | . | +.1 | 1.1 | 1.1 | . | +.1 | 1.1 | III | 0.6 | 2 |
| *Stereocaulon glareosum* | . | . | . | . | 1.1 | 2.1 | 3.1 | . | . | . | II | 0.6 | 2 |
| *Caloplaca cirrochroa* | . | . | +.+ | . | . | +.+ | . | +.+ | +.+ | . | II | 0.4 | 2 |
| *Cornicularia aculeata* | . | . | +.+ | . | . | . | . | +.1 | +.+ | +.+ | II | 0.4 | 3 |
| *Solorina spongiosa* | +.1 | . | . | . | . | 1.1 | +.1 | . | . | . | II | 0.3 | 2 |
| *Buellia epigaea* | . | . | . | . | . | +.1 | . | . | . | +.1 | I | 0.2 | 2 |
| *Cetraria nivalis* | . | . | +.1 | . | . | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Cetraria richardsonii* | . | . | +.1 | . | +.1 | . | . | . | . | . | I | 0.2 | 2 |
| *Lecidea rubiformis* | 2.1 | . | . | . | . | . | . | . | . | . | I | 0.2 | 2 |
| *Lecidea decipiens* | . | . | . | . | . | . | . | . | +.+ | . | I | 0.1 | 2 |
| *Physcia muscigena* | . | . | +.+ | . | . | . | . | . | . | . | I | 0.1 | 2 |

Table 26.

Order: 11. DRYADETALIA INTEGRIFOLIAE

Alliance: 15. Dryado (integrifoliae) - Cassiopion tetragonae

Association: 23. Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae

| Number of plots | 1 | 2 | 3 | 4 | 5 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|
| Plot number | 49 | 121 | 346 | 345 | 330 | | | |
| Date | 23.7. 71 | 17.8. 71 | 15.8. 72 | 15.8. 72 | 7.8. 72 | | | |
| Elevation (feet) | 4320 | 4740 | 5600 | 5700 | 5720 | | | |
| Exposure (degree) | 30 | 30 | 30 | 40 | 0 | | | |
| Slope (degree) | 39 | 43 | 35 | 32 | 22 | | | |
| Hygrotope | 3/4 | 3/4 | 3/4 | 3/4 | 4+ | | | |
| *Salix alaxensis* var. *alaxensis* | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Cassiope tetragona* | 8.4 | 8.4 | 7.3 | 7.5 | 8.5 | V | 7.6 | 3 |
| *Dryas integrifolia* | 5.3 | 7.3 | 6.2 | 6.3 | 6.3 | V | 6.0 | 2 |
| *Carex microchaeta* | 1.1 | 2.1 | 3.1 | 3.1 | 3.1 | V | 2.4 | 3 |
| *Salix reticulata* | 4.2 | 3.2 | +.2 | +.1 | 3.2 | V | 2.4 | 2 |
| *Epilobium latifolium* | 1.1 | 1.1 | 1.1 | +.1 | 3.1 | V | 1.4 | 2+ |
| *Anemone parviflora* | +.+ | 1.+ | +.+ | 1.+ | +.+ | V | 1.0 | 2 |
| *Silene acaulis* | . | 2.1 | 3.1 | 3.1 | 2.1 | IV | 2.0 | 2 |
| *Salix polaris* | 3.2 | . | 2.1 | 2.1 | +.1 | IV | 1.6 | 2 |
| *Saxifraga oppositifolia* | . | 3.1 | 2.1 | 2.+ | 1.1 | IV | 1.6 | 2+ |
| *Saussurea viscida* | +.1 | . | 1.1 | 1.1 | +.1 | IV | 0.8 | 2 |
| *Arctostaphylos alpina* | 3.1 | 2.2 | . | . | +.2 | III | 1.2 | 2+ |
| *Carex scirpoidea* | . | +.+ | +.+ | +.+ | . | III | 0.6 | 2 |
| *Pedicularis kanei* | . | +.+ | 1.1 | +.1 | . | III | 0.6 | 3 |
| *Vaccinium uliginosum* | 3.2 | +.1 | . | . | . | II | 0.8 | 2+ |
| *Oxyria digyna* | . | +.+ | . | 2.1 | . | II | 0.6 | 2 |
| *Astragalus alpinus* | . | . | +.+ | . | +.+ | II | 0.4 | 2- |
| *Polygonum viviparum* | . | . | +.+ | +.+ | . | II | 0.4 | 2 |
| *Pyrola grandiflora* | 1.1 | . | . | . | +.1 | II | 0.4 | 2 |
| *Equisetum scirpoides* | . | . | . | . | 1.+ | I | 0.2 | 2 |
| *Lloydia serotina* | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Oxytropis deflexa* | . | . | +.+ | . | . | I | 0.2 | 2- |
| *Parnassia kotzebuei* | . | . | . | +.+ | . | I | 0.2 | 2 |
| *Parrya nudicaulis* | . | . | . | +.+ | . | I | 0.2 | 2 |
| *Pedicularis capitata* | . | . | +.+ | . | . | I | 0.2 | 2 |
| *Cladonia pocillum* | +.+ | +.1 | +.1 | 1.1 | 3.1 | V | 1.4 | 3 |
| *Dactylina arctica* | +.+ | +.1 | 1.1 | 2.1 | +.1 | V | 1.2 | 3 |
| *Stereocaulon glareosum* | +.+ | . | 3.1 | 4.2 | 3.2 | IV | 2.2 | 3 |
| *Dermatocarpon hepaticum* | . | 1.+ | 1.1 | 1.1 | +.+ | IV | 0.8 | 2 |
| *Lecidea cuprea* | . | 2.1 | 2.+ | +.+ | . | III | 1.0 | 2 |
| *Cetraria tilesii* | . | . | 1.1 | 1.1 | +.1 | III | 0.6 | 2+ |
| *Lecanora epibryon* | . | 1.1 | . | +.1 | 1.+ | III | 0.6 | 2 |
| *Caloplaca cirrochroa* | . | +.+ | . | . | +.+ | II | 0.4 | 2 |
| *Solorina saccata* | . | +.1 | +.1 | . | . | II | 0.4 | 2 |
| *Cetraria cucullata* | 1.+ | . | . | . | . | I | 0.2 | 2 |
| *Peltigera canina* | . | . | . | . | +.1 | I | 0.2 | 2 |
| *Thamnolia subuliformis* | . | . | +.1 | . | . | I | 0.2 | 3 |
| *Distichium capillaceum* | +.+ | 2.1 | 2.1 | 2.1 | 1.+ | V | 1.6 | 2 |
| *Timmia austriaca* | . | +.1 | +.1 | 1.1 | . | III | 0.6 | 2 |
| *Tomentypnum nitens* | . | +.1 | 1.1 | . | +.+ | III | 0.6 | 2 |
| *Hylocomium splendens* | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Hypnum bambergeri* | . | +.+ | . | . | . | I | 0.2 | 2 |

The characteristic combination of species (order and alliance) is:

(C) Herb layer: Artemisia hyperborea
(Calamagrostis purpurascens)*
Draba cinerea
Festuca brachyphylla
Oxytropis huddelsonii
Oxytropis viscida
Poa glauca
Salix dodgeana
Senecio conterminus
Silene acaulis
(Stellaria longipes)*
Trisetum spicatum

(D) Moss layer: Alectoria ochroleuca
(Buellia epigaea)*
(Caloplaca cirrochroa)*
Cetraria cucullata
Cetraria nivalis
Cetraria tilesii
Dactylina madreporiformis
(Dermatocarpon hepaticum)*
(Hypnum vaucheri)*
(Lecanora lentigera)*
(Lecidea rubiformis)*
(Lecidea decipiens)*
Tortula ruralis
Thamnolia subuliformis

Two plant associations belong to this alliance:

Association 24. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati

The characteristic combination of species (plant association) is:

(C) Herb layer: (Agropyron violaceum)*
Anemone drummondii
(Anemone parviflora)*
(Carex filifolia)*
Carex nardina
(Carex scirpoidea)*
Castilleja hyperborea
Erigeron compositus
Erysimum pallasii
Festuca baffinensis
(Melandrium apetalum)*
Minuartia obtusiloba
Polemonium pulcherrimum
(Potentilla hookeriana)*

* Species in brackets are less characteristic than those without brackets.

(Potentilla virgulata)*
(Ranunculus pedatifidus)*

(D) Moss layer: (Lecanora epibryon)*

Figure 22 shows a photograph of this association. It is restricted in its distribution to exposed ridge tops on dry, sunny, south and west facing slopes. In the study area it covers an acreage of about 49 acres in map sections B 3, B 4, B 5, B 6, C 3 and C 4. This association, even though found at alpine elevations, is often used by Dall sheep in mid winter, because strong west winds remove the snow from it.

Association 25. Oxytropo (huddelsonii) - Salicetum dodgeanae

The characteristic combination of species (plant association) is:

(C) Herb layer: Agrostis borealis
Carex rupestris
(Cerastium beeringianum)*
Draba alpina
(Dryas integrifolia)*
Festuca "vivipara"
(Kobresia myosuroides)*
(Lloydia serotina)*
Melandrium affine
(Parrya nudicaulis)*
(Pedicularis kanei)*
Poa arctica
Poa arctica forma vivipara
Potentilla uniflora
Salix arctica
Saxifraga oppositifolia
Saxifraga reflexa
(Saussurea viscida)*
Senecio fuscatus

(D) Moss layer: Cornicularia aculeata
(Dactylina arctica)*
Dactylina ramulosa
Lecidea granulosa

Figure 23 shows a photograph of this association. It is also

* Species in brackets are less characteristic than those without brackets.

FIGURE 22:

Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati occupying a narrow fringe along exposed ridge tops.

FIGURE 23:

Oxytropo (huddelsonii) - Salicetum dodgeanae occupying well drained ridge tops on north-facing ("shady") slopes.

restricted in distribution to well drained ridge tops, but these have northern and eastern exposures and are covered by snow in winter. The total size of this vegetation type is only about 8 acres and located in map sections B 4, B 5 and B 6.

Tables 27, 28, 47 and 53 give details on the analyses and synthesis of the two associations in this order.

Order 13. AGROPYRETALIA VIOLACEI Hoefs and Krajina

occur in the alpine tundra zone on steep scree slopes of coarse colluvial Regosols.

They are represented by only one alliance:

Alliance 17. Agropyrion violacei Hoefs and Krajina

with only one plant association:

Association 26. Agropyretum violacei

The characteristic combination of species (order, alliance and plant association):

Agropyron violaceum
(Artemisia alaskana)*
Astragalus nutzotinensis
Cerastium beeringianum
Crepis nana
(Cystopteris fragilis)*
Erigeron purpuratus
(Festuca brachyphylla)*
Melandrium apetalum
(Saxifraga tricuspidata)*
Smelowskia borealis
Stellaria longipes
(Stellaria monantha)*

A certain floristic relation to the Artemisietum alaskanae (on scree slopes of the subalpine zone) is indicated, among other similarities, by the isolated occurrence of Artemisia alaskana,

* Species in brackets are less characteristic than those without brackets.

Table 27.

Order: 12. OXYTROPO (VISCIDAE) - ARTEMISIO (HYPERBOREAE) - FESTUCO (BRACHYPHYLLAE) - TRISETETALIA SPICATI

Alliance: 16. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetion spicati

Association: 24. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 329 | 328 | 327 | 28 | 29 | 47 | 338 | 350 | 27 | 30 | | | |
| Date | 7.8. 72 | 7.8. 72 | 2.8. 72 | 19.7. 71 | 19.7. 71 | 23.7. 71 | 12.8. 72 | 15.8. 72 | 19.7. 71 | 19.7. 71 | | | |
| Elevation (feet) | 5850 | 5900 | 5950 | 6070 | 6170 | 6170 | 6300 | 6300 | 6320 | 6360 | | | |
| Exposure (degree) | 230 | 210 | 210 | 210 | 170 | 120 | 170 | 260 | 230 | 150 | | | |
| Slope (degree) | 14 | 23 | 15 | 17 | 33 | 33 | 24 | 15 | 32 | 34 | | | |
| Hygrotope | 2/3 | 2/3 | 2 | 2/3 | 2 | 2 | 2/3 | 2/3 | 2 | 2 | | | |
| *Artemisia hyperborea* | 7.2 | 7.3 | 6.2 | 4.2 | 4.2 | 6.2 | 5.1 | 7.2 | 6.2 | 5.2 | V | 5.7 | 3 |
| *Oxytropis viscida* | 4.2 | 5.2 | 5.2 | 3.1 | 5.2 | 4.1 | 2.1 | 4.1 | 5.1 | 4.1 | V | 4.1 | 3 |
| *Trisetum spicatum* | 3.1 | 3.1 | 3.1 | 4.1 | 5.1 | 2.+ | 2.1 | 3.1 | 5.1 | 2.1 | V | 3.2 | 3 |
| *Poa glauca* | 2.1 | 2.1 | +.1 | +.1 | 5.1 | +.1 | 1.1 | 1.1 | 2.1 | 4.1 | V | 2.0 | 2+ |
| *Carex filifolia* | 2.2 | 2.2 | 1.+ | 3.2 | +.2 | 3.2 | +.2 | +.2 | 2.2 | . | V | 1.6 | 2 |
| *Anemone drummondii* | 2.1 | 2.+ | 3.+ | +.1 | +.2 | +.+ | 1.1 | 1.1 | 2.1 | +.1 | V | 1.5 | 3 |
| *Castilleja hyperborea* | 2.1 | 1.1 | 5.1 | +.+ | 1.1 | 2.+ | +.+ | +.1 | +.1 | . | V | 1.5 | 3 |
| *Potentilla hookeriana* | 1.1 | 1.1 | 2.1 | . | +.1 | +.1 | 3.1 | 4.1 | +.1 | +.1 | V | 1.5 | 2+ |
| *Senecio conterminus* | 2.1 | 1.+ | 1.+ | 1.+ | 4.1 | 1.+ | 1.1 | 2.1 | +.1 | 1.1 | V | 1.5 | 3 |
| *Festuca brachyphylla* | 1.1 | 1.1 | +.1 | +.+ | 3.1 | +.1 | +.+ | 2.1 | 1.1 | 2.1 | V | 1.4 | 3 |
| *Silene acaulis* | 1.2 | +.2 | 1.2 | 3.2 | 2.2 | 3.2 | 1.2 | +.2 | +.2 | . | V | 1.4 | 2+ |
| *Calamagrostis purpurascens* | 3.1 | 2.1 | 3.1 | 1.1 | 3.2 | 2.2 | +.1 | . | . | . | IV | 1.5 | 2 |
| *Agropyron violaceum* | 3.1 | 3.2 | 1.1 | . | +.+ | 2.1 | 1.1 | . | 2.1 | +.1 | IV | 1.4 | 3 |
| *Carex scirpoidea* | 1.1 | 3.1 | +.1 | 2.1 | +.1 | 1.1 | . | +.1 | . | 3.1 | IV | 1.3 | 2 |
| *Erigeron compositus* | 2.1 | 2.1 | 2.1 | . | . | +.+ | 1.+ | 1.1 | 1.+ | . | IV | 1.0 | 2+ |
| *Oxytropis huddelsonii* | +.1 | . | +.1 | . | . | . | 1.1 | 1.1 | . | 4.2 | III | 0.8 | 2+ |
| *Erysimum pallasii* | +.1 | +.1 | . | . | . | . | +.1 | +.+ | . | +.+ | III | 0.5 | 3 |
| *Melandrium apetalum* | +.1 | . | ? + | +.+ | . | . | . | +.1 | . | +.+ | III | 0.5 | 2 |
| *Salix dodgeana* | +.2 | . | . | 3.3 | . | . | +.2 | +.2 | . | . | II | 0.6 | 2 |
| *Festuca baffinensis* | +.1 | . | . | . | 3.1 | . | +.1 | . | . | . | II | 0.5 | 2 |
| *Polemonium pulcherrimum* | . | . | +.+ | . | 1.1 | . | . | . | 3.1 | . | II | 0.5 | 2 |
| *Anemone parviflora* | . | . | . | +.+ | +.+ | . | . | . | 1.1 | . | II | 0.3 | 2 |
| *Draba cinerea* | . | . | . | +.+ | . | +.+ | . | . | +.+ | . | II | 0.3 | 2 |
| *Potentilla virgulata* | . | . | . | . | +.1 | . | +.+ | . | +.+ | . | II | 0.3 | 2 |
| *Stellaria longipes* | . | +.+ | . | . | . | . | . | . | +.+ | +.+ | II | 0.3 | 2 |
| *Minuartia obtusiloba* | . | . | . | . | . | 3.1 | 1.1 | . | . | . | I | 0.4 | 2 |
| *Gentiana propinqua* | . | . | . | . | +.+ | +.+ | . | . | . | . | I | 0.2 | 2- |
| *Gentiana prostrata* | . | . | . | . | +.+ | +.+ | . | . | . | . | I | 0.2 | 2- |
| *Saxifraga oppositifolia* | . | . | . | +.1 | . | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Senecio lugens* | . | . | . | . | . | +.+ | . | . | . | 1.1 | I | 0.2 | 2 |
| *Agropyron boreale* | . | . | . | . | +.1 | . | . | . | . | . | I | 0.1 | 2 |
| *Carex nardina* | . | . | . | . | . | . | . | . | +.+ | . | I | 0.1 | 2 |
| *Carex rupestris* | . | . | . | . | . | +.+ | . | . | . | . | I | 0.1 | 2 |
| *Festuca "vivipara"* | . | . | . | . | . | +.+ | . | . | . | . | I | 0.1 | 2 |
| *Myosotis alpestris* | . | . | . | . | 1.1 | . | . | . | . | . | I | 0.1 | 2 |
| *Poa arctica* | . | . | . | . | . | +.+ | . | . | . | . | I | 0.1 | 2 |
| *Ranunculus pedatifidus* | . | . | . | . | +.+ | . | . | . | . | . | I | 0.1 | 2- |
| *Saxifraga tricuspidata* | +.2 | . | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Cetraria tilesii* | 1.+ | +.+ | +.+ | 4.1 | 1.+ | 2.+ | 2.1 | 2.1 | . | +.+ | V | 1.5 | 3 |
| *Thamnolia subuliformis* | 1.+ | +.+ | 3.1 | 2.1 | +.+ | 1.+ | 1.+ | 2.1 | . | +.+ | V | 1.3 | 3 |
| *Dermatocarpon hepaticum* | 1.+ | +.+ | +.+ | 4.2 | 1.+ | 2.2 | 2.1 | 2.1 | . | . | IV | 1.4 | 2 |
| *Cetraria cucullata* | . | 1.+ | 1.+ | 3.1 | +.+ | 2.1 | . | 2.1 | . | +.+ | IV | 1.1 | 3 |
| *Lecidea rubiformis* | +.+ | 2.1 | 3.1 | +.+ | +.+ | +.+ | +.+ | . | +.+ | . | IV | 1.1 | 2 |
| *Caloplaca cirrochroa* | +.+ | +.+ | 1.+ | . | +.+ | +.+ | +.+ | . | +.+ | . | IV | 0.7 | 2 |
| *Lecidea decipiens* | 1.+ | 1.+ | 2.1 | 2.1 | . | +.+ | 1.+ | . | . | . | III | 0.8 | 2 |
| *Lecanora lentigera* | . | . | 2.1 | +.+ | +.+ | . | +.+ | . | +.+ | +.+ | III | 0.7 | 2 |
| *Alectoria ochroleuca* | . | . | +.+ | . | . | . | 1.+ | 1.+ | . | . | II | 0.3 | 2 |
| *Buellia epigaea* | . | . | +.+ | . | . | . | . | +.+ | . | +.+ | II | 0.3 | 2 |
| *Cetraria nivalis* | . | +.+ | . | +.+ | . | . | . | . | . | +.+ | II | 0.3 | 2 |
| *Dactylina madreporiformis* | +.+ | +.+ | . | . | . | +.+ | . | . | . | . | II | 0.3 | 2 |
| *Lecanora epibryon* | +.+ | +.+ | . | . | . | . | . | . | . | . | I | 0.2 | 2 |
| *Cornicularia aculeata* | . | . | . | . | . | +.+ | . | . | . | . | I | 0.1 | 2 |
| *Fulgensia bracteata* | . | . | . | . | . | . | +.+ | . | . | . | I | 0.1 | 2 |
| *Physcia muscigena* | . | . | . | . | . | . | +.+ | . | . | . | I | 0.1 | 2 |
| *Tortula ruralis* | 1.1 | 1.1 | +.1 | . | . | . | 1.1 | +.1 | +.1 | 1.1 | IV | 0.7 | 2 |
| *Hypnum vaucheri* | 1.1 | 1.1 | . | +.1 | . | +.1 | . | . | +.1 | . | III | 0.5 | 2 |

Table 28.

Order: 12. OXYTROPO (VISCIDAE) - ARTEMISIO (HYPERBOREAE) - FESTUCO (BRACHYPHYLLAE) - TRISETETALIA SPICATI

Alliance: 16. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetion spicati

Association: 25. Oxytropo (huddelsonii) - Salicetum dodgeanae

| Number of plots | 1 | 2 | 3 | 4 | 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Plot number | 57 | 122 | 58 | 123 | 59 | | | |
| Date | 2.8. 71 | 18.8. 71 | 2.8. 71 | 18.8. 71 | 2.8. 71 | | | |
| Elevation (feet) | 5710 | 5820 | 5930 | 6320 | 6370 | | | |
| Exposure (degree) | 290 | 350 | 310 | 250 | 310 | | | |
| Slope (degree) | 30 | 26 | 33 | 21 | 25 | | | |
| Hygrotope | 2/3 | 2/3 | 2/3 | 3 | 2/3 | Constancy | Average species significance | Vigor |
| *Salix dodgeana* | 6.4 | 5.4 | 6.4 | 5.3 | 6.4 | V | 5.6 | 3 |
| *Oxytropis huddelsonii* | 4.2 | 4.2 | 5.2 | 4.2 | 5.2 | V | 4.4 | 3 |
| *Carex rupestris* | 3.1 | 3.1 | 3.1 | 1.1 | 3.1 | V | 2.6 | 3 |
| *Saxifraga oppositifolia* | 1.1 | 3.2 | 3.2 | 1.2 | 4.2 | V | 2.4 | 3 |
| *Trisetum spicatum* | 1.+ | 2.1 | 2.+ | 3.1 | 3.1 | V | 2.2 | 3 |
| *Silene acaulis* | 1.1 | 2.2 | 3.2 | 1.1 | 3.1 | V | 2.0 | 2+ |
| *Festuca brachyphylla* | 1.1 | 1.1 | 2.1 | 3.1 | 2.1 | V | 1.8 | 3 |
| *Draba alpina* | +.+ | +.+ | +.+ | +.+ | 1.+ | V | 1.0 | 3 |
| *Senecio conterminus* | +.+ | +.+ | 1.+ | +.+ | +.+ | V | 1.0 | 2 |
| *Festuca "vivipara"* | 3.1 | 3.1 | 4.1 | . | 2.1 | IV | 2.4 | 3 |
| *Lloydia serotina* | 1.+ | 3.+ | 3.+ | . | 3.+ | IV | 2.0 | 2 |
| *Oxytropis viscida* | 2.1 | 4.2 | 1.1 | 1.1 | . | IV | 1.6 | 2 |
| *Artemisia hyperborea* | +.1 | +.+ | . | 3.2 | 2.1 | IV | 1.4 | 2+ |
| *Poa glauca* | 1.+ | . | 1.+ | 2.+ | 2.1 | IV | 1.2 | 2 |
| *Poa arctica* | +.+ | . | 1.+ | +.+ | +.+ | IV | 0.8 | 2 |
| *Kobresia myosuroides* | 1.1 | . | . | 2.2 | 1.1 | III | 0.8 | 2 |
| *Draba cinerea* | +.+ | . | +.+ | . | +.+ | III | 0.6 | 2 |
| *Parrya nudicaulis* | +.+ | . | +.1 | . | 1.1 | III | 0.6 | 2 |
| *Poa arctica forma vivipara* | +.+ | . | +.+ | . | +.+ | III | 0.6 | 3 |
| *Dryas integrifolia* | . | 3.3 | . | . | +.2 | II | 0.8 | 2 |
| *Calamagrostis purpurascens* | . | . | . | 1.1 | 2.1 | II | 0.6 | 2 |
| *Salix arctica* | 1.1 | 2.3 | . | . | . | II | 0.6 | 2 |
| *Saussurea viscida* | +.1 | . | 2.1 | . | . | II | 0.6 | 2 |
| *Cerastium beeringianum* | . | . | +.+ | . | 1.1 | II | 0.4 | 2 |
| *Pedicularis kanei* | . | 1.+ | . | . | +.1 | II | 0.4 | 2 |
| *Potentilla uniflora* | . | . | +.1 | . | +.1 | II | 0.4 | 3 |
| *Senecio fuscatus* | +.+ | . | . | . | 1.1 | II | 0.4 | 2 |
| *Stellaria longipes* | . | . | +.+ | . | +.+ | II | 0.4 | 2 |
| *Melandrium affine* | . | . | . | . | 2.+ | I | 0.4 | 2 |
| *Saxifraga reflexa* | . | . | . | . | 2.1 | I | 0.4 | 3 |
| *Agropyron violaceum* | . | . | . | 1.1 | . | I | 0.2 | 2 |
| *Agrostis borealis* | . | . | . | . | +.1 | I | 0.2 | 2- |
| *Anemone drummondii* | . | . | . | 1.1 | . | I | 0.2 | 2+ |
| *Anemone parviflora* | . | 1.+ | . | . | . | I | 0.2 | 2 |
| *Carex filifolia* | . | . | . | 1.2 | . | I | 0.2 | 2 |
| *Carex scirpoidea* | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Erigeron compositus* | . | . | . | . | +.1 | I | 0.2 | 2 |
| *Cetraria tilesii* | 3.1 | 3.1 | 3.1 | 2.1 | 3.1 | V | 2.8 | 3 |
| *Thamnolia subuliformis* | 2.1 | 3.1 | 3.1 | 2.+ | 3.1 | V | 2.6 | 3 |
| *Dermatocarpon hepaticum* | 2.1 | 3.1 | 2.+ | 2.1 | 2.1 | V | 2.2 | 2- |
| *Lecanora lentigera* | 4.1 | 4.1 | 4.1 | . | 2.1 | IV | 2.8 | 3 |
| *Cetraria cucullata* | 3.1 | 3.1 | 3.1 | . | 3.1 | IV | 2.4 | 3 |
| *Alectoria ochroleuca* | +.+ | 1.+ | +.+ | . | +.+ | IV | 0.8 | 3 |
| *Cornicularia aculeata* | +.+ | +.1 | +.+ | . | +.+ | IV | 0.8 | 3 |
| *Lecidea decipiens* | 2.1 | +.+ | . | . | +.+ | III | 0.8 | 2 |
| *Dactylina arctica* | 1.1 | +.1 | +.1 | . | . | III | 0.6 | 2 |
| *Dactylina ramulosa* | +.1 | . | +.1 | . | +.1 | III | 0.6 | 2 |
| *Buellia epigaea* | . | . | 1.1 | . | 2.1 | II | 0.6 | 2 |
| *Lecidea granulosa* | . | . | +.+ | . | 2.1 | II | 0.6 | 2 |
| *Caloplaca cirrochroa* | +.+ | . | . | +.+ | . | II | 0.4 | 2 |
| *Cetraria nivalis* | +.1 | . | +.1 | . | . | II | 0.4 | 2 |
| *Dactylina madreporiformis* | . | . | +.1 | . | +.1 | II | 0.4 | 2 |
| *Lecidea rubiformis* | . | . | . | 1.1 | +.1 | II | 0.4 | 2 |
| *Cladonia pocillum* | +.1 | . | . | . | . | I | 0.2 | 2- |
| *Solorina spongiosa* | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Tortula ruralis* | 2.1 | +.1 | +.1 | . | 3.1 | IV | 1.4 | 2 |
| *Hypnum vaucheri* | 1.+ | . | +.1 | . | 1.1 | III | 0.6 | 2 |

Cystopteris fragilis, Draba alpina, Papaver macounii and Stellaria monantha.

Figure 24 shows a photograph of this association. Approximately 130 acres in sections B 5, B 6, C 4, C 5 and C 6 are known to be covered by this association; however, since scree slopes make up a total of over 600 acres it is likely that this association may be more widely distributed.

Tables 29, 48 and 53 give details on this association and its higher snysystematic units.

Order 14. FESTUCETALIA ALTAICAE Hoefs & Krajina

form only one alliance:

Alliance 18. Festucion altaicae Hoefs & Krajina

and only one plant association:

Association 27. Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae

It occurs on rich, calcareous soils slightly affected by some temporary seepage, but which are still fairly well drained. Its hygrotope is, therefore, rather subhygric than hygric. The characteristic combination of species (order, alliance and plant association) is:

(C) Herb layer: (Anemone parviflora)*
(Antennaria monocephala)*
(Artemisia arctica)*
(Aster sibiricus)*
(Carex membranacea)*
(Carex scirpoidea)*
(Castilleja hyperborea)*
(Claytonia sarmentosa)*
Delphinium brachycentrum
Draba lanceolata
(Dryas integrifolia)*

* Species in brackets are less characteristic than those without brackets.

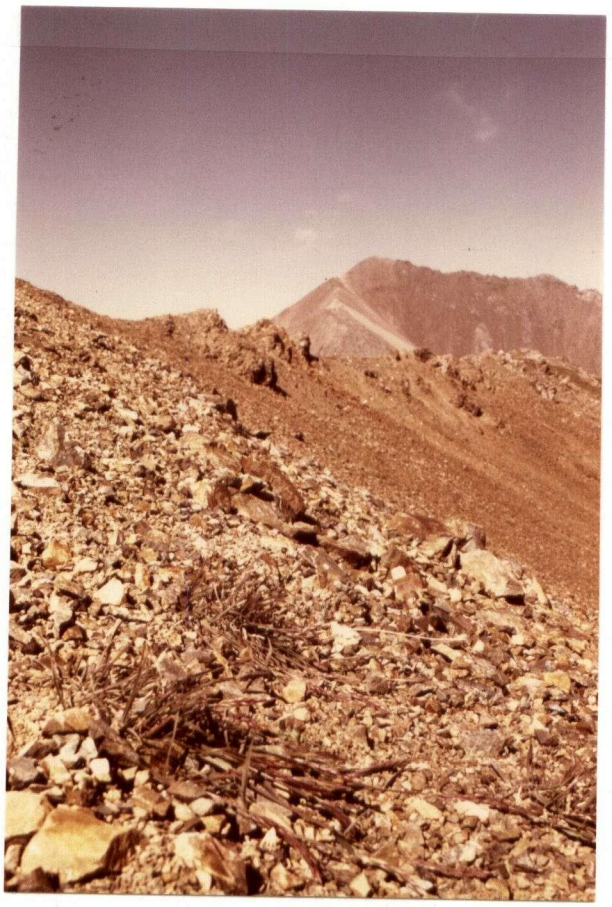


FIGURE 24:

Agropyretum violacei on coarse, active scree slopes.

Table 29.

Order: 13. AGROPYRETALIA VIOLACEI

Alliance: 17. Agropyrion violacei

Association: 26. Agropyretum violacei

| Number of plots | 1 | 2 | 3 | 4 | 5 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|
| Plot number | 62 | 61 | 335 | 321 | 320 | | | |
| Date | 2.8. 71 | 2.8. 71 | 12.8. 72 | 30.7. 72 | 30.7. 72 | | | |
| Elevation (feet) | 6300 | 6320 | 6350 | 6500 | 7100 | | | |
| Exposure (degree) | 260 | 130 | 60 | 300 | 300 | | | |
| Slope (degree) | -32 | -37 | -33 | -34 | -36 | | | |
| Hygrotope | 2 | 2 | 2 | 2 | 2 | | | |
| *Agropyron violaceum* | 3.1 | 2.1 | 1.1 | +.+ | +.1 | V | 1.6 | 3 |
| *Erigeron purpuratus* | 2.1 | 3.1 | 1.1 | +.1 | 1.1 | V | 1.6 | 3 |
| *Stellaria longipes* | 1.+ | 2.1 | +.+ | +.+ | 2.2 | V | 1.4 | 3 |
| *Crepis nana* | 1.+ | 2.1 | +.1 | +.+ | . | IV | 1.0 | 3 |
| *Cerastium beeringianum* | 1.1 | 1.1 | 1.+ | . | +.+ | IV | 0.8 | 3 |
| *Smelowskia borealis* | 1.+ | +.+ | 1.1 | . | 1.+ | IV | 0.8 | 3 |
| *Astragalus nutzotinensis* | +.1 | +.1 | . | . | +.1 | III | 0.6 | 3 |
| *Melandrium apetalum* | . | +.1 | +.1 | +.1 | . | III | 0.6 | 2 |
| *Festuca brachyphylla* | +.+ | +.+ | . | . | . | II | 0.4 | 2 |
| *Artemisia alaskana* | . | . | . | +.1 | . | I | 0.2 | 2- |
| *Cystopteris fragilis* | . | . | . | . | +.1 | I | 0.2 | 2+ |
| *Draba alpina* | . | . | +.+ | . | . | I | 0.2 | 3 |
| *Oxytropis huddelsonii* | . | . | +.1 | . | . | I | 0.2 | 2- |
| *Papaver macounii* | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Saxifraga oppositifolia* | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Saxifraga tricuspidata* | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Stellaria monantha* | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Trisetum spicatum* | . | +.+ | . | . | . | I | 0.2 | 2- |

(Equisetum scirpoides)*
Erigeron eriocephalus
(Erigeron humilis)*
Festuca altaica
(Gentiana propinqua)*
(Gentiana prostrata)*
Hedysarum alpinum
(Kobresia myosuroides)*
(Mertensia paniculata)*
(Minuartia rossii)*
Myosotis alpestris
Oxytropis deflexa
(Parnassia kotzebuei)*
(Pedicularis capitata)*
(Poa alpina)*
(Poa arctica)*
Polemonium boreale
(Polygonum viviparum)*
(Potentilla fruticosa)*
(Salix polaris)*
(Salix reticulata)*
(Saussurea viscida)*
(Sedum roseum)*
(Senecio lugens)*
(Silene acaulis)*
Solidago multiradiata
Stellaria edwardsii
(Trisetum spicatum)*
(Zygadenus elegans)*

(D) Moss layer: (Cladonia pocillum)*
(Distichium capillaceum)*
(Peltigera canina)*
(Timmia austriaca)*

Figure 25 shows a photograph of this association. Its distribution on Sheep Mountain is restricted to about 5.5 acres in map sections A 4.99; B 4.06; B 4.10; A 5.91; B 5.01; and B 5.11.

However, it is fairly common on "Bullion Plateau", an alpine area between Sheep Creek and Bullion Creek, two miles west of the study area.

Tables 30, 49 and 53 give details on this association and its higher synsystematic units.

* Species in brackets are less characteristic than those without brackets.

FIGURE 25:

Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae

FIGURE 26:

Salicetum barrattianae "grading" into Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae

Table 30.

Order: 14. PESTUCETALIA ALTAICAE

Alliance: 18. Festucion altaicae

Association: 27. Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 317 | 37 | 301 | 40 | 316 | 318 | 319 | 130 | 131 | 133 | | | |
| Date | 30.7.72 | 21.7.71 | 27.7.72 | 21.7.71 | 30.7.72 | 30.7.72 | 30.7.72 | 19.8.71 | 19.8.71 | 19.8.71 | | | |
| Elevation (feet) | 5180 | 5300 | 5400 | 5410 | 5410 | 5460 | 5530 | 5770 | 5920 | 6100 | | | |
| Exposure (degree) | 120 | 280 | 130 | 330 | 150 | 150 | 190 | 230 | 220 | 230 | | | |
| Slope (degree) | 12 | 14 | 11 | 15 | 22 | 24 | 26 | 23 | 40 | 30 | | | |
| Hygrotope | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | Constancy | Average species significance | Vigor |
| *Festuca altaica* | 8.3 | 7.2 | 8.3 | 8.2 | 8.3 | 8.3 | 8.3 | 8.4 | 8.3 | 8.4 | V | 7.9 | 3 |
| *Salix reticulata* | 5.3 | 6.4 | 6.4 | 5.3 | 4.3 | 5.3 | 5.4 | 6.4 | 7.4 | 5.4 | V | 5.4 | 2+ |
| *Artemisia arctica* | 3.1 | 2.1 | 3.2 | 4.1 | 4.2 | 3.1 | 4.2 | 3.1 | 4.1 | 2.1 | V | 3.2 | 3 |
| *Hedysarum alpinum* | 4.1 | 2.+ | 3.2 | . | 4.1 | 4.2 | 3.1 | 3.1 | 4.1 | 3.1 | V | 3.0 | 3 |
| *Anemone parviflora* | 2.+ | 1.+ | 2.+ | 1.+ | 2.+ | 3.+ | 2.+ | 2.+ | 3.+ | 3.+ | V | 2.1 | 3 |
| *Mertensia paniculata* | 1.1 | 2.1 | 3.2 | 2.1 | 2.1 | 1.1 | 2.1 | 3.2 | 3.1 | 2.1 | V | 2.1 | 3 |
| *Solidago multiradiata* | 2.+ | +.1 | 2.1 | +.1 | 3.1 | 2.1 | 3.1 | +.1 | 1.1 | 1.1 | V | 1.7 | 2+ |
| *Senecio lugens* | +.1 | 2.+ | . | +.+ | 1.1 | 1.1 | 1.+ | 3.1 | 3.1 | 2.1 | V | 1.5 | 3 |
| *Oxytropis deflexa* | +.+ | +.+ | 2.+ | . | 1.+ | +.+ | 1.+ | 2.+ | 3.+ | 2.+ | V | 1.4 | 2 |
| *Equisetum scirpoides* | 1.+ | 1.+ | . | 3.+ | 1.+ | 1.+ | 1.+ | 1.+ | 2.+ | 2.+ | V | 1.3 | 2 |
| *Gentiana propingua* | 2.+ | 1.+ | 2.+ | . | 2.+ | 1.+ | 2.+ | +.+ | +.+ | +.+ | V | 1.3 | 2+ |
| *Trisetum spicatum* | +.+ | 1.+ | 2.+ | +.+ | +.+ | +.+ | +.+ | 1.+ | 1.+ | 2.+ | V | 1.2 | 2+ |
| *Erigeron humilis* | 1.+ | 1.+ | 1.+ | 1.+ | +.+ | 1.+ | +.+ | 1.+ | 2.+ | 1.+ | V | 1.1 | 3 |
| *Parnassia kotzebuei* | 1.+ | 1.+ | +.+ | +.+ | 1.+ | +.+ | +.+ | 1.+ | +.+ | 1.+ | V | 1.0 | 3 |
| *Kobresia myosuroides* | 3.2 | . | 3.2 | 1.2 | +.1 | 1.2 | 1.2 | 3.3 | . | 2.2 | IV | 1.5 | 2 |
| *Myosotis alpestris* | . | 2.+ | . | 2.1 | 2.1 | +.+ | 1.+ | 1.+ | 1.+ | 2.+ | IV | 1.2 | 3 |
| *Carex scirpoidea* | +.1 | 4.1 | . | . | 1.1 | 1.1 | 1.1 | +.+ | 1.+ | 1.1 | IV | 1.1 | 2 |
| *Dryas integrifolia* | 2.2 | . | 1.2 | +.2 | 2.2 | 1.2 | . | +.1 | 1.2 | 2.2 | IV | 1.1 | 2 |
| *Antennaria monocephala* | 1.+ | +.+ | 1.+ | +.+ | . | 1.+ | . | +.+ | +.+ | +.+ | IV | 0.8 | 2 |
| *Polygonum viviparum* | 1.+ | +.+ | . | +.+ | 1.+ | 1.+ | +.+ | . | +.+ | +.+ | IV | 0.8 | 2 |
| *Zygadenus elegans* | 3.1 | . | 3.2 | . | 3.1 | 4.2 | 3.1 | +.1 | . | . | III | 1.7 | 3 |
| *Castilleja hyperborea* | . | 1.1 | 2.1 | . | . | 1.1 | +.1 | . | +.+ | +.1 | III | 0.7 | 2 |
| *Pedicularis capitata* | +.1 | 1.1 | . | 2.1 | +.+ | +.+ | . | . | 1.1 | . | III | 0.7 | 2 |
| *Poa arctica* | . | +.+ | . | +.+ | . | +.+ | +.+ | 1.+ | . | 2.1 | III | 0.7 | 2 |
| *Saussurea viscida* | . | . | 1.1 | . | 1.1 | . | +.1 | +.1 | 1.1 | 2.1 | III | 0.7 | 2 |
| *Silene acaulis* | +.+ | 1.2 | 2.2 | 1.2 | . | . | . | . | . | +.1 | III | 0.6 | 2 |
| *Stellaria edwardsii* | . | 1.+ | . | +.+ | +.+ | 1.+ | . | +.+ | 1.+ | . | III | 0.6 | 2 |
| *Carex membranacea* | . | . | 2.1 | +.+ | . | +.+ | +.+ | . | . | . | II | 0.5 | 2 |
| *Gentiana prostrata* | 1.+ | . | 2.+ | . | 1.+ | 1.+ | . | . | . | . | II | 0.5 | 2 |
| *Salix polaris* | . | 1.1 | 1.1 | . | . | +.1 | . | . | +.1 | . | II | 0.4 | 2 |
| *Aster sibiricus* | . | . | . | +.1 | . | +.1 | 1.+ | . | . | . | II | 0.3 | 3 |
| *Claytonia sarmentosa* | . | . | . | +.+ | . | . | . | . | +.+ | +.+ | II | 0.3 | 2 |
| *Poa alpina* | . | +.+ | . | . | . | . | . | . | +.+ | +.+ | II | 0.3 | 2 |
| *Potentilla fruticosa* | +.1 | . | . | . | +.1 | . | 1.1 | . | . | . | II | 0.3 | 2 |
| *Sedum roseum* | . | . | . | . | . | . | +.1 | . | +.1 | +.1 | II | 0.3 | 2 |
| *Dodecatheon frigidum* | . | 3.1 | . | 3.1 | . | . | . | . | . | . | I | 0.6 | 2 |
| *Delphinium brachycentrum* | . | . | . | . | 2.1 | . | 1.1 | . | . | . | I | 0.3 | 2 |
| *Valeriana capitata* | . | . | 2.1 | . | +.1 | . | . | . | . | . | I | 0.3 | 2 |
| *Arctostaphylos alpina* | 2.2 | . | . | . | . | . | . | . | . | . | I | 0.2 | 2 |
| *Carex microchaeta* | . | . | . | . | 2.1 | . | . | . | . | . | I | 0.2 | 2 |
| *Festuca "vivipara"* | . | . | . | . | . | . | . | +.+ | +.+ | . | I | 0.2 | 2- |
| *Minuartia rossii* | . | . | +.+ | . | . | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Parrya nudicaulis* | . | . | . | . | +.1 | . | . | . | . | +.1 | I | 0.2 | 2 |
| *Polemonium boreale* | . | . | 2.2 | . | . | . | . | . | . | . | I | 0.2 | 2 |
| *Achillea borealis* | . | . | . | . | . | . | +.1 | . | . | . | I | 0.1 | 2 |
| *Arnica alpina* | . | +.1 | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Astragalus umbellatus* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Draba lanceolata* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Erigeron eriocephalus* | . | . | . | . | . | . | . | . | +.+ | . | I | 0.1 | 2 |
| *Oxyria digyna* | . | . | . | +.+ | . | . | . | . | . | . | I | 0.1 | 2 |
| *Poa lanata* | . | . | . | . | . | . | . | . | . | +.+ | I | 0.1 | 2 |
| *Potentilla diversifolia* | . | . | . | . | . | . | +.1 | . | . | . | I | 0.1 | 2+ |
| *Saxifraga hieracifolia* | . | . | . | . | . | . | . | +.1 | . | . | I | 0.1 | 2- |
| *Cladonia pocillum* | +.+ | +.+ | . | . | . | . | . | +.+ | +.+ | +.+ | III | 0.5 | 2 |
| *Peltigera canina* | 1.1 | 1.+ | . | . | . | +.+ | . | . | +.+ | . | II | 0.4 | 2 |
| *Cetraria tilesii* | . | . | . | . | . | . | . | . | . | +.+ | I | 0.1 | 2 |
| *Dactylina arctica* | . | . | . | +.1 | . | . | . | . | . | . | I | 0.1 | 2 |
| *Stereocaulon glareosum* | . | . | 1.1 | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Distichium capillaceum* | . | 1.1 | 2.1 | +.+ | . | . | 1.1 | 1.1 | . | 1.1 | III | 0.7 | 2 |
| *Timmia austriaca* | 1.1 | . | . | +.+ | 1.1 | . | . | . | . | . | II | 0.3 | 2 |

Order 15. SALICETALIA BARRATTIANAE Hoefs & Krajina

include the only low shrub community occurring in the alpine tundra biogeoclimatic zone in habitats well protected by snow (however, not yet in the form of "Schneetälchen") against the severity of frosts, common in this zone. The snow pack in this habitat is thick, but usually melts about two or three weeks earlier than in habitats of typical "Schneetälchen" (snowbeds) where the snow either disappears only for about 4 - 6 weeks toward the late summer or, in some unusual years of heavy snowfall, remains unmelted until covered by new snow of the next winter.

It is represented by only one alliance:

Alliance 19. Salicion barrattianae Hoefs & Krajina

with only one plant association:

Association 28. Salicetum barrattianae

The characteristic combination of species (order, alliance and plant association) is:

(B) Shrub layer: Salix barrattiana
Salix niphoclada

(C) Herb layer: (Anemone parviflora)*
(Antennaria monocephala)*
(Artemisia arctica)*
(Carex scirpoidea)*
(Dryas integrifolia)*
(Equisetum scirpoides)*
(Erigeron humilis)*
(Festuca altaica)*
(Gentiana propinqua)*
Gentiana prostrata
(Hedysarum alpinum)*
Kobresia myosuroides
(Lupinus arcticus)*
(Mertensia paniculata)*
(Myosotis alpestris)*
(Oxytropis deflexa)*
(Parnassia kotzebuei)*
(Pedicularis capitata)*
(Poa arctica)*

* Species in brackets are less characteristic than those without brackets.

(Polemonium boreale)*
(Polygonum viviparum)*
(Potentilla fruticosa)*
(Salix reticulata)*
(Saussurea viscida)*
(Senecio lugens)*
(Silene acaulis)*
(Solidago multiradiata)*
Stellaria laeta
(Trisetum spicatum)*
(Valeriana capitata)*
(Zygadenus elegans)*

(D) Moss layer: Cetraria islandica
(Cladonia pocillum)*
(Distichium capillaceum)*
(Peltigera canina)*

Figure 26 shows a photograph of this association. Its distribution in the map area is limited to about 7.5 acres in sections B 5.02, B 5.12, B 5.23, B 5.45 and B 5.56. However, it also is fairly common on "Bullion Plateau" (see Figure 26).

Tables 31, 50 and 53 give details on this association and its higher synsystematic units.

Order 16. SALICETALIA POLARIS Hoefs & Krajina (corresponds to the European Arabidetalia)

These are snowbed ("Schneetälchen") communities in the alpine tundra bio-geoclimatic zone on calcareous substrates with Snow Basin Rutmarks or Snow Basin Anmoors (Kubiena, 1953) derived mainly from aeolian calcareous loess sediments, settled yearly on snow. These soils are formed under the prolonged effect of water dripping from melting of snow drifts. The vegetative season here is usually only about 3 - 8 weeks (after the snow beds melted) toward the end of summer.

The characteristic combination of species (order) is:

(C) Herb layer: Anemone parviflora
Antennaria monocephala

* Species in brackets are less characteristic than those without brackets.

Table 31.

Order: 15. SALICETALIA BARRATTIANAE

Alliance: 19. Salicion barrattianae

Association: 28. Salicetum barrattianae

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 307 | 308 | 303 | 304 | 302 | 310 | 312 | 129 | 132 | 134 | | | |
| Date | 27.7. 72 | 28.7. 72 | 27.7. 72 | 27.7. 72 | 27.7. 72 | 28.7. 72 | 28.7. 72 | 19.8. 71 | 19.8. 71 | 20.8. 71 | | | |
| Elevation (feet) | 5320 | 5350 | 5360 | 5380 | 5390 | 5420 | 5460 | 5770 | 5970 | 6070 | | | |
| Exposure (degree) | 190 | 135 | 190 | 220 | 190 | 135 | 150 | 250 | 220 | 250 | | | |
| Slope (degree) | 22 | 12 | 17 | 16 | 14 | 21 | 13 | 35 | 36 | 37 | | | |
| Hygrotope | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | | | |
| *Salix barrattiana* | 9.6 | 8.6 | 8.6 | 9.6 | 8.6 | 9.6 | 8.6 | 7.6 | 7.5 | 7.6 | V | 8.0 | 3 |
| *Salix niphoclada* | . | . | 3.2 | . | . | . | . | . | . | . | I | 0.3 | 2 |
| *Kobresia myosuroides* | 5.2 | 1.2 | 2.2 | 2.2 | 3.2 | 5.3 | 3.2 | 6.3 | 7.3 | 5.3 | V | 3.9 | 3 |
| *Salix reticulata* | 2.3 | 5.4 | 4.3 | 4.3 | 5.4 | 3.3 | 5.5 | 3.3 | +.1 | 2.2 | V | 3.4 | 2+ |
| *Festuca altaica* | 4.2 | 4.2 | 3.2 | 2.2 | 3.2 | 4.3 | 4.2 | 4.3 | 4.3 | . | V | 3.2 | 3 |
| *Hedysarum alpinum* | 3.1 | 4.2 | 1.1 | 2.1 | 2.1 | 2.1 | 4.1 | 2.1 | 3.1 | 1.1 | V | 2.4 | 3 |
| *Carex scirpoidea* | 1.1 | 2.1 | 2.1 | 2.1 | 4.1 | 2.1 | 1.1 | 3.1 | 2.1 | 3.1 | V | 2.2 | 3 |
| *Mertensia paniculata* | 2.1 | 2.1 | 2.1 | 1.1 | 2.1 | 3.1 | +.1 | 3.1 | 3.1 | 2.1 | V | 2.1 | 2+ |
| *Anemone parviflora* | 1.1 | 3.1 | 2.1 | . | 1.1 | 1.1 | +.1 | 3.1 | 2.1 | 3.1 | V | 1.7 | 2 |
| *Artemisia arctica* | +.1 | 1.1 | 2.1 | 1.1 | 2.1 | 2.1 | 2.1 | 1.1 | 2.1 | 3.1 | V | 1.7 | 2+ |
| *Senecio lugens* | +.1 | +.1 | 1.1 | 1.1 | 1.1 | +.1 | +.1 | 2.1 | 2.1 | 2.1 | V | 1.3 | 3 |
| *Gentiana propinqua* | +.+ | 2.+ | 2.+ | +.+ | +.+ | . | 1.+ | +.+ | +.+ | +.+ | V | 1.1 | 3 |
| *Pedicularis capitata* | 1.1 | 1.1 | 2.1 | 1.1 | 2.1 | +.+ | 1.+ | +.+ | +.+ | . | V | 1.1 | 2 |
| *Solidago multiradiata* | . | +.1 | +.1 | 1.1 | +.1 | 2.1 | 2.1 | +.1 | 1.1 | 1.1 | V | 1.1 | 3 |
| *Trisetum spicatum* | . | +.1 | 2.1 | 1.1 | 2.1 | 1.1 | +.+ | 1.1 | +.1 | 1.1 | V | 1.1 | 2 |
| *Zygadenus elegans* | 3.2 | 2.2 | 2.2 | 2.1 | 3.2 | 3.2 | +.1 | 2.1 | . | . | IV | 1.8 | 3 |
| *Oxytropis deflexa* | 1.1 | . | 2.1 | +.+ | . | . | +.1 | 1.+ | 3.1 | 3.1 | IV | 1.2 | 2 |
| *Equisetum scirpoides* | . | 2.+ | 1.+ | 1.+ | 2.+ | 1.+ | 1.+ | 1.+ | . | 1.+ | IV | 1.0 | 2 |
| *Potentilla fruticosa* | 2.2 | 1.2 | 2.2 | 1.2 | +.1 | 2.2 | . | . | 1.2 | . | IV | 1.0 | 2+ |
| *Gentiana prostrata* | 1.+ | 2.+ | 1.+ | 1.+ | 1.+ | 2.1 | 1.+ | . | . | . | IV | 0.9 | 3 |
| *Antennaria monocephala* | . | 2.1 | . | +.+ | . | +.1 | +.+ | +.+ | 1.+ | 1.+ | IV | 0.8 | 2 |
| *Saussurea viscida* | . | +.1 | . | . | . | +.1 | . | 1.1 | 3.1 | 2.1 | III | 0.8 | 2 |
| *Erigeron humilis* | . | . | +.+ | +.+ | . | +.+ | +.+ | . | . | +.+ | III | 0.5 | 2 |
| *Poa arctica* | +.+ | . | +.+ | +.+ | . | . | . | . | 1.+ | +.+ | III | 0.5 | 2 |
| *Polygonum viviparum* | . | 1.+ | +.+ | +.+ | +.+ | . | . | . | +.+ | . | III | 0.5 | 2- |
| *Stellaria laeta* | . | +.+ | . | . | . | . | +.+ | +.+ | +.+ | +.+ | III | 0.5 | 2 |
| *Dryas integrifolia* | . | 2.3 | 4.3 | 2.2 | . | . | 3.3 | . | . | . | II | 1.1 | 2+ |
| *Silene acaulis* | . | 1.1 | . | . | . | . | +.1 | . | +.1 | 4.2 | II | 0.7 | 2- |
| *Parnassia kotzebuei* | . | . | 2.+ | . | 1.+ | . | . | +.+ | . | . | II | 0.4 | 2 |
| *Valeriana capitata* | . | 2.1 | . | 1.1 | 1.1 | . | . | . | . | . | II | 0.4 | 2 |
| *Myosotis alpestris* | . | . | . | +.+ | . | 1.+ | . | . | . | +.+ | II | 0.3 | 2 |
| *Oxytropis viscida* | . | . | . | . | . | . | . | 2.1 | . | 1.1 | I | 0.3 | 2 |
| *Arctostaphylos alpina* | 1.2 | +.2 | . | . | . | . | . | . | . | . | I | 0.2 | 2 |
| *Castilleja hyperborea* | . | . | . | . | . | +.1 | . | . | . | +.1 | I | 0.2 | 2 |
| *Equisetum arvense* | . | . | . | . | 2.+ | . | . | . | . | . | I | 0.2 | 2 |
| *Festuca "vivipara"* | . | . | . | . | . | . | . | . | +.+ | 1.+ | I | 0.2 | 2 |
| *Lupinus arcticus* | . | . | . | . | . | 2.2 | . | . | . | . | I | 0.2 | 3 |
| *Poa alpina* | . | . | . | . | . | . | +.+ | . | +.+ | . | I | 0.2 | 2 |
| *Polemonium boreale* | . | . | . | . | 2.1 | . | . | . | . | . | I | 0.2 | 2 |
| *Salix dodgeana* | . | . | . | . | . | . | . | . | . | 2.2 | I | 0.2 | 2- |
| *Arnica alpina* | . | . | . | . | . | . | . | . | . | 1.+ | I | 0.1 | 2 |
| *Artemisia hyperborea* | . | . | . | . | . | . | . | . | . | +.1 | I | 0.1 | 2 |
| *Carex microchaeta* | . | . | . | . | 1.+ | . | . | . | . | . | I | 0.1 | 2 |
| *Draba cinerea* | . | . | . | . | . | . | . | . | . | +.+ | I | 0.1 | 2 |
| *Epilobium latifolium* | . | . | . | . | . | . | . | . | +.+ | . | I | 0.1 | 2- |
| *Festuca brachyphylla* | . | . | . | . | . | . | . | . | . | +.1 | I | 0.1 | 2 |
| *Minuartia rossii* | . | . | . | . | . | . | . | . | . | 1.+ | I | 0.1 | 2 |
| *Poa lanata* | . | . | . | . | +.+ | . | . | . | . | . | I | 0.1 | 2 |
| *Saxifraga reflexa* | . | . | . | . | . | . | . | . | . | +.+ | I | 0.1 | 2 |
| *Peltigera canina* | 1.1 | . | +.1 | 1.1 | . | . | +.1 | +.1 | +. 1 | +.1 | IV | 0.7 | 2 |
| *Cladonia pocillum* | 3.1 | . | . | +.1 | . | . | +.1 | +.+ | +.+ | +.+ | III | 0.8 | 2 |
| *Cetraria islandica* | . | . | . | . | . | . | . | +.1 | . | . | I | 0.1 | 2+ |
| *Solorina spongiosa* | 1.1 | . | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Distichium capillaceum* | 1.1 | +.1 | . | +.1 | . | +.+ | +.1 | . | +.1 | . | III | 0.6 | 2+ |

(Artemisia arctica)*
(Carex membranacea)*
(Carex scirpoidea)*
(Dodecatheon frigidum)*
Draba hirta
(Dryas integrifolia)*
Erigeron humilis
Equisetum variegatum
Gentiana propinqua
(Gentiana prostrata)*
Lloydia serotina
(Myosotis alpestris)*
(Oxyria digyna)*
(Oxytropis deflexa)*
Parnassia kotzebuei
(Pedicularis capitata)*
(Petasites frigidus)*
(Poa alpina)*
(Polemonium acutiflorum)*
(Polygonum viviparum)*
Salix polaris
Salix reticulata
Saussurea viscida
(Silene acaulis)*
(Trisetum spicatum)*

(D) Moss layer: Distichium capillaceum
(Lecanora epibryon)*
(Peltigera canina)*
Solorina spongiosa
(Timmia austriaca)*

There are some evident relationships between SALICETALIA POLARIS, SALICETALIA BARRATTIANAE, FESTUCETALIA ALTAICAE and even DRYADETALIA INTEGRIFOLIAE. However, all four orders have their own floristic and environmental substantiations which cannot be overlooked.

In the study area SALICETALIA POLARIS have two new alliances, each with its own one plant association.

Alliance 20. Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicion polaris Hoefs & Krajina

is clearly distinct from the Salicion polaris (originally as Salicion pseudopolaris, Lambert & Krajina in Lambert, 1969) by the floristic structure with many calcicolous species which are

missing in the Salicion polaris.

Association 29. Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris

The characteristic combination of species (alliance and plant association) is:

(C) Herb layer: Arnica lessingii
(Carex podocarpa)*
Papaver macounii
(Parrya nudicaulis)*
(Pedicularis kanei)*
(Poa arctica)*
Ranunculus nivalis
Ranunculus pygmaeus
(Saxifraga davurica)*
(Saxifraga oppositifolia)*
Senecio atropurpureus
Taraxacum alaskanum

(D) Moss layer: (Cladonia pocillum)*
(Dermatocarpon hepaticum)*
(Stereocaulon glareosum)*

Figure 27 shows a photograph of this association. It reveals a typical site of maximum snow accumulation and long duration of cover. Typical snowbed sites of this association are restricted in the study area to about 29 acres in map sections A 6, B 4, B 5 and B 6. However, large transition zones particularly to Dryadetum integrifoliae are common.

Alliance 21. Seneciono (lugentis) - Salicion polaris - reticulatae Hoefs & Krajina

is represented here by:

Association 30. Seneciono (lugentis) - Salicetum polaris - reticulatae

The characteristic combination of species (alliance and plant association) is:

(C) Herb layer: (Achillea borealis)*

* Species in brackets are less characteristic than those without brackets.

FIGURE 27:

Saxifrago (oppositifoliae) - Oxyrio (digynae)
- Salicetum polaris

Typical "snow bed" site.

FIGURE 28:

Seneciono (lugentis)
- Salicetum polaris
- reticulatae occupying moist depression on "Bullion Plateau".

(Anemone richardsonii)
(Carex microchaeta)*
(Castilleja hyperborea)*
(Epilobium latifolium)*
(Equisetum arvense)*
(Equisetum scirpoides)*
(Festuca altaica)*
(Hedysarum alpinum)*
(Mertensia paniculata)*
Minuartia biflora
(Poa lanata)*
(Potentilla diversifolia)*
Senecio lugens
(Solidago multiradiata)*
Valeriana capitata

(D) Moss layer: Tortula norvegica

Figure 28 shows a photograph of this association. It occupies moist depressions or the bases of slopes, however its snow cover is much less thick nor does it stay as long as in the previous association. Approximately 11 acres are covered by this association in the study area in map sections A 4, A 5, B 4 and B 5.

Tables 32, 33, 51 and 53 reveal details of the two associations and their higher synsystematic units.

Order 17. PETASITETALIA FRIGIDI Lambert & Krajina in Lambert, 1969

They occur in the alpine tundra biogeoclimatic zone on habitats permanently saturated by seepage water, moving during the vegetative season along the moderate slopes. Soils are strongly gleyed with anmoor (low moor) humus. The characteristic combination of species (order) is:

(C) Herb layer: (Anemone parviflora)*
Anemone richardsonii
Artemisia arctica
Astragalus umbellatus
Carex podocarpa
Draba praealta
Equisetum arvense
(Equisetum scirpoides)*

* Species in brackets are less characteristic than those without brackets.

Table 32.

Order: 16. SALICETALIA POLARIS

Alliance: 20. Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicion polaris

Association: 29. Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 315 | 41 | 323 | 42 | 325 | 324 | 333 | 326 | 334 | 43 | | | |
| Date | 28.7. 72 | 22.7. 71 | 1.8. 72 | 22.7. 71 | 2.8. 72 | 2.8. 72 | 7.8. 72 | 2.8. 72 | 7.8. 72 | 22.7. 71 | | | |
| Elevation (feet) | 5400 | 5540 | 5600 | 5650 | 5700 | 5800 | 5600 | 5860 | 5900 | 5940 | | | |
| Exposure (degree) | 320 | 20 | 0 | 20 | 50 | 20 | 10 | 70 | 30 | 10 | | | |
| Slope (degree) | 22 | 22 | 20 | 27 | 27 | 18 | 25 | 30 | 20 | 35 | | | |
| Hygrotope | 4+ | 3/4 | 3/4 | 4+ | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 4+ | Constancy | Average species significance | Vigor |
| *Salix polaris* | 9.6 | 8.4 | 8.4 | 8.4 | 8.5 | 8.4 | 8.4 | 9.5 | 8.4 | 7.3 | V | 8.1 | 3 |
| *Oxyria digyna* | 1.1 | 4.2 | 2.1 | 3.2 | 4.2 | 4.2 | 4.2 | 3.1 | 3.1 | 3.1 | V | 3.1 | 3 |
| *Carex membranacea* | +.+ | +.+ | 3.1 | . | 3.1 | 3.1 | 3.1 | 3.1 | 4.1 | 2.+ | V | 2.3 | 2 |
| *Saxifraga oppositifolia* | 2.2 | +.1 | +.2 | 5.2 | 2.2 | 1.1 | 1.1 | 2.2 | 2.1 | 5.2 | V | 2.2 | 3 |
| *Artemisia arctica* | 2.1 | 4.2 | 2.1 | +.1 | 3.1 | 2.1 | 1.+ | 2.1 | +.+ | +.+ | V | 1.9 | 2+ |
| *Anemone parviflora* | 2.+ | 2.+ | 2.+ | +.+ | 2.+ | 2.+ | 1.+ | 2.1 | 2.+ | +.+ | V | 1.7 | 3 |
| *Antennaria monocephala* | 3.+ | +.+ | 2.+ | +.+ | 2.+ | 2.+ | 2.+ | 2.+ | 1.+ | +.+ | V | 1.7 | 3 |
| *Lloydia serotina* | 2.+ | 4.+ | 1.+ | . | 1.+ | 2.+ | 2.+ | 2.+ | 2.+ | 1.+ | V | 1.7 | 2 |
| *Erigeron humilis* | 3.+ | +.+ | 3.+ | +.+ | 1.+ | 1.+ | +.+ | 1.+ | 2.+ | +.+ | V | 1.5 | 2+ |
| *Silene acaulis* | 1.2 | +.2 | 1.2 | 1.2 | 2.2 | 1.+ | 1.1 | 2.2 | 1.2 | . | V | 1.1 | 2 |
| *Trisetum spicatum* | . | +.+ | +.+ | +.+ | +.+ | +.+ | 2.1 | 1.1 | 1.1 | +.1 | V | 1.0 | 2 |
| *Saussurea viscida* | +.+ | +.1 | . | . | 3.1 | 2.1 | 1.1 | 3.1 | 2.1 | +.+ | IV | 1.4 | 2 |
| *Salix reticulata* | 2.3 | 3.3 | 2.3 | . | +.2 | . | +.2 | 1.3 | +.2 | 1.3 | IV | 1.2 | 2+ |
| *Carex scirpoidea* | 1.1 | +.+ | +.+ | +.+ | 3.1 | 2.1 | . | 2.+ | . | . | IV | 1.1 | 2 |
| *Parnassia kotzebuei* | +.+ | +.+ | 1.+ | . | 1.+ | 2.+ | +.+ | 1.+ | . | . | IV | 0.8 | 3 |
| *Petasites frigidus* | 3.2 | 4.2 | . | . | +.2 | 1.2 | . | 3.2 | . | . | III | 1.2 | 2 |
| *Pedicularis kanei* | . | . | . | 2.1 | 1.1 | 1.1 | +.+ | 3.1 | . | . | III | 0.8 | 2 |
| *Polygonum viviparum* | . | . | . | . | 1.+ | 1.+ | 3.+ | 1.+ | 1.+ | . | III | 0.7 | 2 |
| *Parrya nudicaulis* | . | +.+ | . | . | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | . | III | 0.6 | 3 |
| *Poa arctica* | +.+ | +.+ | . | . | +.+ | +.+ | +.+ | . | +.+ | . | III | 0.6 | 2 |
| *Taraxacum alaskanum* | 1.+ | . | +.+ | +.1 | . | +.1 | . | +.+ | 1.1 | . | III | 0.6 | 3 |
| *Oxytropis deflexa* | . | . | +.1 | . | +.+ | . | 1.1 | . | +.+ | +.+ | III | 0.5 | 2 |
| *Senecio atropurpureus* | . | . | . | . | +.1 | 1.1 | 1.1 | 1.1 | 1.1 | . | III | 0.5 | 2 |
| *Arnica lessingii* | . | . | . | +.1 | +.1 | +.1 | . | 1.1 | . | . | II | 0.4 | 3 |
| *Equisetum variegatum* | . | 1.+ | 2.+ | +.+ | . | . | . | . | . | . | II | 0.4 | 2 |
| *Myosotis alpestris* | . | 1.1 | +.1 | . | . | . | +.1 | . | +.+ | . | II | 0.4 | 2 |
| *Pedicularis capitata* | . | 1.1 | . | . | +.+ | +.+ | . | 1.1 | . | . | II | 0.4 | 2 |
| *Carex podocarpa* | . | . | . | . | +.1 | +.1 | . | +.+ | . | . | II | 0.3 | 2 |
| *Draba hirta* | . | . | . | +.+ | . | . | . | +.+ | +.+ | . | II | 0.3 | 2 |
| *Dryas integrifolia* | . | . | . | . | +.1 | . | +.2 | . | . | 1.1 | II | 0.3 | 2- |
| *Gentiana propinqua* | . | . | +.+ | . | 1.+ | 1.+ | . | . | . | . | II | 0.3 | 2 |
| *Ranunculus nivalis* | . | . | . | 1.+ | +.+ | . | . | . | 1.+ | . | II | 0.3 | 3 |
| *Ranunculus pygmaeus* | . | . | . | 1.+ | +.+ | . | . | . | . | 1.+ | II | 0.3 | 3 |
| *Saxifraga davurica* | . | +.+ | . | . | . | +.+ | . | . | +.+ | . | II | 0.3 | 3 |
| *Equisetum scirpoides* | . | 1.+ | . | . | . | . | . | . | +.+ | . | I | 0.2 | 2 |
| *Gentiana prostrata* | . | . | . | . | +.+ | . | . | 1.+ | . | . | I | 0.2 | 2 |
| *Anemone richardsonii* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Cardamine purpurea* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Carex microchaeta* | . | . | . | . | . | . | +.+ | . | . | . | I | 0.1 | 2 |
| *Castilleja hyperborea* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Claytonia sarmentosa* | . | . | . | . | +.+ | . | . | . | . | . | I | 0.1 | 3 |
| *Dodecatheon frigidum* | . | +.1 | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Draba stenoloba* | . | . | . | . | +.+ | . | . | . | . | . | I | 0.1 | 2 |
| *Eriophorum angustifolium* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Papaver macounii* | . | . | . | . | . | . | +.+ | . | . | . | I | 0.1 | 2- |
| *Poa alpina* | . | . | +.+ | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Polemonium acutiflorum* | . | . | . | . | . | . | . | +.1 | . | . | I | 0.1 | 2 |
| *Senecio lugens* | . | . | +.1 | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Stereocaulon glareosum* | 2.1 | +.+ | 2.2 | . | 2.1 | 3.2 | 3.1 | 1.1 | 2.1 | . | IV | 1.6 | 3 |
| *Peltigera canina* | 2.1 | . | 3.2 | . | 2.1 | 1.1 | 1.1 | +.1 | 2.1 | . | IV | 1.2 | 3 |
| *Dermatocarpon hepaticum* | . | . | 1.1 | . | 2.+ | 2.+ | 1.+ | . | 1.1 | . | III | 0.7 | 2 |
| *Solorina spongiosa* | . | . | +.+ | . | +.+ | +.+ | +.1 | . | +.1 | . | III | 0.5 | 2 |
| *Cladonia pocillum* | . | . | . | . | 1.1 | . | +.1 | . | +.1 | . | II | 0.3 | 2 |
| *Lecanora epibryon* | . | . | . | . | . | 2.+ | 1.+ | . | . | . | I | 0.3 | 2 |
| *Distichium capillaceum* | 4.2 | 2.1 | 4.2 | +.1 | 3.2 | 4.2 | +.1 | 1.2 | +.1 | +.1 | V | 2.2 | 3 |
| *Timmia austriaca* | +.1 | 1.+ | 2.1 | . | 2.1 | 2.1 | 1.+ | +.+ | +.+ | . | IV | 1.1 | 2 |
| ? *Brachythecium turgidum* | . | . | . | . | +.+ | . | . | . | . | . | I | 0.1 | 2 |
| *Mnium blyttii* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Pohlia sp.* | . | . | . | +.+ | . | . | . | . | . | . | I | 0.1 | 2 |

Table 33

Order: 16. SALICETALIA POLARIS

Alliance: 21. Seneciono (lugentis) - Salicion polaris - reticulatae

Association: 30. Seneciono (lugentis) - Salicetum polaris - reticulatae

| Number of plots | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 38 | 39 | 309 | 313 | 311 | 322 | 314 | 305 | 45 | 136 | | | |
| Date | 21.7. 71 | 21.7. 71 | 28.7. 72 | 28.7. 72 | 28.7. 72 | 1.8. 72 | 28.7. 72 | 27.7. 72 | 22.7. 71 | 20.8. 71 | | | |
| Elevation (feet) | 5290 | 5300 | 5320 | 5350 | 5440 | 5570 | 5580 | 5660 | 6100 | 6270 | | | |
| Exposure (degree) | 20 | 330 | 105 | 320 | 65 | 270 | 320 | 60 | 270 | 230 | | | |
| Slope (degree) | 18 | 16 | 13 | 10 | 8 | 19 | 11 | 13 | 23 | 22 | | | |
| Hygrotope | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 4 | 3/4 | 3/4 | 3/4 | | | |
| *Salix reticulata* | 8.6 | 7.4 | 8.4 | 8.4 | 9.4 | 8.5 | 9.5 | 8.4 | 8.4 | 8.5 | V | 8.1 | 3 |
| *Salix polaris* | 3.2 | 5.3 | . | 3.2 | 5.3 | 4.3 | 3.2 | 4.3 | 1.2 | 2.2 | V | 3.0 | 2+ |
| *Artemisia arctica* | 1.1 | 3.2 | 4.2 | 3.2 | 3.2 | 4.3 | 3.1 | 4.2 | 1.1 | 3.1 | V | 2.9 | 2+ |
| *Anemone parviflora* | 4.1 | 3.1 | 2.+ | 3.1 | 2.+ | 2.1 | 2.1 | 2.+ | 2.+ | 2.+ | V | 2.4 | 3 |
| *Equisetum scirpoides* | 3.+ | 4.1 | 1.+ | 2.1 | 1.+ | 2.+ | 2.1 | 2.+ | 1.+ | 1.+ | V | 1.9 | 3 |
| *Parnassia kotzebuei* | 1.+ | +.+ | 1.+ | 2.+ | 2.+ | 3.+ | 2.+ | 3.+ | 1.+ | +.+ | V | 1.7 | 3 |
| *Senecio lugens* | +.1 | +.1 | +.1 | 2.1 | 1.1 | 3.1 | 2.1 | 3.1 | 2.1 | 1.1 | V | 1.7 | 3 |
| *Carex membranacea* | +.1 | 1.1 | 1.1 | 4.3 | +.+ | 1.1 | +.+ | 5.2 | 1.1 | . | V | 1.6 | 2 |
| *Poa lanata* | +.1 | +.1 | 1.+ | 2.1 | +.+ | +.1 | . | 3.1 | 3.1 | 3.1 | V | 1.6 | 3 |
| *Trisetum spicatum* | +.+ | +.+ | 2.1 | 1.+ | +.+ | 3.1 | 1.+ | 3.1 | 2.1 | 1.+ | V | 1.6 | 2 |
| *Carex scirpoidea* | +.1 | +.+ | 2.1 | 1.1 | 2.1 | . | 3.1 | +.+ | +.+ | 3.1 | V | 1.5 | 2 |
| *Gentiana propingua* | . | +.+ | 2.+ | 2.+ | 2.+ | 1.+ | 2.+ | 2.+ | +.+ | +.+ | V | 1.4 | 2 |
| *Erigeron humilis* | . | +.+ | +.+ | +.+ | 1.+ | +.+ | 2.1 | 1.1 | 1.+ | 1.+ | V | 1.0 | 3 |
| *Petasites frigidus* | 3.3 | 3.3 | 2.1 | 3.2 | 2.1 | . | 3.2 | +.1 | . | . | IV | 1.7 | 2 |
| *Pedicularis capitata* | 2.1 | 2.1 | 1.+ | . | 2.1 | 3.1 | 2.+ | +.+ | . | . | IV | 1.3 | 2+ |
| *Festuca altaica* | 1.2 | 2.2 | 3.2 | 2.2 | +.1 | 1.1 | 1.1 | . | . | . | IV | 1.1 | 2+ |
| *Polygonum viviparum* | . | +.+ | 2.+ | 2.+ | . | . | 3.+ | 1.+ | +.+ | +.+ | IV | 1.1 | 2 |
| *Castilleja hyperborea* | . | . | +.+ | 1.1 | 2.1 | 3.1 | . | 1.1 | 1.1 | +.+ | IV | 1.0 | 2 |
| *Myosotis alpestris* | . | +.+ | . | . | 1.1 | 1.1 | 1.1 | 3.+ | 2.+ | +.+ | IV | 1.0 | 2+ |
| *Lloydia serotina* | +.+ | . | 1.+ | 1.+ | 1.+ | 1.+ | . | 3.+ | +.+ | . | IV | 0.9 | 2 |
| *Mertensia paniculata* | +.1 | . | 2.1 | 1.1 | 2.2 | 1.1 | . | . | +.1 | 1.1 | IV | 0.9 | 2 |
| *Antennaria monocephala* | +.+ | +.+ | . | 2.+ | 1.+ | 1.+ | . | 1.+ | +.+ | . | IV | 0.8 | 2 |
| *Saussurea viscida* | +.1 | +.1 | +.1 | . | 1.+ | . | . | +.+ | 1.+ | 2.1 | IV | 0.8 | 2 |
| *Solidago multiradiata* | . | . | 1.1 | +.+ | +.+ | +.1 | . | +.+ | +.+ | +.+ | IV | 0.7 | 2 |
| *Oxyria digyna* | 4.1 | 3.1 | 2.1 | 3.1 | . | . | . | . | +.+ | +.1 | III | 1.4 | 2 |
| *Carex microchaeta* | +.1 | +.1 | +.1 | 1.1 | +.+ | 2.1 | . | . | . | . | III | 0.7 | 2 |
| *Oxytropis deflexa* | . | . | . | 1.1 | +.1 | 1.2 | . | +.+ | 2.1 | 1.1 | III | 0.7 | 2 |
| *Silene acaulis* | +.1 | 2.2 | . | . | . | +.2 | . | . | +.2 | 1.2 | III | 0.6 | 2 |
| *Valeriana capitata* | . | . | 1.1 | 1.1 | 1.1 | 1.1 | 2.1 | . | . | . | III | 0.6 | 2 |
| *Poa alpina* | . | . | . | . | 1.+ | +.+ | 2.1 | 3.1 | . | . | II | 0.7 | 2 |
| *Dodecatheon frigidum* | . | 2.2 | . | 2.2 | . | . | 2.1 | . | . | . | II | 0.6 | 2 |
| *Hedysarum alpinum* | . | . | +.1 | . | . | +.1 | 1.1 | . | . | 3.1 | II | 0.6 | 2 |
| *Equisetum arvense* | . | . | 1.+ | . | 1.+ | +.1 | 2.+ | . | . | . | II | 0.5 | 2 |
| *Epilobium latifolium* | +.1 | 1.1 | . | . | . | . | . | . | 1.1 | 1.1 | II | 0.4 | 2 |
| *Polemonium acutiflorum* | . | . | . | +.1 | . | +.+ | +.1 | +.1 | . | . | II | 0.4 | 2 |
| *Equisetum variegatum* | . | . | +.+ | . | +.+ | . | . | 1.+ | . | . | II | 0.3 | 2 |
| *Gentiana prostrata* | . | . | +.+ | . | 1.+ | . | . | . | +.+ | . | II | 0.3 | 2 |
| *Dryas integrifolia* | . | . | . | . | . | . | . | . | +.2 | 2.2 | I | 0.3 | 2- |
| *Achillea borealis* | . | . | +.1 | . | . | . | . | +.1 | . | . | I | 0.2 | 2 |
| *Astragalus nutzotinensis* | . | . | . | . | . | . | . | . | 2.1 | . | I | 0.2 | 2 |
| *Minuartia biflora* | . | 1.1 | . | . | 1.1 | . | . | . | . | . | I | 0.2 | 2 |
| *Potentilla diversifolia* | . | . | . | . | . | . | . | 2.1 | . | . | I | 0.2 | 2+ |
| *Zygadenus elegans* | . | . | 1.1 | . | 1.1 | . | . | . | . | . | I | 0.2 | 2 |
| *Anemone richardsonii* | +.+ | . | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Claytonia sarmentosa* | . | . | . | . | . | . | . | . | . | +.+ | I | 0.1 | 2 |
| *Draba hirta* | . | . | . | . | . | . | . | . | +.+ | . | I | 0.1 | 2 |
| *Parrya nudicaulis* | . | . | . | . | . | . | . | . | +.1 | . | I | 0.1 | 2 |
| *Saxifraga oppositifolia* | . | . | . | . | . | . | . | . | . | +.1 | I | 0.1 | 2 |
| *Sedum roseum* | . | . | . | . | . | . | . | +.1 | . | . | I | 0.1 | 2 |
| *Lecanora epibryon* | +.+ | +.1 | . | . | . | . | . | . | . | +.+ | II | 0.3 | 2 |
| *Peltigera canina* | . | +.+ | . | . | +.1 | . | . | . | . | +.1 | II | 0.3 | 2 |
| *Solorina spongiosa* | +.+ | +.1 | . | . | . | . | . | . | . | +.1 | II | 0.3 | 2 |
| *Cetraria cucullata* | . | +.+ | . | . | . | . | . | . | . | . | I | 0.1 | 2 |
| *Distichium capillaceum* | +.1 | 2.1 | +.1 | +.2 | 2.1 | 1.2 | +.1 | . | . | . | IV | 0.9 | 2+ |
| *Timmia austriaca* | +.1 | . | +.+ | +.1 | . | . | +.1 | . | . | . | II | 0.4 | 2 |
| *Tortula norvegica* | . | . | . | +.+ | +.1 | . | +.1 | . | . | +.1 | II | 0.4 | 2 |

(Myosotis alpestris)*
(Pedicularis capitata)*
Petasites frigidus
Poa alpina
Polemonium acutiflorum
Polygonum viviparum
(Salix polaris)*
(Salix reticulata)*
(Senecio lugens)*
(Valeriana capitata)*

(D) Moss layer: Timmia austriaca
Tomentypnum nitens

Two alliances (each with one plant association) are distinguished here in the PETASITETALIA FRIGIDI.

Alliance 22. Oxyrio (digynae) - Artemision arcticae - tilesii Hoefs & Krajina

The hygrotope is hygric.

Association 31. Oxyrio (digynae) - Artemisietum arcticae - tilesii

The characteristic combination of species (alliance and association) is:

(B) Shrub layer: (Salix alaxensis)*

(C) Herb layer: Achillea borealis
Aconitum delphinifolium
(Agropyron violaceum)*
Alopecurus alpinus
Arnica alpina
Artemisia tilesii
Aster sibiricus
(Castilleja hyperborea)*
Delphinium glaucum
Epilobium latifolium
(Erigeron humilis)*
(Festuca altaica)*
(Gentiana propinqua)*
(Hedysarum alpinum)*
Hierochloe odorata
Mertensia paniculata
(Minuartia biflora)*
Oxyria digyna
(Parnassia kotzebuei)*
(Poa arctica)*

* Species in brackets are less characteristic than those without brackets.

Poa lanata
Poa paucispicula
Potentilla diversifolia
Ranunculus sulphureus
Sedum roseum
(Solidago multiradiata)*
(Trisetum spicatum)*
(Zygadenus elegans)*

(D) Moss layer: Philonotis tomentella
Plagiomnium rostratum

Figure 29 shows a photograph of this association. It is restricted in distribution on Sheep Mountain to less than 1.5 acres in map sections A 4.99, A 4.100, A 5.91 and B 4.07. It has also been sampled along a creek on the west side of Mount Wallace and on the "Bullion Plateau". With 59 species it is the association with the richest floristic composition in the study area.

Alliance 23. Saxifrago (hirculi) - Caricion membranaceae Hoefs & Krajina

These are wetlands of the alpine tundra biogeoclimatic zone, the hygrotope of which is subhydric (with water completely saturating the anmoor humus).

Association 32. Saxifrago (hirculi) - Caricetum membranaceae

The characteristic combination of species (alliance and plant association) is:

(C) Herb layer: Cardamine purpurea
Carex membranacea
Claytonia bostockii
Claytonia sarmentosa
Dodecatheon frigidum
(Dryas integrifolia)*
(Equisetum variegatum)*
Eriophorum angustifolium
Parrya nudicaulis
Pedicularis kanei
Saxifraga caespitosa
Saxifraga davurica

* Species in brackets are less characteristic than those without brackets.

FIGURE 29:

Oxyrio (digynae) - Artemisietum arcticae - tilesii occupying banks of an alpine creek.

FIGURE 30:

Saxifrago (hirculi) - Caricetum membranaceae occupying wet alpine depression.

Table 34.

Order: 17. PETASITETALIA FRIGIDI

Alliance: 22. Oxyrio (digynae) - Artemision arcticae - tilesii

Association: 31. Oxyrio (digynae) - Artemisietum arcticae - tilesii

| Number of plots | 1 | 2 | 3 | 4 | 5 | | | |
|---|---|---|---|---|---|---|---|---|
| Plot number | 340 | 63 | 64 | 65 | 344 | | | |
| Date | 13.8. 72 | 3.8. 71 | 3.8. 71 | 3.8. 71 | 15.8. 72 | | | |
| Elevation (feet) | 5100 | 5270 | 5330 | 5400 | 5600 | | | |
| Exposure (degree) | 140 | 260 | 250 | 200 | 180 | | | |
| Slope (degree) | -43 | -10 | -12 | -10 | -29 | | | |
| Hygrotope | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | Constancy | Average species significance | Vigor |
| *Salix alaxensis* | . | +.1 | +.2 | . | . | II | 0.4 | 2- |
| *Artemisia tilesii* | 7.3 | 6.3 | 5.3 | 5.3 | 7.4 | V | 6.0 | 3 |
| *Mertensia paniculata* | 5.3 | 4.3 | 5.3 | 4.2 | 5.2 | V | 4.6 | 3 |
| *Epilobium latifolium* | 3.3 | 6.3 | 5.4 | 3.2 | 4.2 | V | 4.2 | 3 |
| *Artemisia arctica* | 3.2 | 4.2 | 3.2 | 4.2 | 6.3 | V | 4.0 | 2+ |
| *Oxyria digyna* | 1.2 | 5.4 | 4.2 | 4.3 | 2.2 | V | 3.2 | 2+ |
| *Sedum roseum* | 3.2 | 1.2 | 2.2 | 3.2 | 3.2 | V | 2.4 | 3 |
| *Anemone parviflora* | 2.+ | 3.1 | 2.+ | 1.+ | 3.1 | V | 2.2 | 2 |
| *Poa lanata* | 3.+ | 3.+ | 2.+ | 2.+ | 1.+ | V | 2.2 | 2 |
| *Salix reticulata* | 3.2 | 2.2 | +.2 | 1.2 | 3.2 | V | 2.0 | 2+ |
| *Trisetum spicatum* | 1.+ | 1.+ | 3.+ | 2.+ | 2.+ | V | 1.8 | 2 |
| *Parnassia kotzebuei* | 1.+ | 2.1 | 2.1 | +.+ | +.+ | V | 1.4 | 2 |
| *Poa alpina* | 2.+ | 1.+ | 1.+ | 2.+ | 1.+ | V | 1.4 | 2 |
| *Erigeron humilis* | 1.+ | +.1 | 1.+ | 1.+ | 2.1 | V | 1.2 | 2 |
| *Gentiana propinqua* | +.+ | +.+ | 1.+ | +.+ | 2.+ | V | 1.2 | 2 |
| *Polygonum viviparum* | 2.+ | 1.+ | +.+ | +.+ | +.+ | V | 1.2 | 2 |
| *Senecio lugens* | +.1 | 1.1 | 2.1 | +.1 | 1.1 | V | 1.2 | 2 |
| *Petasites frigidus* | 4.3 | 4.2 | 4.3 | 4.3 | . | IV | 3.2 | 3 |
| *Aconitum delphinifolium* | 1.2 | 2.2 | +.1 | 4.2 | . | IV | 1.6 | 3 |
| *Zygadenus elegans* | 2.1 | +.1 | . | +.1 | 3.1 | IV | 1.4 | 2 |
| *Achillea borealis* | +.1 | 1.1 | . | 2.1 | 2.1 | IV | 1.2 | 2 |
| *Aster sibiricus* | 1.1 | 1.1 | +.+ | . | 2.1 | IV | 1.0 | 2 |
| *Castilleja hyperborea* | . | +.+ | 2.1 | +.+ | +.+ | IV | 1.0 | 2 |
| *Festuca altaica* | . | 1.1 | +.1 | +.1 | 1.2 | IV | 0.8 | 2+ |
| *Delphinium glaucum* | 1.1 | . | +.1 | 4.2 | . | III | 1.2 | 3 |
| *Equisetum arvense* | 1.1 | 4.1 | . | 1.1 | . | III | 1.2 | 2 |
| *Carex podocarpa* | +.1 | . | . | 2.+ | 2.+ | III | 1.0 | 2 |
| *Myosotis alpestris* | . | . | 1.1 | 2.1 | 2.1 | III | 1.0 | 2+ |
| *Solidago multiradiata* | +.1 | . | . | 2.1 | +.+ | III | 0.8 | 2 |
| *Polemonium acutiflorum* | +.1 | . | +.1 | 1.1 | . | III | 0.6 | 2 |
| *Salix polaris* | . | 1.2 | 1.2 | . | 1.2 | III | 0.6 | 2 |
| *Valeriana capitata* | 3.1 | . | . | 1.1 | . | II | 0.8 | 2 |
| *Agropyron violaceum* | +.1 | +.1 | . | . | . | II | 0.4 | 2 |
| *Draba praealta* | +.+ | . | +.+ | . | . | II | 0.4 | 2 |
| *Equisetum scirpoides* | . | +.+ | +.+ | . | . | II | 0.4 | 2 |
| *Hedysarum alpinum* | 1.1 | . | . | . | +.1 | II | 0.4 | 2 |
| *Poa arctica* | . | +.+ | +.+ | . | . | II | 0.4 | 2 |
| *Poa paucispicula* | . | +.+ | +.+ | . | . | II | 0.4 | 2 |
| *Potentilla diversifolia* | . | . | . | +.1 | 1.1 | II | 0.4 | 2 |
| *Ranunculus sulphureus* | 1.+ | . | . | 1.+ | . | II | 0.4 | 2 |
| *Saxifraga hieracifolia* | . | . | . | 2.1 | . | I | 0.4 | 2 |
| *Alopecurus alpinus* | . | . | . | 1.+ | . | I | 0.2 | 3 |
| *Anemone richardsonii* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Antennaria monocephala* | . | . | +.+ | . | . | I | 0.2 | 2 |
| *Arnica alpina* | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Astragalus umbellatus* | +.+ | . | . | . | . | I | 0.2 | 2 |
| *Claytonia bostockii* | . | . | . | +.+ | . | I | 0.2 | 2 |
| *Hierochloe odorata* | . | +.+ | . | . | . | I | 0.2 | 3 |
| *Minuartia biflora* | . | +.1 | . | . | . | I | 0.2 | 2 |
| *Pedicularis capitata* | . | . | . | . | +.+ | I | 0.2 | 2 |
| *Potentilla fruticosa* | . | . | . | . | +.2 | I | 0.2 | 2 |
| *Salix arctica* | . | +.2 | . | . | . | I | 0.2 | 2- |
| *Saussurea viscida* | . | . | . | +.1 | . | I | 0.2 | 2 |
| *Plagiomnium rostratum* | +.1 | +.1 | . | +.+ | . | III | 0.6 | 2 |
| *Timmia austriaca* | +.1 | . | +.1 | . | +.1 | III | 0.6 | 2 |
| *Philonotis tomentella* | +.1 | . | . | +.1 | . | II | 0.4 | 2 |
| *Tomentypnum nitens* | +.+ | . | . | . | +.1 | II | 0.4 | 2 |
| *Ceratodon purpureus* | . | . | +.+ | . | . | I | 0.2 | 2 |
| *Tortula norvegica* | . | . | +.+ | . | . | I | 0.2 | 2 |

Table 35.

Order: 17. PETASITETALIA FRIGIDI

Alliance: 23. Saxifrago (hirculi) - Caricion membranaceae

Association: 32. Saxifrago (hirculi) - Caricetum membranaceae

| Number of plots | 1 | 2 | 3 | 4 | 5 | Constancy | Average species significance | Vigor |
|---|---|---|---|---|---|---|---|---|
| Plot number | 31 | 32 | 33 | 34 | 35 | | | |
| Date | 20.7. 71 | 20.7. 71 | 20.7. 71 | 20.7. 71 | 20.7. 71 | | | |
| Elevation (feet) | 5620 | 5690 | 5720 | 5800 | 5860 | | | |
| Exposure (degree) | 290 | 280 | 290 | 300 | 280 | | | |
| Slope (degree) | -11 | -10 | -10 | 0 | -20 | | | |
| Hygrotope | 4 | 4+ | 4 | 4+ | 4 | | | |
| *Carex membranacea* | 6.2 | 7.4 | 7.4 | 7.4 | 8.3 | V | 7.0 | 3 |
| *Petasites frigidus* | 5.2 | 6.2 | 5.2 | 4.2 | 4.2 | V | 4.8 | 3 |
| *Salix reticulata* | 7.3 | 5.3 | 3.2 | 6.3 | 3.2 | V | 4.8 | 2 |
| *Eriophorum angustifolium* | 3.1 | 2.1 | 3.1 | 2.1 | 3.2 | V | 2.6 | 3 |
| *Equisetum arvense* | 3.1 | 2.+ | +.+ | 4.1 | 2.+ | V | 2.4 | 2+ |
| *Cardamine purpurea* | 2.1 | +.1 | 3.1 | 2.1 | 2.1 | V | 2.0 | 3 |
| *Salix polaris* | 1.2 | 1.2 | 1.2 | 4.3 | 3.2 | V | 2.0 | 2 |
| *Polemonium acutiflorum* | 1.1 | 2.1 | 2.1 | +.+ | 3.1 | V | 1.8 | 3 |
| *Saxifraga hirculus* | 2.1 | 3.1 | 2.2 | 1.1 | 1.1 | V | 1.8 | 3 |
| *Claytonia bostockii* | 2.+ | 1.1 | 2.1 | +.+ | 2.+ | V | 1.6 | 3 |
| *Saxifraga hieracifolia* | 2.1 | 2.1 | +.1 | +.1 | 1.1 | V | 1.4 | 3 |
| *Senecio lugens* | 2.1 | +.1 | +.1 | 1.1 | 2.1 | V | 1.4 | 2 |
| *Claytonia sarmentosa* | +.+ | 1.+ | +.+ | +.+ | 1.1 | V | 1.0 | 3 |
| *Pedicularis kanei* | +.1 | +.1 | +.1 | +.+ | 1.1 | V | 1.0 | 3 |
| *Dryas integrifolia* | +.2 | . | 2.2 | 3.2 | 3.2 | IV | 1.8 | 2- |
| *Parrya nudicaulis* | 2.1 | +.1 | +.1 | . | 2.1 | IV | 1.2 | 2+ |
| *Dodecatheon frigidum* | 1.1 | +.1 | . | +.1 | 2.1 | IV | 1.0 | 2 |
| *Carex podocarpa* | . | +.1 | +.+ | +.1 | +.+ | IV | 0.8 | 2 |
| *Polygonum viviparum* | . | +.+ | +.+ | +.+ | +.+ | IV | 0.8 | 2 |
| *Artemisia arctica* | 1.1 | 1.1 | . | . | 3.1 | III | 1.0 | 2- |
| *Anemone parviflora* | +.+ | +.+ | . | . | 1.+ | III | 0.6 | 2- |
| *Draba praealta* | . | +.+ | +.+ | . | +.+ | III | 0.6 | 2 |
| *Poa alpina* | . | 1.+ | +.+ | . | +.+ | III | 0.6 | 2- |
| *Saxifraga davurica* | . | . | +.1 | 1.1 | 1.1 | III | 0.6 | 3 |
| *Equisetum variegatum* | . | +.+ | . | 1.+ | . | II | 0.4 | 2 |
| *Saxifraga caespitosa* | . | . | +.1 | . | +.+ | II | 0.4 | 2 |
| *Valeriana capitata* | 1.1 | 1.1 | . | . | . | II | 0.4 | 2 |
| *Anemone richardsonii* | . | . | . | +.1 | . | I | 0.2 | 2 |
| *Astragalus umbellatus* | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Carex microchaeta* | . | . | . | +.+ | . | I | 0.2 | 2 |
| *Carex scirpoidea* | . | +.+ | . | . | . | I | 0.2 | 2- |
| *Equisetum scirpoides* | . | . | . | +.+ | . | I | 0.2 | 2- |
| *Festuca altaica* | . | +.2 | . | . | . | I | 0.2 | 2- |
| *Gentiana propinqua* | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Myosotis alpestris* | . | +.+ | . | . | . | I | 0.2 | 2- |
| *Parnassia kotzebuei* | . | +.+ | . | . | . | I | 0.2 | 2 |
| *Pedicularis capitata* | . | . | . | . | +.1 | I | 0.2 | 2 |
| *Trisetum spicatum* | . | 1.+ | . | . | . | I | 0.2 | 2- |
| *Dactylina arctica* | +.1 | . | +.1 | +.1 | +.1 | IV | 0.8 | 2+ |
| *Cetraria richardsonii* | . | . | . | +.1 | +.1 | II | 0.4 | 2 |
| *Cladonia pocillum* | . | . | +.1 | . | +.+ | II | 0.4 | 2 |
| *Peltigera canina* | . | . | +.1 | . | +.1 | II | 0.4 | 2 |
| *Stereocaulon glareosum* | +.1 | . | +.1 | . | . | II | 0.4 | 2 |
| *Thamnolia subuliformis* | . | . | . | +.+ | . | I | 0.2 | 2 |
| *Timmia austriaca* | 2.2 | 3.2 | 2.1 | 3.2 | 2.1 | V | 2.4 | 2 |
| *Tomentypnum nitens* | +.1 | +.1 | 1.1 | 2.1 | 2.+ | V | 1.4 | 2 |
| *Plagiomnium rugicum* | +.1 | . | +.+ | . | . | II | 0.4 | 2 |
| *Bryum sp.* | +.+ | . | . | . | . | I | 0.2 | 2 |
| ? *Hypnum bridelianum* | +.+ | . | . | . | . | I | 0.2 | 2 |

Saxifraga hieracifolia
Saxifraga hirculus

(D) Moss layer: Cetraria richardsonii
(Cladonia pocillum)*
Dactylina arctica
(Peltigera canina)*
(Stereocaulon glareosum)*
(Plagiomnium rugicum)*

Figure 30 shows a photograph of this association. In the study area it occupies about 12.5 acres in map sections A 5.88, A 5.89, A 5.92, A 5.93, A 5.94, A 5.95, A 5.96, A. 5.97 and A 5.98.

Tables 34, 35, 52 and 53 reveal details on the analyses and synthesis of these two associations and their higher units.

All alpine associations are utilized by sheep in summer (late June to October). Other characteristic mammals are Ursus arctos (grizzly bear), Gulo gulo (wolverine), Spermophilus parryii (Arctic ground squirrel), Ochotona princeps collaris (pika) and Marmota caligata (marmot). The most frequently observed birds include Aquila chrysaetos (golden eagle), Lagopus leucurus (white-tailed ptarmigan), Lagopus mutus (rock ptarmigan), Oenanthe oenanthe (wheatear), Anthus spinoletta (water pipit), Eremophila alpestris (horned lark) and Leucosticte tephrocotis (gray-crowned rosy finch).

* Species in brackets are less characteristic than those without brackets.

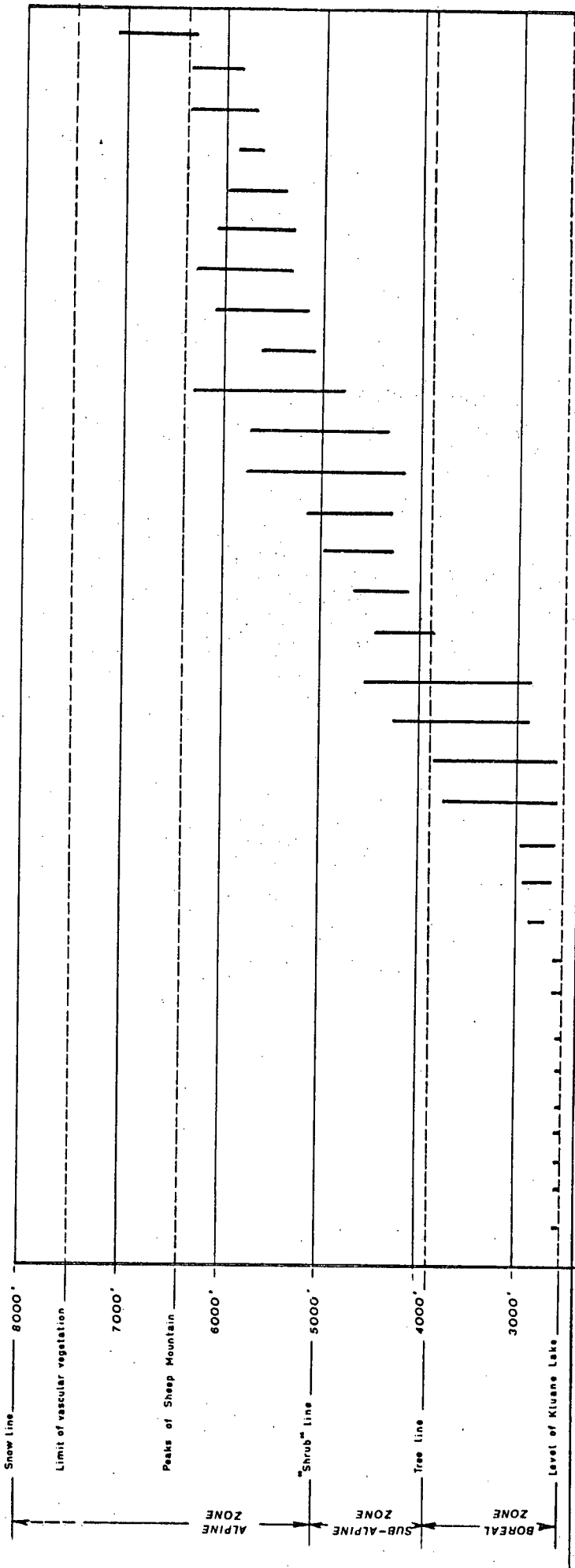
## DISCUSSION

Even though no detailed analyses of soils were carried out for this study and habitat descriptions are therefore somewhat incomplete, the habitats occupied by the various associations described can be largely distinquished on the basis of altitude (Figure 31), soil moisture during the growing season (Figure 32), duration and depth of snow cover (Figure 33), and to a lesser degree on the basis of aspect, steepness of slope, and type of substrate.

The vegetation cover of Sheep Mountain is still youthful in an evolutionary sense, even though great differences in age exist between the various biogeoclimatic zones. The last Ice sheet (Kluane glaciation) began to retreat only 12500 to 9780 years B.P., however it only reached an altitude of 2900 to 3530 feet in the study area, which means that the subalpine as well as the alpine zones extended above the ice sheet as a nunatak. The Icefield glaciation which ended about 37700 years B.P. covered Sheep Mountain to an elevation of about 5000 feet, leaving the alpine zone unglaciated. The entire mountain was covered last during the Shakwak glaciation more than 49000 years ago. This indicates that the alpine associations and, to a lesser degree, the subalpine ones have had a much longer time to develop compared to those of the boreal zones, and it will in part explain the greater species diversity encountered with increasing altitudes.

The youngest associations of the study area are those of the Slims River floodplain, and in no other area is succession more obvious. According to Bostock (1952) the Slims River is extending its delta

FIGURE: 31 Altitudinal range of plant associations




26 Agropyretum violacei

24 Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati

25 Oxytropo (huddelsonii) - Salicetum dodgeanae

32 Saxifrago (hirculi) - Caricetum membranaceae

29 Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris

28 Salicetum barrattianae

30 Seneciono (lugentis) - Salicetum polaris - reticulatae

27 Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae

31 Oxyrio (digynae) - Artemisietum arcticae - tilesii

22 Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae

23 Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae

17 Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum filifoliae

20 Artemisietum alaskanae

21 Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae

18 Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae

19 Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - lanatae - glaucae

16 Agropyro (yukonensis) - Artemisietum frigidae - rupestris

14 Artemisio (frigidae) - Agropyro (yukonensis) - Eurotietum lanatae

12 Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae

10 Roso (acicularis) - Shepherdio (canadensis) - Populetum tremuloidis

11 Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi

13 Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis

15 Pentstemono (gormanii) - Artemisietum frigidae

9 Dryadetum drummondii

7 Astero (yukonensis) - Junco (arctici) - Salicetum brachycarpae

1 Puccinellio (deschampsioidis) - Taraxacetum laceri

2 Astero (yukonensis) - Hordeo (jubati) - Puccinellii deschampsioidis

3 Hordeo (jubati) - Asteretum yukonensis

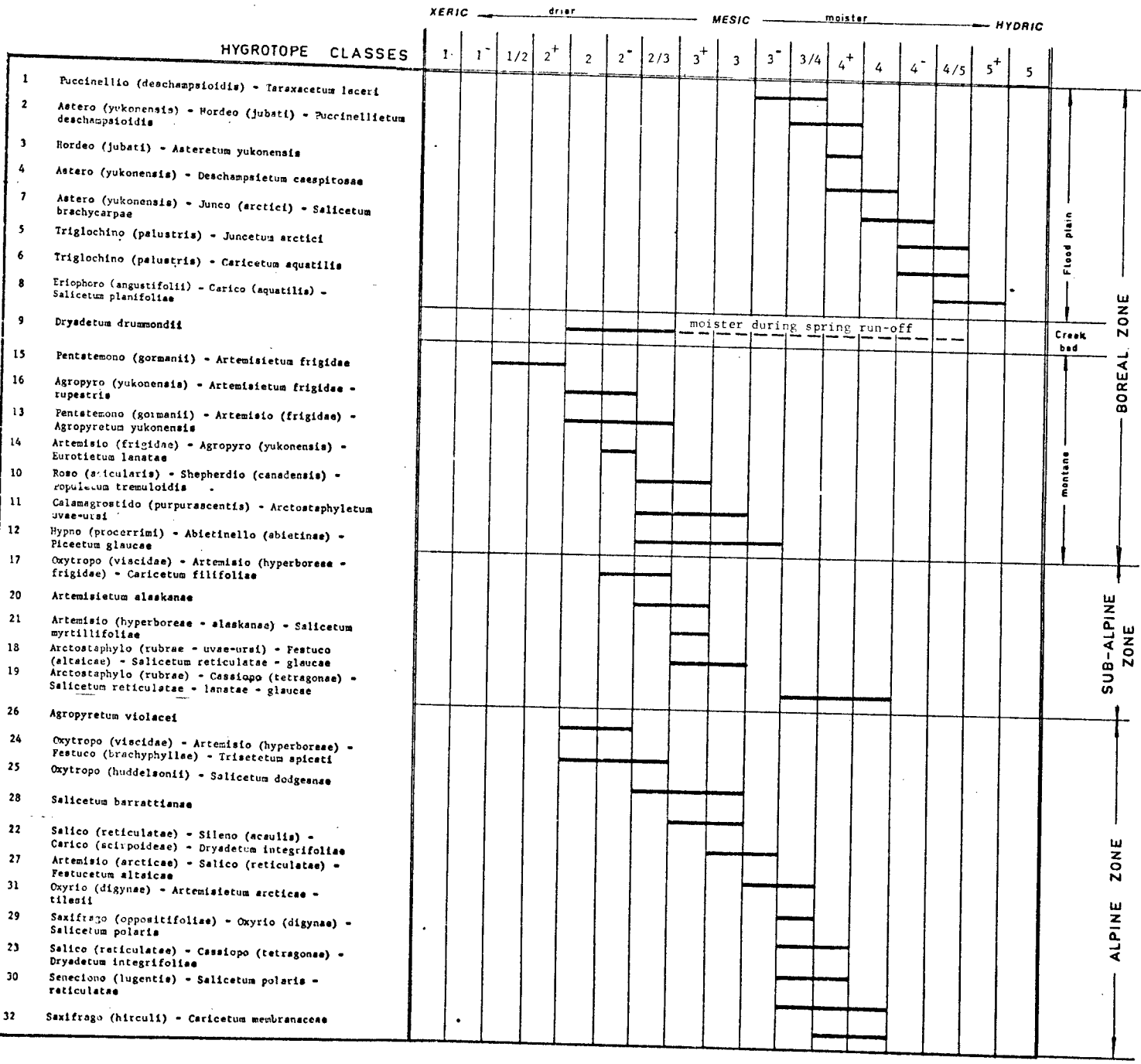
4 Astero (yukonensis) - Deschampsietum caespitosae

5 Triglochino (palustris) - Juncetum arctici

6 Triglochino (palustris) - Caricetum aquatilis

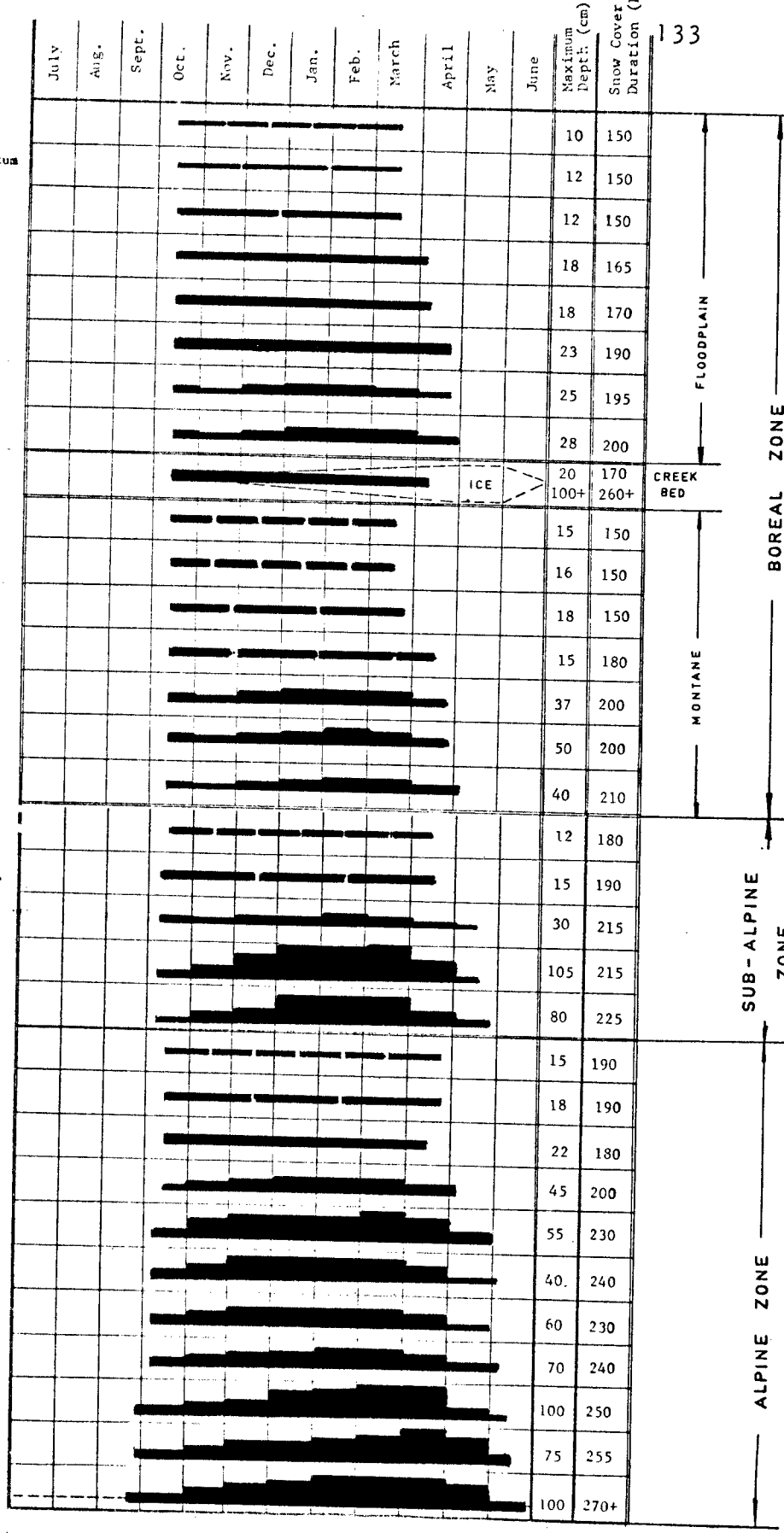
8 Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae

FIGURE 32 Soil moisture characteristics of plant associations



# FIGURE: 33 Duration of snow cover and depth






## Associations

1 Puccinellio (deschampsioidis) - Taraxacetum laceri

2 Astero (yukonensis) - Hordeo (jubati) - Puccinellietum deschampsioidis

3 Hordeo (jubati) - Asteretum yukonensis

4 Astero (yukonensis) - Deschampsietum caespitosae

5 Triglochino (palustris) - Juncetum arctici

7 Astero (yukonensis) - Junco (arctici) - Salicetum brachycarpae

6 Triglochino (palustris) - Caricetum aquatilis

8 Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae

9 Dryadetum drummondii

15 Pentstemono (gormanii) - Artemisietum frigidae

13 Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis

14 Artemisio (frigidae) - Agropyro (yukonensis) - Eurotietum lanatae

16 Agropyro (yukonensis) - Artemisietum frigidae - rupestris

11 Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi

10 Roso (acicularis) - Shepherdio (canadensis) - Populetum tremuloidis

12 Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae

17 Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum fillifoliae

20 Artemisietum alaskanae

21 Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae

18 Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae

19 Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - laratae - glaucae

24 Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati

25 Oxytropo (huddelsonii) - Salicetum dodgeanae

26 Agropyretum violacei

22 Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae

27 Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae

28 Salicetum barrattianae

30 Seneciono (lugentis) - Salicetum polaris - reticulatae

31 Oxyrio (digynae) - Artemisietum arcticae - tilesii

23 Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae

32 Saxifrago (hirculi) - Caricetum membranaceae

29 Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris

at an average rate of 160 to 240 feet/year, which means that the majority of plot locations analysed were as recently as 100 years ago under the waters of Kluane Lake.

The soils of the various associations described for the Slims River floodplain are water saturated and often inundated during spring and early summer; however during late summer and fall a very distinct moisture gradient can be observed between them (Figure 32). All four associations of the order PUCCINELLIO - SALICORNIETALIA show various degrees of desiccation, Puccinellio (deschampsioides) - Taraxacetum laceri occupying the driest elevations while Astero (yukonensis) - Deschampsietum caespitosae the moistest sites. The habitats occupied by this order are gradually invaded by Populus balsamifera.

The soils of the other two orders in the Slims River floodplain - CARICETALIA AQUATILIS and SALICETALIA PLANIFOLIAE - are water saturated throughout the growing season, in particular those of Triglochino (palustris) - Caricetum aquatilis and Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae are usually inundated. Triglochino (palustris) - Juncetum arctici is invaded by Salix brachycarpa and develops into Astero (yukonensis) - Junco (arctici) - Salicetum brachycarpae, while Triglochino (palustris) - Caricetum aquatilis is succeeded by Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae. Both of these willow associations develop into the climax white spruce forest of the area.

Dryadetum drummondii is distinct from all other associations by species composition and habitat, being the pioneer association occupying the

gravel substrate of creek beds. Similar to some of the floodplain communities it is exposed to great variation in soil moisture over the growing season. Often inundated during spring run-off, by late summer its substrate approaches the aridity of the grasslands. This association is invaded by Shepherdia canadensis, Populus balsamifera, Picea glauca, or Salix glauca. In the boreal zone it usually develops into poplar forest and in the subalpine zone into willow - birch associations.

The environments of the four orders of the boreal (montane) zone of Sheep Mountain can be differentiated according to soil moisture, snow cover and duration, as well as to aspect and slope. At the one extreme is the mesic climax association Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae having a soil moisture characteristic of 2/3 to 3 - (hygrotope units), a maximum snow cover of about 40 cm, a duration of snow cover of about 210 days, and occupying primarily level sites, or declining slopes with eastern and northern exposures; at the other extreme is the driest of the grassland associations, Pentstemono (gormanii) - Artemisietum frigidae, with a soil moisture classification of 1/2 to 2+ (hygrotope units), an intermittent snow cover of a maximum depth of 15 cm and a duration of only 150 days, occupying very steep, south-facing slopes with a heavy loess deposit and rapid sub-surface run-off. The other associations occupy intermediate sites as is obvious from Figures 32 and 33. On the other hand, it is difficult to separate the habitats of the various grassland associations in the order ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS. They are very similar in soil moisture and snow cover characteristics as well as aspects and slope.

Some separation is possible on the basis of altitude. Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum filifoliae is a subalpine association which ranges into the alpine zone (Figure 31) while the other associations in this order are more or less confined to the boreal zone. Agropyro (yukonensis) - Artemisietum frigidae - rupestris was separated into two variants. Our observations indicate that these two variants occupy different substrates. Variant caricosum filifoliae occupies sites with an average inclination of 27° and a substrate where coarse fragments make up less than 50%, variant agropyro - artemisiosum frigidae - rupestris occupies sites with an average slope of 37° and a substrate where the coarse fragments make up to 80%, as is found under eroding cliffs.

Pentstemono (gormanii) - Artemisietum frigidae is confined to the 2700 to 2900 feet elevation, where it occupies extremely steep (28° to 45°), south-facing slopes. This association is the only grassland community which is not utilized by Dall sheep, because it is restricted to very low elevations and is cut off from escape terrain by large tracts of forest. It is distinct from the other grassland association by a complete cover of crustose lichens. This lichen cover is very delicate and is easily destroyed when walking over it. This is the reason why it is found only in rudimentary form in grasslands utilized by sheep.

While it is not possible to separate the environments of the various grassland associations by means of the few physical factors investigated, there can be no doubt that some of the differences observed

in floristic composition as well as species significance will be due to differential grazing by sheep.

Observations by the writer (present study and Hoefs, 1974) reveal that Agropyron yukonense, Poa glauca, and to a lesser degree Eurotia lanata and Pentstemon gormanii are preferred by sheep to Artemisia frigida, Artemisia rupestris, and Calamagrostis purpurascens, if a choice is possible. The presence of up to 200 sheep on the mountain during the winter months, a grazing intensity which according to our research has been maintained since the mid 1950's, will have restricted the distribution of preferred species and enhanced that of those species which are less well liked. The sheep's selection will in part explain the rather spotty occurrence of such preferred species as Poa glauca and Eurotia lanata and the fact that Agropyron yukonense and Pentstemon gormanii are most abundant at sites where grazing pressure is insignificant. On the other hand, it will also be a factor in explaining the predominance of Artemisia frigida which is more resistant to grazing and that of Artemisia rupestris which is largely avoided.

Succession would normally proceed from one of the grassland associations of the order ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS via Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi to Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae. At certain sites Roso (acicularis) - Shepherdio (canadensis) - Populetum tremuloidis serves as an intermediate successional stage before the white spruce climax vegetation is introduced. There are also a few sites (map sections D 2 and D4) where Populus tremuloides

may directly invade grasslands of the order ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS. While such spread of Roso (acicularis) - Shepherdio (canadensis) - Populetum tremuloidis has been observed in a number of locations, as well as the invasion by Calamogrostido (purpurascentis) - Arctostaphyletum uvae-ursi of dry grasslands of the order ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS, the white spruce forest [Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae] appears to be in balance with the existing environmental conditions and no spread of it into surrounding associations could be documented. Comparisons of old photographs taken of Sheep Mountain (Auer, 1917; Porsild, 1966) also supports our observations that the present distribution of white spruce forest is rather "stagnant" and has been for the past 60 years. This observation does not include the spread of spruce forest onto the Slims River floodplain.

Disturbed sites in the spruce forest, as for instance road cuts or telephone lines, are first invaded by willows and poplar. On disturbed grassland areas Artemisia frigida as well as Artemisia dracunculus become established first, than follow Erigeron caespitosus, Linum perenne, Lappula myosotis and Chamaerhodos erecta; after more than 30 years only a few plants of Agropyron yukonense and Poa glauca have made a comeback, and neither Carex filifolia nor any of the crustose lichen species characteristic of dry grasslands have reappeared.

In the alpine and subalpine biogeoclimate zones duration of snow cover and depth are much more important environmental factors characterizing habitats of various associations than in the boreal

zone (Figure 33). Snow cover increases with altitude and redistribution of snow by winds is much more important above tree line where wind velocities reach much greater magnitudes.

The habitats of the two predominant willow associations of the subalpine biogeoclimate zone can be easily distinquished. Arctostaphylo (rubrae-uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae occupies almost exclusively southern and western aspects of mesic sites (3+ to 3 hygrotope units), while Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - lanatae - glaucae is restricted to northern and northeastern aspects with fairly moist substrates (3/4 to 4 hygrotope units). A third willow association of the subalpine zone, Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae is restricted in the study area to the 4300 to 5000 feet elevations and is a pioneer community invading coarse, unstable scree slopes.

Three "scree slope associations" have been described for the study area. Sites directly under eroding cliffs, where the scree material retained is relatively fine, are occupied by Agropyretum violacei. Such locations are limited to altitudes of the alpine zone. Further down along such scree slopes, where coarse material accumulates and the rather steep angle of the scree slopes begins to level off, is found the above mentioned willow association Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae. Because of the coarse substrate, more level ground, and shrubby vegetation the sites occupied by these willow stands retain more snow and are more moist during the entire growing season due to seepage water from above. The third scree slope association described is Artemisietum alaskanae

which occupies fairly dry ridges of stabilized, old scree. The substrate consist of relatively fine-grained, weathered scree - material, often mixed with considerable amounts of wind-blown loess.

The majority of scree slopes in the study area are on fairly dry, wind-swept, south and southeast facing slopes and the associations found on them will for the most part gradually develop into dry grassland associations of the types Oxytropo (viscidae) - Artemisio (hyperboreae-frigidae) - Caricetum filifoliae (in the subalpine zone) or Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati (in the alpine zone).

The habitats of the various associations described for the alpine biogeoclimatic zone can be arranged according to a distinct soil moisture gradient (Figure 32) as well as to one of snow depth and duration (Figure 33). However, it is difficult to separate the environments of closely related associations on the basis of the few environmental factors analysed, and more work, particularly with respect to soil characteristics, is necessary.

The habitats of the two associations of the order OXYTROPO (VISCIDAE) - ARTEMISIO (HYPERBOREAE) - FESTUCO (BRACHYPHYLLAE) - TRISETETALIA SPICATI, at the dry extreme of the moisture and snow gradients, can be separated on the basis of aspect, snow cover, and exposure to wind.

Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati is a continuation into the alpine zone of the grassland associations of the order ARTEMISIO (FRIGIDAE) - AGROPHYRETALIA YUKONENSIS of the boreal and subalpine zones, in particular the association Oxytropo (viscidae) - Artemisio

(hyperboreae - frigidae) - Caricetum filifoliae, with which it shares a number of species (Tables 27 and 20). It occupies primarily south and west facing exposed slopes, on which the snow cover is low and intermittent because of frequent strong winds from the west. On the other hand, the closely related Oxytropo (huddelsonii) - Salicetum dodgeanae also occupies fairly dry ridge tops, but these have northern and northeastern aspects and receive less sunshine and wind. The substrate is considerably moister during the growing season.

The two closely related associations of the order DRYADETALIA INTEGRIDOLIAE have distinctly different habitats with respect to aspect, snow depth and duration. Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae is the predominant association in the alpine zone on mesic sites. The maximum depth of snow cover does not exceed 45 cm and the duration of snow cover is on the average 200 days. This association occupies sites with a great range of slope inclination and exposure, but usually not north facing slopes. The closely related Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae on the other hand, is almost exclusively restricted to north facing slope which have a deeper snow cover in winter, a longer duration of snow cover (Figure 33) and therefore a shorter growing season, as well as moister soil conditions than the previous association. The sites occupied by this association closely resemble that of the "snow bed community" Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris, but differ from it by having a longer growing season, a deeper soil with a much lower percentage of coarse

material and better drained conditions during the growing season.

Two other alpine associations which are very closely related in species composition and often join to form large transitional zones are Salicetum barrattianae and Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae.

Along an altitudinal gradient, the latter association is usually found below the former, having a deeper soil with a smaller percentage of coarse material, and more favourable moisture conditions during the growing season because of more seepage from above. Our observations lead us to assume that the soils under Festuca altaica grasslands are probably the most fertile of any of the alpine associations described, and the productivity and standing crop of the association appears to be higher than those on any other alpine site.

The habitats of the two associations of the order SALICETALIA POLARIS differ with respect to snow depth and duration of cover, which in turn are primarily determined by aspect.

Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris occupies primarily typical "snow bed sites" on north facing slopes. Snow depths of up to 100 cm have been measured and the duration of snow cover is at least 270 days, and may in certain sites and during certain cool summers extend throughout the year. It is the association with the shortest growing season. Seneciono (lugentis) - Salicetum polaris - reticulatae grows on flat sites or gentle slopes with exposure other than north facing, the maximum snow depth observed did not exceed 60 cm, and the period of snow cover did not extend

beyond 230 days.

The two associations of the order PETASITETALIA FRIGIDI grow in alpine depressions along creeks. While similar in snow depth and period of cover, their habitats differ considerably with respect to slope, drainage and soil characteristics. Saxifrago (hirculi) - Caricetum membranaceae is an alpine marsh community, occupying flat or gently sloping depressions on a soil water saturated throughout the growing season, being of an anmoor humus type.

Oxyrio (digynae) - Artemisietum arcticae - tilesii grows on fairly steep stream banks, which are well drained during the growing season. The soil is deep, dark and fertile and resembles that of Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae.

SUGGESTIONS FOR FURTHER SYNECOLOGICAL WORK

Even though Sheep Mountain supports representative samples of the various plant associations utilized by Dall sheep in the central portion of the Kluane Game Sanctuary, it is not representative of all plant associations encountered in the area.

For reasons of physiography and local climate mentioned earlier Sheep Mountain is very dry which has brought about a predominance of grasslands and other "dryland" vegetation. The proportion of such dryland associations to others occupying mesic or moist sites is much higher on Sheep Mountain than on any of the surrounding mountains, and this no doubt is an important factor in accounting for the high number of sheep supported on the mountain during winter.

Two other physiographic characteristics of Sheep Mountain eliminate certain plant associations encountered in surrounding areas. Firstly, its peaks only reach an altitude of about 6400 feet, while the altitudinal limits of vascular plants in the area is between 7000 feet and 7500 feet, and that of lichens between 8000 feet and 8500 feet. In particular several lichen communities have been observed at high elevations which were not described in this study. Secondly, the north slope of Sheep Mountain is essentially restricted to the alpine biogeoclimatic zone. Both, the shrub associations of the sub-alpine zone as well as the forests of the boreal zone on north facing slopes vary considerably from those described in this study. In particular Alnus crispa is an important element of associations on northern aspects, but it has not been encountered in any of the associations described in this study. It requires a good protection of snow against severe winter which is more easily obtainable on northern aspects.

A number of other associations have been observed in surrounding areas but were not found on the study area. Starting at the north end of Kluane Lake there are forest associations in which Picea mariana and Betula papyrifera are important elements. Large tracts of shoreline of Kluane Lake are occupied by almost pure stands of Hedysarum mackenzii. Along the Slims River valley are certain marshy areas in which Equisetum palustre and Eriophorum angustifolium are predominant. A grassland association of only sporadic occurrence on Sheep Mountain is dominated by Plantago canescens.

Kluane Lake as well as the ponds of the Slims River valley have

associations of submerged vegetation, which were not investigated.

Lastly, all associations described for the study area are of a size "useful" to sheep. This means they had to occupy an area of the pre-determined plot size of 10 meters by 10 meters or 5 meters by 20 meters. "Miniature" associations, as for instance the lichen communities of a rotten tree trunk or a "micro ecosystem" around a spring were not dealt with in this study.

## SUMMARY

1) The study area - Sheep Mountain - is located near the centre of the newly-proposed Kluane National Park, southwest Yukon Territory, where the Slims River enters Kluane Lake. It constitutes the winter range of a herd of up to 200 Dall sheep.

2) The boundaries of the area mapped are Kluane Lake in the east, Slims River in the south, Sheep Creek in the west, and the depression between Sheep Mountain and adjacent Mount Wallace in the north. The western portion of the depression is occupied by a small creek called "Fortyeight Pup", and the eastern portion is occupied by a smaller unnamed creek.

3) The area mapped is on the average 4 miles long and 2.2 miles wide and occupies approximately 9.3 square miles map surface or about 11 square miles if slope is taken into consideration. The average level of Kluane Lake is 2563 feet above sea level, while the peaks of Sheep Mountain are at an elevation of about 6400 feet, giving the peaks a height of about 3800 feet above

the valley floor.

4) Sheep Mountain is one of the mountains of the Kluane Range, which is part of the St. Elias Mountains. Its bedrock formations are of Triassic, Permian, Cretaceous and Tertiary ages. Four glaciations covering Sheep Mountain to varying degrees have been documented. The Shakwak Glaciation retreated prior to 49000 B.P., the Icefield Glaciation ended about 37700 B.P., the Kluane Glaciation ended between 12500 to 9780 B.P. and the Neoglaciation is current.

5) Most soils of Sheep Mountain belong to the Regosol order. Almost all soils are affected by continuing loess depositions, even though the magnitude of this decreases with increasing altitudes. Some wetland soils of the Slims River floodplain as well as of alpine depressions show characteristics of gleysols, while the mesic alpine zonal associations grow on Rendzina soils. Most soils in the study area are alkaline, while those of a few moist sites with northern aspects approach neutrality.

6) The climate of the study area is continental and semi-arid. Under the Köppen classification of climates of the earth the boreal as well as the subalpine zones of Sheep Mountain would fall into the Dfc (sub-arctic) category, while the alpine zone experiences an ET (tundra) climate.

The mean annual temperature is around 25°F, while the total annual precipitation is around 10 inches or less.

7) The geographic location of Sheep Mountain, the areas of low relief surrounding it, and the presence of Kluane Lake have brought about some modification of the regional climate. These include moderation of temperatures, strong west winds and a high degree of exposure to direct sunshine, which bring about increased evapotranspiration rates and increased aridity during the growing season.

8) Three biogeoclimatic zones are distinquished in the study area. i) The boreal (montane) zone from the lowest elevations of the valley floor to an altitude of about 3800 feet. ii) The subalpine zone between 3800 and 5000 feet altitudes, and iii) The alpine zone above the 5000 feet elevation.

9) A total of 32 plant associations are described and grouped into 23 alliances and 17 orders; the great majority are restricted in distribution to one of the three biogeoclimatic zones.

10) The distribution of the majority of associations could be correlated to distinct environmental gradients with respect to snow depth and duration of snow cover, soil moisture during the growing season, aspect, slope and some physical characteristics of the soils.

11) Eight associations, grouped into 5 alliances and 3 orders, have been described for the Slims River floodplain. This substrate is only 100 years old or even younger, and the

associations occupying it are pioneer and successional.

12) The climax vegetation on mesic zonal sites of the boreal zone is the white spruce forest. Dry sites are occupied by various grassland (steppe) associations. Poplar stands or associations dominated by bearberry (Arctostaphylos uva-ursi) occupy intermediate locations. This vegetation cover appears to be "in balance" with existing environmental conditions and very little succession could be documented. In particular the distribution of spruce forest is stable and has been for at least the past 60 years.

13) The climax vegetation of the subalpine biogeoclimatic zone of mesic sites are birch - willow shrub associations. As in the boreal zone, dry sites are occupied by grassland associations. Succession in this zone is limited to the colonization of scree slopes. Even though white spruce may become established at the lower levels of the subalpine zone, the trees observed are not vigorous and are of the "Krummholz" type.

14) Eleven associations are described for the alpine biogeoclimatic zone, making up 10 alliances and 7 orders. Their habitats cover a wide range of soil moisture and snow cover characteristics. Associations occupying mesic sites are dominated by mountain avens (Dryas integrifolia). As in the subalpine zone the present distribution of the various associations appears to be stable and succession was only observed on scree slopes.

LITERATURE CITED

Bakewell, A. (1943). Botanical collections at the Wood Yukon expeditions of 1939-41. Rhodora 45:305-316.

Banfield, A.W.F. (1974). The Mammals of Canada. University of Toronto Press.

Barrett, P.E. and V.J. Krajina in Barrett (1972). Phytogeocoenoses of a coastal lowland ecosystem, Devon Island, N.W.T. Ph. D. Thesis, Dept. of Botany, University of British Columbia.

Becking, R.W. (1956). Die natürlichen Douglasien-Waldgesellschaften Washingtons und Oregons. Allgemeine Jagdzeitung, Band 127, Heft 213:42-56.

Becking, R.W. (1954). Site indicators and forest types of the Douglas fir region of western Washington and Oregon. Ph. D. Thesis, University of Washington, Seattle, Washington.

Borns, H.W. Jr. and R.P. Goldthwait (1966). Late Pleistocene fluctuations of the Kaskawulsh Glacier, southwestern Yukon Territory, Canada. Amer. J. Science 264:600-619.

Bostock, H.S. (1969). Kluane Lake, Yukon Territory, its drainage and allied problems. Geological Survey of Canada, Paper 69-28.

Bostock, H.S. (1952). Geology of northwest Shakwak Valley, Yukon Territory. Geological Survey of Canada, Mem. 267.

Bostock, H.S. (1948). Physiography of the Canadian Cordillera, with special reference to the area north of the fifty-fifth parallel. Geological Survey of Canada, Mem 247.

Braun-Blanquet, J. (1951). Pflanzensoziologie. 2. Auflage, Wien.

Braun-Blanquet, J. and W.C. de Leeuw (1936). Vegetationskizze von Ameland. Comm. S.I.G.M.A. 50. Nederl. Kruidk. Arch. 46.

Brooke, R.C. (1966). Vegetation - environment relationships of Subalpine Mountain Hemlock Zone ecosystems. Ph. D. Thesis, Dep. of Botany, University of British Columbia.

Brooke, R.C., Peterson, and V.J. Krajina (1970). The Subalpine Mountain Hemlock Zone. Ecol. of Western North America 2(2):148-349.

Capps, S.R. (1915). An ancient volcanic eruption in the upper Yukon basin. U.S. Geol. Survey, Prof. Paper 95:59-64.

Dahl, E. (1956). Rondane; Mountain vegetation in south Norway and its relation to the environment. Norske Vidensk. - Akad. Oslo, Mat. - Naturv. Kl., Skr. 1956 (3):1-374.

Day, J.H. (1962). Reconnaissance soil survey of the Takhini and Dezadeash valleys in the Yukon Territory. Research Branch, Canada Dept. of Agriculture. 1 - 78.

Deevey, E.S. and R.F. Flint (1957). Postglacial hypsithermal interval. Science 125:182-184.

Denton, G.H. and M. Stuiver (1966). Neoglacial Chronology, Northeastern St. Elias Mountains, Canada. Amer. J. Science 264:577-599.

Denton, G.H. and M. Stuiver (1967). Late Pleistocene Glacial Stratigraphy and Chronology, Northeastern St. Elias Mountains. Geol. Soc. of America Bull. 78:485-510.

Drees, E.M. (1953). A tentative design for rules of phytosociological nomenclature. Vegetatio 4:205-214.

Drury, W.H. Jr. (1953). Birds of the St. Elias Quadrangle in the south-western Yukon Territory. Can. Field Nat. 67:103-128.

Fahnestock, R.K. (1969). Morphology of the Slims River. In Bushnell, V.C. and R.H. Ragle (eds.) Icefield Ranges Research Project Scientific Results, Vol. 1:161-172. Published jointly by American Geographical Society and Arctic Institute of North America.

Godfrey, W.E. (1966). The Bird of Canada, Bulletin No. 203. National Museum of Canada.

Hansen, H.P. (1953). Postglacial forests in the Yukon Territory and Alaska. Amer. J. Science 251:505-542.

Hoefs, M. (1973). Birds of the Kluane Game Sanctuary, Yukon Territory, and adjacent areas. Can. Field Nat. 87(4):345-355.

Hoefs, M. (1974). Food selection by Dall sheep. In Geist, V. (ed.) The behaviour of ungulates and its relation to management. International Union for conservation of nature and natural resources, Morges, Switzerland. Vol. II:759-786.

Hoefs, M. and J.W. Thomson (1972). Lichens from the Kluane Game Sanctuary, S.W. Yukon Territory. Can. Field Nat. 86(3):249-252.

Hulten, E. (1940). History of botanical exploration in Alaska and Yukon Territory from the time of their discovery to 1940. Botaniska Notiser 1940:289-346.

Hulten, E. (1968). Flora of Alaska and neighbouring Territories. Stanford University Press, Stanford, California. PP. 1-1008.

Johnson, F. and H.M. Raup (1964). Investigations in Southwest Yukon. Geobotanical, Archaeological Reconnaissance. Papers of the Robert S. Peabody Foundation for Archaeology, vol. 6,1.

Kendrew, W.G. and D. Kerr (1955). The climate of British Columbia and the Yukon Territory. Queens Printer, Ottawa.

Kindle, E.D. (1953). Dezadeash Map - Area, Yukon Territory. Geological Survey of Canada, Mem.268:1-68.

Krajina, V.J. (1933). Die Pflanzen gesellschaften des Megnica Tales in den Vysoke Tatry (Hohe Tatra), mit besonderer Berücksichtigung der ökologischer Verhältnisse. Bot. Zentralblatt, Beiheft, Abt. 2. 50:744-957; 51:1-244.

Krajina, V.J. (1965). Biogeoclimatic Zones and Classification of British Columbia. Ecol. of Western North America 1:1-17.

Krajina, V.J. (1969). Ecology of forest trees in British Columbia. Ecol. of Western North America 2(1):1-146.

Krajina, V.J. (1974). Some observations on the three subalpine biogeoclimatic zones in British Columbia, Yukon and Mackenzie District. Phytologia (accepted for publication).

Küchler, A.W. (1967). Vegetation Mapping. The Ronald Press Company, New York. Pages 1-472.

Lambert, J.D.H. and V.J. Krajina (1968) in Lambert, J.D.H. (1968). The

ecology and successional trends of tundra plant communities in the low arctic subalpine zone of the Richardson and British Mountains of the Canadian Western Arctic. Ph. D. Thesis, Dept. of Botany, University of British Columbia.

Löve, D. and N.J. Freedman (1956). A plant collection from S.W. Yukon. Botaniska Notiser 109:153-211.

Lutz, H.J. (1956). Ecological effects of forest fires in the interior of Alaska. U.S. Dept. of Agriculture, Tech. Bull. 1133.

Miller, O.K. Jr. (1968). Interesting Fungi of the St. Elias Mountains, Yukon Territory, and adjacent Alaska. Mycologia 60:1190-1203.

Miller, O.K. Jr. (1969). Notes on Gastromycetes of the Yukon Territory and adjacent Alaska. Can. J. Botan. 47:247-250.

Miller, O.K. Jr. and R.L. Gilbertson (1969). Notes on Homobasidiomycetes from northern Canada and Alaska. Mycologia 61:840-844.

Muller, J.E. (1958). Tectonics of the Shakwak lineament, southwest Yukon and eastern Alaska. Geol. Soc. America Bull. 69:1619-20.

Muller, J.E. (1967). Kluane Lake Map - Area, Yukon Territory. Geological Survey of Canada, Mem. 340:1-137.

Murray, D.F. (1965). Ecological studies on a nunatak in the Kaskawulsh Glacier, Yukon Territory. Final report to the Arctic Institute of North America for Grant I.R.R.P.-95. (Unpubl. M.S.).

Murray, D.F. (1968). A plant collection from the Wrangell Mountains, Alaska. Arctic 21(2):106-109.

Murray, D.F. (1971a). Comments of the flora of the Steele Glacier region, Yukon Territory. In Fisher, M. (ed.) Expedition Yukon. Thomas Nelson and Sons (Canada) Ltd. Don Mills. Pages 178-181.

Murray, D.F. (1971b). Notes on the alpine flora of the St. Elias Mountains. Arctic 24(4):301-304.

Neilson, J.A. (1968). New and important Additions to the Flora of the southwestern Yukon Territory, Canada. Can. Field Nat. 82:114-119.

Neilson, J.A. (1972). A checklist of Vascular Plants from the Icefield Ranges Research Project Area. In Bushnell, V.C. and R.H. Ragle (eds.), Icefield Ranges Research Project Scientific Results, Vol.3:221-239. Published jointly by American Geographical Society and Arctic Institute of North America.

Neuhäusl, R. (1968). Draft proposal for nomenclature principles in floristic phytosociology. Folia Geobot. Phytotax., Praha 3:47-55.

Otto, G.F. and T. Ahti (1967). Lichens of British Columbia. Dept. of Botany, University of British Columbia, M.S. (40 p. mimeo.).

Orloci, L. (1964). Vegetational and environmental variations in the ecosystems of the Coastal Hemlock Zone. Ph. D. Thesis, Dept. of Botany, University of British Columbia.

Poore, M.E.D. (1955). The use of phytosociological methods in ecological investigations. I. The Braun-Blanquet system. II. Practical issues involved in an attempt to apply the Braun-Blanquet System. III. Practical applications. J. Ecol. 43:226-244, 245-269, 606-651.

Poore, M.E.D. (1956). The use of phytosociological methods in ecological investigations. IV. General discussion of phytosociological problems. J. Ecol. 44:28-50.

Poore, M.E.D. (1962). The method of successive approximation in descriptive ecology. Adv. Ecol. Res. 1:35-68.

Porsild, A.E. (1939). Contribution to the flora of Alaska. Rhodora 41, 1939:141-183, 199-254, 262-301.

Porsild, A.E. (1966). Contributions to the flora of southwestern Yukon Territory. National Museum of Canada, Bull. 216:1-86.

Price, L.W. (1971). Vegetation, microtopography, and depth of active layer on different exposures in subarctic alpine tundra. Ecol. 52(4):638-647.

Rampton, V. (1971). Late Quaternary Vegetational and Climatic History of the Snag - Klutlan Area, Southwest Yukon Territory, Canada. Geol. Soc. America Bull. 82:959-978.

Raup, H.M. (1944). Expedition to the Alaska Military Highway. Arnoldia 4:65-72.

Schofield, W.B. (1969a). A checklist of Hepaticae and Anthocerotae of British Columbia. Syesis 1(1968):157-162.

Schofield, W.B. (1969b). A selectively annotated checklist of British Columbia mosses. Syesis 1(1968):163-175.

Scott, R.W. (1968). Vascular plants of the Chitistone Pass area, Alaska. Tech. Report No. 2, High Mountain environment project, Arctic Institute

of North America, PP. 1-18.

Smith, C.C. and M.M. Thomson (1958). Standard time and time zones in Canada. J. Royal Astron. Soc. Canada 52:193-223.

Stuiver, M., Borns, H.W. and G.H. Denton (1964). Age of a widespread layer of volcanic ash in the southwestern Yukon Territory. Arctic 17:259-260.

Taylor-Barge, B. (1969). The summer climate of the St. Elias Mountain Region. Arctic Institute of North America, Res. Paper No. 53:1-265.

Trewartha, G.T. (1943). An introduction to weather and climate. McGraw - Hill Book Company, New York, PP. 1-543.

Wheeler, J.O. (1963). Kaskawulsh Map - Area, Yukon Territory. Geological Survey of Canada, Map 1134 A.

# APPENDIXES

Synthesis tables of orders and their lower units

List of vascular plants

List of lichens

List of mosses and hepaticae

Standard ecological forms

Condensed table of floristic structure of plant associations and their higher units

Vegetation map of Sheep Mountain

Table 36.

Order: 1. PUCCINELLIO - SALICORNIETALIA

Alliance: 1. Puccinellion deschampsioidis | 2. Deschampsion caespitosae

Association: 1. Puccinellio (deschampsioidis) - Taraxacetum laceri | 2. Astero (yukonensis) - Hordeo (jubati) - Puccinellietum deschampsioidis | 3. Hordeo (jubati) - Asteretum yukonensis | 4. Astero (yukonensis) - Deschampsietum caespitosae

| Plot number | 85 | 86 | 90 | 401 | 402 | 88 | 89 | 94 | 97 | 98 | 82 | 84 | 87 | 102 | 400 | 81 | 83 | 93 | 95 | 99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hygrotope | 3- | 3- | 3/4 | 3- | 3- | 4+ | 4+ | 3/4 | 3/4 | 4+ | 4+ | 4+ | 4+ | 4+ | 4+ | 4 | 4+ | 4 | 4 | 4 |
| Order 1 & alliance 1 charac. species: | | | | | | | | | | | | | | | | | | | | |
| *Aster yukonensis* | +.1 | +.+ | . | . | +.1 | 2.1 | 3.1 | 1.1 | 1.1 | 5.2 | 5.1 | 4.1 | 6.2 | 4.2 | 4.2 | 1.1 | 2.+ | 3.1 | 2.1 | 2.1 |
| *Hordeum jubatum* | . | . | . | . | . | 2.1 | 2.1 | 3.1 | 2.1 | 1.1 | 2.1 | 1.1 | 1.1 | 1.1 | 1.1 | . | . | 2.1 | . | . |
| *Puccinellia deschampsioides* | +.+ | +.1 | +.1 | +.1 | . | 6.2 | 5.1 | 7.2 | 5.2 | 2.2 | +.1 | . | 2.1 | +.1 | 1.1 | . | . | 1.1 | . | . |
| *Taraxacum lacerum* | 3.1 | 3.1 | 3.1 | 3.2 | 3.1 | +.1 | +.1 | . | . | +.1 | . | . | +.1 | . | . | . | . | . | . | . |
| Alliance 2 charac. species: | | | | | | | | | | | | | | | | | | | | |
| *Deschampsia caespitosa* | . | . | . | . | . | +.1 | . | . | . | . | +.1 | 1.1 | 2.1 | . | 1.1 | 4.1 | 5.1 | 6.2 | 5.1 | 5.2 |
| *Ranunculus cymbalaria* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | 2.1 | . | +.+ |
| Companion species: | | | | | | | | | | | | | | | | | | | | |
| *Equisetum variegatum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.+ |
| *Juncus arcticus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.1 | . |
| *Triglochin palustre* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2.+ | +.+ |

Table 37.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Order: | 2. CARICETALIA AQUATILIS | | | | | | | | | |
| Alliance: | 3. Triglochinion palustris | | | | | | | | | |
| Association: | 5. Triglochino (palustris) - Juncetum arctici | | | | | 6. Triglochino (palustris) - Caricetum aquatilis | | | | |
| Plot number | 70 | 71 | 75 | 76 | 100 | 74 | 77 | 91 | 101 | 403 |
| Hygrotope | 4- | 4- | 4- | 4/5 | 4/5 | 4/5 | 4/5 | 4- | 4- | 4/5 |
| Order & alliance charac. species: | | | | | | | | | | |
| *Calamagrostis neglecta* | 2.1 | 3.1 | 3.+ | . | . | +.+ | . | +.+ | . | +.1 |
| *Carex aquatilis* | 1.+ | +.+ | +.1 | +.+ | 1.+ | 7.6 | 7.4 | 7.3 | 6.6 | 7.4 |
| (*Juncus arcticus*) | 7.5 | 7.5 | 6.5 | 6.3 | 5.1 | . | +.1 | . | . | . |
| *Triglochin palustre* | 3.1 | +.+ | +.+ | 2.+ | 5.1 | 4.1 | +.+ | +.+ | +.+ | +.1 |
| Association 5 charac. species: | | | | | | | | | | |
| *Castilleja yukonis* | . | . | . | +.+ | . | . | . | . | . | . |
| *Lomatogonium rotatum* | 2.+ | 2.+ | 1.+ | . | . | . | . | . | . | . |
| *Primula stricta* | . | . | +.1 | . | . | . | . | . | . | . |
| Association 6 charac. species: | | | | | | | | | | |
| (*Eriophorum angustifolium*) | . | . | . | . | . | 2.+ | .- | . | +.+ | +.1 |
| (*Eriophorum brachyantherum*) | . | . | . | . | . | . | . | +.+ | . | . |
| Companion species: | | | | | | | | | | |
| (B) *Salix brachycarpa* | . | . | +.+ | +.2 | . | . | . | . | . | . |
| (C) *Aster yukonensis* | +.1 | 1.1 | +.+ | 3.1 | . | . | 3.1 | . | . | . |
| *Carex parryana* | . | . | . | +.+ | . | . | +.+ | . | . | . |
| *Deschampsia caespitosa* | 2.+ | +.+ | . | 2.+ | 1.+ | . | 2.+ | . | . | . |
| *Elymus glaucus* | +.+ | . | . | . | . | . | . | . | . | . |
| *Hordeum jubatum* | 3.1 | 2.1 | 2.1 | . | . | +.+ | . | . | . | . |
| *Parnassia palustris* | . | . | 3.+ | 3.1 | . | . | 2.1 | . | . | . |
| *Pedicularis sudetica* | +.1 | . | . | . | . | . | . | . | . | . |
| *Ranunculus cymbalaria* | +.1 | 1.1 | +.1 | . | . | . | . | . | . | . |

Species in brackets are relatively less characteristic.

Table 38.

| Order: | 3. SALICETALIA PLANIFOLIAE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Alliance: | 4. Salicion brachycarpae | | | | | 5. Salicion planifoliae | | | | |
| Association: | 7. Astero (yukonensis) - Junco (arctici) - Salicetum brachycarpae | | | | | 8. Eriophoro (angustifolii) - Carico (aquatilis) - Salicetum planifoliae | | | | |
| Plot number | 79 | 80 | 105 | 108 | 113 | 73 | 78 | 104 | 109 | 115 |
| Hygrotope | 4 | 4- | 4- | 4- | 4 | 5+ | 5+ | 4/5 | 4/5 | 5+ |
| Order charac. species: | | | | | | | | | | |
| (B) *Salix brachycarpa* | 6.5 | 5.4 | 5.3 | 5.4 | 7.4 | . | 4.2 | 2.2 | . | . |
| *Salix planifolia* | . | 1.2 | 1.2 | . | +.2 | 7.5 | 5.4 | 7.7 | 7.5 | 7.5 |
| (C) *Carex hassei* | . | 1.+ | +.+ | . | . | +.+ | . | . | . | . |
| *Equisetum palustre* | 2.1 | 2.1 | 1.+ | +.1 | . | . | . | 2.1 | 3.1 | 6.4 |
| *Juncus arcticus* | 6.5 | 6.5 | 6.6 | 6.6 | 7.5 | 4.2 | . | +.+ | +.+ | +.1 |
| (*Parnassia palustris*) | 1.+ | . | 3.+ | +.1 | 2.+ | 2.+ | 2.+ | 1.+ | . | +.1 |
| (D) *Catoscopium nigritum* | 2.1 | . | 1.1 | . | 3.1 | . | +.1 | . | 2.1 | +.1 |
| *Cinclidium stygium* | . | . | 2.1 | . | +.+ | . | . | +.1 | +.1 | . |
| Alliance 4 & association 7 charac. species: | | | | | | | | | | |
| (C)(*Aster yukonensis*) | 3.1 | 1.+ | 1.+ | 2.+ | 2.+ | +.+ | . | . | . | . |
| (*Calamagrostis neglecta*) | 1.+ | 1.+ | +.+ | . | . | . | . | . | . | . |
| *Carex microglochin* | 1.+ | . | 1.+ | +.+ | 1.+ | . | . | . | . | . |
| *Carex parryana* | 2.+ | 1.+ | 3.+ | +.+ | 1.+ | . | . | . | . | . |
| (*Lomatogonium rotatum*) | +.+ | . | +.+ | . | +.+ | 2.+ | . | . | . | . |
| *Pedicularis sudetica* | +.+ | +.+ | 1.+ | +.1 | 2.+ | . | . | . | . | . |
| *Spiranthes romanzoffiana* | +.+ | +.+ | +.1 | . | . | +.1 | . | . | . | . |
| Alliance 5 & association 8 charac species: | | | | | | | | | | |
| (C)(*Carex aquatilis*) | +.+ | . | 1.1 | . | . | 5.2 | 6.5 | 7.6 | 7.6 | 2.1 |
| (*Eriophorum angustifolium*) | . | . | . | . | . | +.1 | 1.1 | 2.+ | 1.1 | +.1 |
| *Eriophorum brachyantherum* | . | . | . | . | . | . | 1.+ | . | +.+ | . |
| *Juncus alpinus* | . | . | . | . | . | . | . | 2.+ | . | . |
| (D)(*Campylium stellatum*) | . | . | . | . | . | +.1 | +.1 | +.1 | . | . |
| *Marchantia polymorpha* | . | . | . | . | . | . | +.1 | . | . | . |
| *Meesea uliginosa* | . | . | . | . | . | . | +.1 | . | . | . |
| Companion species: | | | | | | | | | | |
| (B) *Picea glauca* | . | . | . | . | +.1 | +.2 | . | . | . | . |
| *Salix myrtillifolia* | . | +.2 | . | . | . | . | . | . | . | . |
| *Salix novae-angliae* | . | . | . | . | +.2 | . | 1.2 | . | +.2 | . |
| (C) *Carex maritima* | . | +.1 | . | . | . | . | . | . | . | . |
| *Deschampsia caespitosa* | . | . | +.+ | 1.+ | . | . | . | . | . | . |
| *Equisetum variegatum* | . | . | +.1 | . | . | . | . | . | . | . |
| *Hordeum jubatum* | . | . | . | 1.+ | . | . | . | . | . | . |
| *Pyrola asarifolia* | . | +.1 | . | . | +.+ | 1.+ | . | . | . | . |
| *Ranunculus cymbalaria* | . | . | . | +.+ | . | . | . | . | . | . |
| *Tofieldia pusilla* | +.+ | . | . | . | . | . | . | . | . | . |
| *Trichophorum pumilum* | . | +.+ | . | . | . | . | . | . | . | . |
| *Triglochin palustre* | +.+ | . | 1.+ | +.+ | . | . | . | . | . | . |

Species names in brackets are relatively less characteristic.

Table 39.

Order: 4. DRYADETALIA DRUMMONDII

Alliance: 6. Dryadion drummondii

Association: 9. Dryadetum drummondii

| Plot number | 372 | 373 | 374 | 375 | 376 |
|---|---|---|---|---|---|
| Hygrotope | 2- | 2/3 | 2 | 2 | 2- |
| **Order, alliance & association charac. species:** | | | | | |
| (B) *Elaeagnus commutata* | +.1 | . | . | . | . |
| (*Populus balsamifera*) | . | +.1 | 2.2 | . | . |
| (C) *Crepis elegans* | 1.1 | 1.1 | 1.1 | 2.1 | +.1 |
| *Dryas drummondii* | 6.5 | 5.5 | 7.6 | 6.5 | 6.5 |
| (*Epilobium latifolium*) | 2.1 | +.1 | +.1 | 1.1 | +.1 |
| *Lupinus arcticus* | +.2 | 1.2 | . | +.2 | . |
| *Oxytropis campestris* | +.1 | . | 2.1 | +.1 | . |
| **Companion species:** | | | | | |
| (C) *Artemisia alaskana* | . | . | . | . | +.2 |
| *Potentilla multifida* | . | . | +.1 | . | . |

Species in brackets are relatively less characteristic.

Table 40.

Order: 5. POPULETALIA BALSAMIFERAE

Alliance: 7. Junipero (communis & horizontalis) - Shepherdio (canadensis) - Populion tremuloidis

Association: 10. Roso (acicularis) - Shepherdio (canadensis) - Populetum balsamiferae

| Plot number | 395 | 397 | 359 | 155 | 166 |
|---|---|---|---|---|---|
| Hygrotope | 3+ | 3+ | 3+ | 3+ | 2/3 |
| Order, alliance & association charac. species: | | | | | |
| (A) *Populus balsamifera* | 7.6 | 7.7 | 7.7 | 7.6 | 6.5 |
| *Populus tremuloides* | 7.6 | 7.7 | 4.5 | 4.5 | . |
| (B) *Juniperus communis* | 7.5 | 7.6 | 7.7 | 5.5 | +.2 |
| *Rosa acicularis* | 5.2 | 3.2 | 3.1 | 3.3 | 2.1 |
| *Shepherdia canadensis* | 4.3 | 6.6 | 7.6 | +.1 | 3.4 |
| *Viburnum edule* | 4.2 | 5.4 | . | 5.6 | . |
| (C)(*Arctostaphylos uva-ursi*) | +.1 | 1.2 | 4.5 | 6.6 | 5.5 |
| *Epilobium angustifolium* | +.1 | 3.1 | 2.1 | . | 1.+ |
| (*Geocaulon lividum*) | 1.1 | +.1 | 1.4 | . | . |
| *Juniperus horizontalis* | +.2 | +.1 | +.3 | 2.3 | 8.7 |
| (D)(*Hypnum procerrimum*) | +.1 | +.2 | +.1 | . | . |
| Companion species: | | | | | |
| (B) *Picea glauca* | +.2 | +.2 | . | . | . |
| *Salix glauca* | . | . | 1.5 | . | +.2 |
| (C) *Achillea borealis* | . | . | . | . | 1.+ |
| *Artemisia frigida* | . | . | . | . | +.+ |
| *Artemisia rupestris* | . | . | . | . | +.1 |
| *Linnaea borealis* | +.1 | . | +.2 | . | . |
| *Pyrola secunda* | +.1 | . | . | . | . |
| *Mertensia paniculata* | . | . | . | 2.1 | . |
| *Smilacina stellata* | . | . | . | . | 2.+ |
| (D) *Tortula ruralis* | . | . | +.1 | . | . |

Species in brackets are relatively less characteristic.

Table 41.

Order: 6. CALAMAGROSTIDO (PURPURASCENTIS) - ARCTOSTAPHYLETALIA UVAE-URSI

Alliance: 8. Calamagrostido (purpurascentis) - Arctostaphylion uvae-ursi

Association: 11. Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi

| Plot number | 11 | 2 | 373 | 13 | 201 | 7/70 | 374 | 17 | 372 | 6/70 |
|---|---|---|---|---|---|---|---|---|---|---|
| Hygrotope | 2/3 | 2/3 | 3+ | 2/3 | 2/3 | 3 | 3+ | 3 | 2/3 | 3 |
| **Order, alliance & association charac. species:** | | | | | | | | | | |
| (B)(*Juniperus communis*) | . | 4.5 | +.4 | 1.3 | . | . | +.2 | . | 1.4 | . |
| (*Rosa acicularis*) | 4.2 | +.2 | +.2 | 3.2 | 5.3 | 2.1 | 3.2 | +.1 | 3.1 | +.2 |
| (*Shepherdia canadensis*) | 3.4 | 3.4 | +.3 | 1.2 | . | . | . | +.2 | +.4 | +.4 |
| (C) *Achillea lanulosa* | 2.+ | 1.+ | 3.1 | . | 1.+ | +.1 | 1.1 | . | 2.1 | 1.1 |
| *Anemone multifida* | 3.1 | 3.1 | +.1 | 2.+ | . | . | . | +.1 | +.1 | +.1 |
| *Arctostaphylos uva-ursi* | 6.4 | 8.6 | 7.6 | 5.3 | 7.6 | 8.5 | 8.5 | 7.5 | 7.5 | 7.4 |
| *Astragalus williamsii* | 4.3 | . | 2.2 | 4.2 | . | 2.2 | 1.2 | 6.2 | 4.2 | 3.3 |
| *Bromus pumpellianus* | 5.1 | 1.1 | +.1 | 1.1 | 3.1 | . | . | . | 1.1 | . |
| *Calamagrostis purpurascens* | 5.2 | 5.2 | 8.4 | 5.2 | 3.2 | 7.5 | 6.3 | 6.2 | 7.4 | 6.5 |
| *Comandra umbellata* | . | +.+ | . | +.+ | . | . | . | . | . | . |
| *Galium boreale* | 1.1 | 1.+ | . | 1.+ | 1.+ | . | . | . | . | . |
| (*Hedysarum mackenzii*) | 5.3 | . | . | . | . | . | . | 1.2 | +.2 | . |
| (*Juniperus horizontalis*) | . | 2.3 | . | +.3 | . | . | 5.5 | 4.4 | . | . |
| (*Linum perenne*) | +.+ | +.+ | . | . | +.+ | +.+ | . | . | . | +.+ |
| *Pulsatilla patens* | 3.1 | 3.1 | 3.1 | 2.1 | 2.+ | 3.2 | 2.1 | . | 2.+ | 2.2 |
| *Smilacina stellata* | . | . | . | . | . | 1.1 | 3.1 | . | . | 3.2 |
| *Solidago decumbens* | . | 1.+ | 2.1 | 1.1 | . | 1.1 | +.1 | . | 3.1 | 1.1 |
| **Companion species:** | | | | | | | | | | |
| (B) *Picea glauca* | . | . | . | . | . | . | . | +.2 | . | . |
| *Populus balsamifera* | . | . | . | +.2 | . | . | . | . | . | +.2 |
| *Salix glauca* | . | . | . | +.2 | . | +.3 | . | . | . | . |
| (C) *Agropyron subsecundum* | . | . | . | +.+ | . | . | . | . | . | . |
| *Agropyron yukonense* | . | +.1 | . | . | 2.1 | . | . | . | . | +.+ |
| *Antennaria media* | . | +.1 | . | . | . | . | . | . | . | . |
| *Artemisia dracunculus* | . | . | +.1 | . | . | . | +.1 | . | . | . |
| *Artemisia frigida* | +.1 | . | . | +.1 | 2.1 | 2.2 | +.1 | . | . | 2.1 |
| *Aster alpinus* | +.1 | . | . | +.1 | . | . | +.1 | . | . | . |
| *Carex filifolia* | . | +.1 | . | . | . | . | . | . | . | +.1 |
| *Erigeron caespitosus* | . | +.1 | 1.+ | . | . | 1.+ | . | +.1 | +.1 | 1.+ |
| *Erysimum angustatum* | . | . | . | +.1 | . | . | . | . | . | . |
| *Mertensia paniculata* | 1.1 | . | . | . | . | . | . | . | . | . |
| *Pentstemon gormanii* | . | . | . | +.1 | +.+ | 1.1 | . | . | . | 1.1 |
| *Poa glauca* | . | . | . | +.+ | . | . | . | . | . | . |
| *Potentilla hookeriana* | . | +.1 | . | . | . | . | . | . | . | . |
| (D) *Buellia epigaea* | . | . | . | . | 2.1 | +.+ | . | . | +.1 | . |
| *Caloplaca cirrochroa* | . | . | . | . | +.1 | +.+ | . | . | +.+ | +.+ |
| *Dermatocarpon hepaticum* | . | . | . | . | 2.2 | 1.1 | . | . | 1.1 | +.1 |
| *Hypnum vaucheri* | . | . | . | 1.1 | . | 2.1 | . | . | 1.1 | 2.1 |
| *Lecidea decipiens* | . | . | . | . | +.1 | . | . | . | . | . |
| *Lecidea rubiformis* | . | . | +.1 | . | 2.2 | +.1 | . | . | +.1 | +.1 |
| *Tortula ruralis* | . | +.+ | . | . | . | . | . | . | . | +.+ |

Species in brackets are relatively less characteristic.

Table 42.

Order: 7. PICEETALIA GLAUCAE - MARIANAE

Alliance: 9. Hypno (procerrimi) - Abietinello (abietinae) - Piceion glaucae

Association: 12. Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae

| Plot number | 393 | 396 | 391 | 392 | 6 | 390 | 394 | 361 | 360 | 154 |
|---|---|---|---|---|---|---|---|---|---|---|
| Hygrotope | 3 | 3 | 3 | 3- | 2/3 | 3 | 3- | 3 | 3+ | 2/3 |
| **Order charac. species:** | | | | | | | | | | |
| (A) *Picea glauca* | 8.7 | 8.7 | 7.7 | 7.7 | 7.5 | 7.7 | 7.7 | 7.7 | 7.7 | 7.6 |
| (B)(*Rosa acicularis*) | . | . | . | . | . | . | . | . | +.1 | +.+ |
| (C)(*Anemone multifida*) | . | 1.1 | 1.1 | +.1 | . | 1.1 | 1.1 | 1.1 | . | 1.+ |
| *Carex concinna* | +.+ | 1.1 | . | 1.1 | 1.2 | . | 2.1 | +.1 | +.1 | +.+ |
| *Geocaulon lividum* | . | . | . | 2.1 | 3.3 | . | 4.3 | 3.5 | 4.5 | 2.4 |
| *Linnaea borealis* | 1.1 | +.+ | +.1 | 4.3 | 5.4 | . | 6.6 | 7.6 | 5.6 | 4.4 |
| *Pyrola secunda* | +.1 | . | +.+ | +.1 | +.+ | . | +.1 | 2.+ | +.1 | 2.1 |
| **Alliance & association charac. species:** | | | | | | | | | | |
| (B)(*Juniperus communis*) | . | . | . | . | . | . | . | 1.2 | +.3 | 3.4 |
| (*Salix glauca*) | . | . | +.5 | . | 3.4 | . | 1.3 | . | . | 3.4 |
| (*Shepherdia canadensis*) | . | . | . | . | . | . | . | . | . | 2.3 |
| (C)(*Arctostaphylos uva-ursi*) | . | . | . | . | 3.4 | . | +.2 | +.1 | +.2 | 2.4 |
| *Cypripedium passerinum* | . | . | . | +.1 | . | . | 1.1 | . | . | . |
| *Hedysarum mackenzii* | . | +.2 | +.1 | +.1 | 3.2 | +.1 | . | . | . | . |
| (*Mertensia paniculata*) | . | . | +.1 | +.1 | . | +.1 | . | +.1 | +.1 | . |
| (D) *Abietinella abietina* | 7.6 | 7.5 | 7.7 | 4.4 | 3.3 | 6.6 | 5.5 | 3.3 | 2.2 | 2.4 |
| (*Distichium capillaceum*) | 1.2 | 2.1 | 2.2 | +.1 | +.1 | +.2 | +.2 | +.2 | . | 1.2 |
| *Hypnum procerrimum* | 4.4 | 7.6 | 6.6 | 6.5 | 4.3 | 7.6 | 6.5 | 4.3 | 4.3 | 3.5 |
| *Peltigera canina* | 3.2 | 3.2 | 2.2 | 2.2 | 1.1 | 2.3 | +.1 | 4.3 | 2.1 | 2.2 |
| (*Stereocaulon glareosum*) | +.1 | . | . | . | . | . | +.1 | +.1 | . | +.1 |
| **Companion species:** | | | | | | | | | | |
| (B) *Ledum palustre* | . | . | . | . | +.1 | . | . | . | . | . |
| (C) *Arctostaphylos rubra* | . | . | . | 3.3 | 4.3 | . | 3.3 | . | . | 3.4 |
| *Astragalus williamsii* | . | . | . | . | 2.2 | . | . | . | . | . |
| *Equisetum scirpoides* | . | . | . | 3.2 | . | . | 3.1 | . | . | 1.1 |
| *Gentiana propinqua* | . | . | . | . | . | . | . | +.+ | . | 1.+ |
| *Senecio lugens* | . | . | . | . | +.1 | . | . | . | . | . |
| *Zygadenus elegans* | . | . | . | . | +.1 | . | . | . | . | . |
| (D) *Ceratodon purpureus* | . | . | . | +.1 | +.1 | . | . | . | . | . |
| *Cetraria tilesii* | . | . | . | . | +.1 | +.1 | . | . | . | . |
| *Cladonia pocillum* | +.1 | . | . | . | . | +.1 | . | . | +.1 | 2.2 |
| *Ditrichum flexicaule* | . | +.1 | . | . | . | +.1 | . | . | . | . |
| *Lecanora epibryon* | . | . | . | . | +.1 | +.1 | +.1 | . | . | . |
| *Solorina saccata* | . | . | . | . | . | . | +.1 | . | . | . |
| *Stereocaulon rivulorum* | . | . | . | . | . | +.1 | . | . | . | +.1 |
| *Tomentypnum nitens* | . | +.1 | . | . | +.1 | . | . | . | . | +.1 |
| *Tortula ruralis* | 1.2 | . | +.2 | . | . | . | . | 1.2 | . | . |

Species in brackets are relatively less characteristic.

Table 43.

## 8. ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS

Order:

Alliance:

### 10. Artemisio (frigidae) - Agropyrion yukonensis

| Association: | 13. Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis | | | | | | | | | | 14. Artemisio (frigidae) - Agropyro (yukonensis) - Eurotietum lanatae | | | | | 15. Pentstemono (gormanii) - Artemisietum frigidae | | | | | 16. Agropyro (yukonensis) - Artemisietum frigidae - rupestris | | | | | | | | | | 17. Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum filifoliae | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 10 | 4 | 4/70 | 1/70 | 8/70 | 8 | 2/70 | 151 | 1 | 193 | 16 | 157 | 178 | 179 | 170 | 21 | 381 | 12 | 152 | 382 | 176 | 177 | 168 | 169 | 199 | 15 | 202 | 161 | 204 | 160 | 162 | 163 | 159 | 25 | 158 |
| Hygrotope | 2 | 2 | 2 | 2 | 2 | 2- | 2 | 2 | 2+ | 2/3 | 2 | 2- | 2 | 2 | 2 | 2+ | 2+ | 1/2 | 2+ | 2+ | 2 | 2 | 2 | 2- | 2- | 2 | 2- | 2 | 2- | 2- | 2/3 | 2- | 2- | 2- | 2/3 |
| **Order & alliance charac. species:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) *Agropyron yukonense* | 4.1 | 4.1 | 3.2 | 4.+ | 6.2 | 2.1 | 5.1 | 6.2 | 3.1 | 7.3 | 3.1 | 2.1 | 3.+ | 3.2 | 3.1 | . | . | 2.+ | . | . | 3.1 | 4.1 | 3.1 | 4.1 | 2.1 | 1.+ | 1.+ | 2.+ | . | 2.+ | 2.+ | . | . | . | . |
| *Artemisia frigida* | 6.2 | 4.2 | 7.2 | 7.3 | 6.3 | 4.2 | 7.2 | 5.2 | 4.2 | 5.3 | 6.3 | 6.3 | 5.2 | 5.2 | 6.3 | 5.2 | 6.3 | 5.1 | 5.2 | 5.2 | 5.3 | 4.2 | 4.2 | 1.1 | 3.2 | +.2 | 3.1 | 5.2 | 4.1 | 3.1 | 3.1 | 2.2 | 4.2 | 5.2 | 5.2 |
| *Aster alpinus* | . | 1.1 | . | 1.+ | . | . | . | 1.1 | +.1 | 2.+ | . | . | . | . | . | . | . | . | . | . | . | +.1 | +.1 | . | . | . | 1.+ | . | 1.+ | . | +.1 | . | . | . | . |
| (*Calamagrostis purpurascens*) | 2.1 | 2.+ | . | +.1 | . | +.+ | 2.2 | . | 3.1 | . | 2.1 | . | . | . | . | . | . | . | . | . | . | +.1 | 3.2 | 1.1 | 3.1 | 1.1 | 2.1 | 2.1 | 4.1 | +.1 | 5.1 | 3.1 | 3.1 | 4.1 | 3.1 |
| *Carex filifolia* | 4.3 | 4.1 | 1.2 | . | 2.2 | 4.2 | 5.3 | 1.1 | 5.2 | +.2 | 2.1 | . | +.1 | . | . | 1.1 | . | 2.1 | . | . | . | . | . | . | . | 4.1 | 6.2 | 6.2 | 6.2 | 5.2 | 6.3 | 5.2 | 5.2 | 6.2 | 4.2 |
| *Erigeron caespitosus* | 2.1 | 2.1 | 3.1 | 3.+ | 2.1 | 2.1 | 5.1 | 2.1 | 3.1 | 3.1 | +.1 | . | . | . | . | . | . | 1.+ | . | . | +.+ | . | . | 1.1 | 1.+ | 2.1 | 2.+ | 1.+ | +.+ | +.+ | 1.+ | +.+ | +.+ | 1.+ | +.+ |
| *Linum perenne* | 1.+ | 1.+ | . | . | 2.+ | . | 2.+ | 2.+ | +.+ | 1.+ | +.+ | . | . | . | . | 3.1 | +.+ | . | 1.+ | . | . | . | 1.+ | . | +.+ | +.+ | . | . | . | . | . | . | . | . | . |
| (*Oxytropis viscida*) | . | . | 3.1 | . | . | . | . | +.+ | 2.1 | . | 1.1 | . | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | 3.1 | . | 4.1 | 1.+ | 4.1 | 4.1 | 4.1 | 3.1 | 4.1 | 4.1 |
| *Pentstemon gormanii* | 3.1 | 4.1 | 2.1 | 1.+ | 2.1 | 3.1 | 3.1 | 1.1 | 2.1 | 1.+ | +.1 | 1.1 | +.1 | . | . | 4.2 | 4.1 | 5.1 | 4.1 | 4.1 | 2.1 | 3.1 | 1.1 | 1.1 | +.+ | +.1 | 2.+ | . | . | 3.1 | . | . | . | . | . |
| (*Poa glauca*) | +.1 | . | . | . | . | 1.+ | . | . | 1.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.1 | . | . | +.+ | 1.+ | 1.1 | 4.1 | 1.1 |
| (*Pulsatilla patens*) | 2.1 | +.1 | . | +.+ | . | . | +.+ | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | +.+ | . | . | . | 1.+ | . | . |
| (D) *Caloplaca cirrochroa* | . | 1.+ | 2.+ | 1.+ | +.+ | . | . | 1.+ | 1.+ | +.+ | +.+ | . | . | . | . | +.+ | 2.+ | . | +.+ | +.+ | +.+ | +.+ | . | . | . | +.+ | +.+ | +.1 | . | . | +.+ | +.+ | +.+ | +.+ | +.+ |
| *Dermatocarpon hepaticum* | 5.2 | 4.2 | 7.3 | 5.2 | 4.1 | 4.1 | 6.2 | 5.2 | 4.2 | 4.2 | 3.1 | . | . | . | . | 5.2 | 4.2 | 5.2 | 3.2 | 5.2 | +.1 | +.1 | . | . | . | +.+ | 2.1 | +.1 | . | . | 2.1 | 1.1 | . | . | . |
| *Hypnum vaucheri* | +.1 | . | . | 3.1 | . | . | . | +.1 | +.1 | . | 1.1 | . | . | . | . | 3.1 | +.1 | 1.1 | . | +.1 | . | . | . | . | . | +.+ | . | +.+ | . | . | 2.1 | 1.1 | . | +.1 | +.1 |
| *Lecidea decipiens* | 1.1 | 2.1 | +.1 | 1.1 | . | . | . | +.1 | 1.+ | 1.+ | +.1 | . | . | . | . | 3.1 | 2.1 | +.+ | +.+ | 1.1 | . | . | . | . | . | . | 1.1 | 1.1 | . | . | 2.1 | . | . | +.1 | . |
| *Lecidea rubiformis* | 3.2 | +.1 | 4.2 | 1.1 | 3.2 | 4.2 | 4.2 | 4.2 | 2.1 | 2.2 | 1.1 | . | . | . | . | 5.2 | 6.2 | 4.2 | 6.3 | 6.3 | . | +.1 | . | +.+ | . | . | 1.1 | 2.1 | . | +.+ | 1.1 | 1.1 | +.1 | 1.1 | . |
| (*Tortula ruralis*) | 3.2 | +.1 | . | 1.1 | . | . | . | 1.1 | 1.1 | 1.2 | 3.1 | . | . | . | . | . | +.1 | 1.1 | 1.1 | . | +.+ | . | . | . | . | . | 2.1 | . | +.+ | . | . | 1.1 | +.1 | 1.1 | +.1 |
| **Association 13 charac. species:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) *Arabis holboellii* | . | . | . | . | 1.+ | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Astragalus aboriginum* | . | . | . | +.+ | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (*Solidago decumbens*) | . | +.1 | . | . | . | . | +.+ | . | 1.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | +.+ | . | . | . | . | . | . | . | . | . |
| (D) *Lecanora lentigera* | 5.1 | 3.1 | 1.1 | +.1 | +.1 | 3.1 | . | 4.1 | 4.1 | 1.2 | . | . | . | . | . | . | 1.1 | . | 1.1 | +.+ | . | +.1 | . | . | . | . | 1.1 | . | . | . | +.1 | . | . | . | . |
| *Parmelia taractica* | 2.1 | 2.+ | . | . | . | . | . | . | 4.1 | 1.+ | . | . | . | . | . | . | . | 2.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Association 14 charac. species:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Chamaerhodos erecta* | . | . | . | . | . | . | . | . | . | . | . | 2.1 | +.+ | . | 1.+ | . | . | . | . | . | . | +.+ | 1.+ | . | . | . | . | . | . | 1.+ | . | . | . | . | . |
| *Eurotia lanata* | . | +.+ | . | . | . | . | . | . | . | . | 4.2 | 6.3 | 6.3 | 5.3 | 5.2 | . | . | . | . | . | 2.1 | 2.1 | 2.1 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Association 15 charac. species:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Buellia epigaea* | . | . | . | . | . | . | . | 2.1 | . | . | 1.1 | . | . | . | . | 5.2 | 1.1 | 3.+ | 2.1 | 3.1 | . | +.+ | . | . | . | . | 2.1 | . | . | . | . | . | . | . | . |
| **Association 16 charac. species:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Artemisia dracunculus* | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | 1.1 | . | . | . | . | . | 1.2 | +.1 | 2.1 | +.1 | . | . | . | . | . | . | . | . | . | . | . |
| *Artemisia rupestris* | . | . | . | . | . | . | . | . | +.2 | . | . | +.2 | +.2 | . | . | . | . | . | . | . | 6.4 | 6.4 | 5.2 | 6.4 | 5.3 | 6.3 | 5.2 | 4.3 | 5.2 | 5.3 | +.1 | . | 1.2 | . | . |
| *Plantago canescens* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 4.1 | . | 1.1 | . | . | . | . | . | . |
| **Association 17 charac. species:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (*Artemisia hyperborea*) | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.1 | . | 4.2 | 2.1 | 4.2 | 5.2 | 6.3 |
| (*Carex scirpoidea*) | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2.+ | . | +.+ | . | . |
| *Minuartia rossii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3.1 | +.1 | . | 2.1 | 2.1 | 4.2 | . | +.+ |
| *Potentilla hookeriana* | . | +.1 | . | . | . | . | . | . | 1.1 | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | 2.1 | 1.1 | . | 2.1 | 4.1 | 4.1 | +.1 | 1.+ |
| *Potentilla virgulata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.+ | . | . | . | . | . | . | . | . | . | . | +.1 | 2.2 |
| (*Senecio conterminus*) | . | . | . | 1.+ | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | +.1 | +.+ | +.+ | . | . |
| **Companion species:** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) *Agropyron boreale* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . |
| *Agropyron violaceum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.1 | . | . |
| *Anemone multifida* | +.1 | 2.1 | . | . | . | . | . | . | 3.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.+ | +.+ | . | . | . |
| *Antennaria media* | . | . | . | . | . | . | . | . | +.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . |
| *Antennaria rosea* | . | . | . | . | . | +.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Antennaria stolonifera* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . |
| *Astragalus williamsii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . | . | . | . | . | . | . | . |
| *Bromus pumpellianus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2.+ | . | . | . | . | . | . |
| *Carex rupestris* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . | . |
| *Castilleja hyperborea* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | 2.1 | . | . |
| *Comandra umbellata* | . | . | . | . | . | . | . | . | +.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Lappula myosotis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ |
| *Orobanche fasciculata* | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Oxytropis huddelsonii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ |
| *Oxytropis splendens* | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Rosa acicularis* | 1.1 | 1.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Solidago multiradiata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . | . | . |
| *Townsendia hookeri* | . | . | . | . | +.+ | +.+ | . | . | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (D) *Barbula icmadophila* | . | . | . | +.1 | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.1 | . | . | . | . |
| *Cetraria cucullata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.+ | . | . | . | . |
| *Cetraria tilesii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . | . | . |
| *Collema coccophorum* | . | . | . | +.+ | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | +.+ | . | +.+ | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Fulgensia bracteata* | . | . | +.+ | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | 1.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Physcia muscigena* | +.+ | . | . | +.+ | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Thamnolia subuliformis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | +.+ | . | . | . | . |

Species in brackets are relatively less characteristic.

TABLE 44

Order: 9. BETULETALIA GLANDULOSAE

Alliance: 11. Potentillo (fruticosae) - Salicion glaucae

| Association: | 18. Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae | | | | | | | | | | 19. Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - lanatae - glaucae | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot number | 358 | 355 | 356 | 54 | 354 | 353 | 53 | 357 | 351 | 352 | 367 | 368 | 365 | 366 | 369 | 370 | 371 | 364 | 362 | 363 |
| Hygrotope | 3 | 3 | 3+ | 3+ | 3 | 3 | 3 | 3 | 3+ | 3 | 4 | 4 | 4+ | 4+ | 4 | 4 | 4+ | 4+ | 4 | 3/4 |
| **Order & alliance charac. species:** | | | | | | | | | | | | | | | | | | | | |
| (B) *Betula glandulosa* | . | 3.3 | 5.4 | 5.4 | 3.3 | 4.3 | 4.4 | 5.4 | 3.3 | 4.4 | 5.3 | 4.2 | 4.2 | 5.2 | 3.2 | 4.2 | 6.3 | 3.2 | 3.3 | 4.2 |
| *(Juniperus communis)* | . | +.3 | +.3 | . | . | +.3 | 4.3 | +.2 | . | . | . | . | +.2 | +.2 | . | +.3 | 2.3 | . | . | . |
| *(Picea glauca)* | +.2 | +.2 | +.5 | +.3 | . | . | . | +.2 | . | . | +.3 | +.2 | . | +.2 | . | +.3 | . | +.2 | +.3 | +.2 |
| *Potentilla fruticosa* | 1.3 | 4.3 | 4.4 | 2.3 | 3.4 | 4.4 | +.3 | 4.4 | 4.4 | 4.3 | 1.2 | 2.2 | 4.2 | 3.2 | 1.2 | . | 2.2 | 2.1 | 3.3 | 2.2 |
| *Salix alaxensis* | 1.5 | . | . | 4.5 | . | . | . | . | . | . | . | . | +.4 | . | +.3 | . | . | . | . | . |
| *(Salix brachycarpa)* | . | . | . | . | . | +.3 | . | . | . | . | . | . | . | . | . | . | . | . | +.2 | . |
| *Salix glauca* | 8.7 | 8.7 | 8.7 | 6.6 | 8.7 | 8.7 | 8.7 | 7.6 | 8.7 | 8.6 | 7.6 | 7.6 | 6.6 | 7.7 | 7.7 | 7.6 | 8.7 | 7.7 | 7.6 | 8.6 |
| *Salix lanata* | . | 2.4 | +.4 | 2.5 | . | +.4 | +.4 | 1.5 | 2.4 | 3.5 | 6.6 | 7.6 | 7.7 | 5.6 | 8.7 | 7.6 | 7.6 | 5.6 | 6.6 | 7.6 |
| *(Shepherdia canadensis)* | +.2 | +.2 | . | . | +.2 | +.2 | . | 1.3 | . | . | +.2 | +.2 | +.2 | . | . | +.2 | 1.2 | . | . | . |
| *(Viburnum edule)* | . | 2.1 | . | . | . | . | . | . | . | . | . | . | +.1 | . | . | . | 1.2 | . | . | . |
| (C)(*Anemone parviflora*) | 1.+ | 2.1 | 2.+ | 1.+ | 2.+ | 2.+ | 5.1 | 2.+ | 1.+ | 2.+ | 2.+ | 2.1 | 2.+ | 1.+ | 2.+ | 1.+ | 3.+ | 1.+ | +.1 | 1.+ |
| *Arctostaphylos rubra* | 4.4 | 5.4 | 5.4 | 3.4 | 4.4 | 4.3 | 5.4 | 4.3 | 4.4 | 3.3 | 7.5 | 6.5 | 6.5 | 7.5 | 4.5 | 4.5 | 5.3 | 5.5 | 5.5 | 5.3 |
| *(Carex scirpoidea)* | 1.+ | 1.+ | 3.1 | 1.1 | 2.1 | 2.1 | 3.1 | 3.1 | 2.1 | 3.1 | 1.1 | 1.1 | 2.1 | 3.1 | 3.+ | 1.+ | +.1 | +.+ | +.+ | +.+ |
| *(Dryas integrifolia)* | . | +.3 | . | +.1 | . | +.2 | . | +.1 | . | . | 2.2 | 3.2 | +.2 | 2.2 | 3.2 | +.2 | 2.2 | 5.4 | 4.5 | +.2 |
| *(Epilobium latifolium)* | . | . | . | . | . | . | . | +.1 | . | . | . | . | +.1 | . | 1.1 | . | . | +.1 | . | . |
| *(Equisetum arvense)* | . | +.1 | 1.+ | . | . | +.1 | . | . | +.+ | . | . | 1.+ | +.+ | . | . | . | +.1 | . | 2.+ | 2.+ |
| *Equisetum scirpoides* | 3.+ | 2.+ | +.+ | . | 2.+ | 3.+ | +.+ | +.+ | +.+ | 2.+ | 4.1 | 3.1 | 3.1 | 3.2 | 3.2 | 2.1 | 2.1 | 4.2 | 3.2 | 3.+ |
| *(Festuca altaica)* | 2.2 | 1.2 | 4.2 | 3.2 | 4.2 | 3.2 | 2.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 1.1 | 2.1 | 2.1 | 4.2 | 2.1 | +.1 | +.1 | +.2 |
| *(Gentiana propinqua)* | 2.+ | 1.+ | +.+ | 1.+ | 1.+ | 1.+ | 1.+ | +.+ | +.+ | 1.+ | +.+ | +.+ | +.+ | +.+ | . | +.+ | 1.+ | . | +.+ | 1.+ |
| *(Hedysarum alpinum)* | 1.1 | 3.1 | 2.1 | 2.1 | 3.1 | 3.1 | 1.1 | 3.1 | 1.1 | 2.1 | 3.1 | 2.1 | 2.1 | 2.1 | 2.1 | 3.2 | 2.1 | 3.1 | 2.1 | 2.1 |
| *(Linnaea borealis)* | +.2 | 3.1 | 1.2 | +.2 | 1.2 | 2.1 | 3.1 | 3.3 | +.1 | +.1 | . | . | 3.2 | 2.2 | . | +.2 | 2.2 | . | +.1 | 2.3 |
| *(Mertensia paniculata)* | 2.1 | 2.1 | 2.+ | 2.1 | 2.1 | 3.1 | 1.1 | +.1 | 2.1 | 2.1 | 1.1 | 2.1 | 1.1 | 1.1 | 1.1 | 1.1 | 3.2 | +.1 | 1.1 | 1.1 |
| *Parnassia palustris* | 1.+ | 2.+ | . | . | 2.+ | 3.+ | 1.+ | . | +.+ | 3.+ | 2.+ | 3.+ | +.+ | . | 1.+ | 2.+ | 2.+ | . | 1.+ | 1.+ |
| *Pedicularis capitata* | +.+ | +.+ | . | . | 2.1 | +.+ | 2.1 | +.1 | +.+ | +.+ | 2.+ | 1.+ | 1.+ | +.+ | 2.+ | 2.+ | +.1 | 1.+ | 1.+ | 1.+ |
| *(Petasites frigidus)* | . | . | . | . | . | . | . | . | +.2 | . | +.1 | 1.2 | +.1 | . | . | +.1 | 1.1 | +.1 | . | . |
| *(Pyrola secunda)* | 1.+ | +.+ | +.+ | . | +.1 | . | . | . | . | . | . | . | . | . | +.1 | . | . | . | . | +.+ |
| *(Salix reticulata)* | 2.3 | 6.4 | 3.3 | 3.3 | 5.3 | 5.4 | 5.4 | 3.3 | 5.4 | 5.3 | 4.2 | 5.3 | 4.3 | 3.2 | 5.3 | 4.3 | 3.2 | 5.5 | 3.3 | 4.4 |
| *(Valeriana capitata)* | +.+ | +.+ | . | . | . | +.1 | . | . | . | . | . | +.1 | . | . | . | . | +.1 | . | . | . |
| (D)(*Abietinella abietina*) | +.1 | . | +.1 | . | 1.1 | 1.1 | . | . | 1.+ | . | . | . | 1.1 | . | . | . | . | +.1 | . | . |
| *Campylium stellatum* | 1.1 | +.1 | 1.1 | . | 1.+ | 2.1 | . | +.+ | +.1 | +.1 | 1.1 | 1.1 | 2.1 | 1.1 | 2.1 | 1.1 | 1.1 | 1.2 | +.2 | +.1 |
| *Ceratodon purpureus* | +.1 | . | . | . | 1.1 | 1.1 | . | . | 2.+ | 2.1 | 3.1 | 3.1 | 2.1 | . | 2.1 | 2.1 | 2.1 | 1.1 | 1.2 | +.+ |
| *(Peltigera canina)* | +.1 | +.1 | +.1 | . | 1.1 | 2.1 | . | +.1 | +.1 | 1.1 | +.1 | +.1 | +.1 | . | . | +.+ | . | +.1 | . | . |
| **Association 18 charac. species:** | | | | | | | | | | | | | | | | | | | | |
| (B)(*Salix myrtillifolia*) | +.3 | 2.3 | 3.4 | . | +.3 | 1.3 | . | 6.5 | 1.3 | 3.4 | . | . | . | . | . | . | . | . | . | . |
| (C)(*Achillea lanulosa*) | . | +.+ | +.1 | . | . | . | . | +.+ | . | +.1 | . | . | . | . | . | . | . | . | . | . |
| *(Aconitum delphinifolium)* | +.1 | +.1 | +.1 | . | 1.1 | +.1 | 1.1 | . | +.1 | +.1 | . | . | . | . | . | . | . | . | . | . |
| *(Arctostaphylos uva-ursi)* | 4.5 | 3.3 | 6.5 | 3.3 | 1.3 | 3.3 | +.2 | 3.3 | 2.3 | 3.3 | . | . | . | . | . | . | . | . | . | . |
| *(Artemisia arctica)* | . | 1.+ | . | . | 2.1 | 2.1 | . | . | +.1 | 1.1 | . | . | . | . | . | . | +.1 | . | . | . |
| *(Astragalus alpinus)* | . | +.+ | . | . | +.1 | +.1 | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . |
| *(Carex filifolia)* | 4.3 | +.1 | 4.2 | 2.1 | 3.1 | 5.2 | +.1 | +.1 | 4.1 | 4.1 | . | . | . | . | . | . | . | . | . | . |
| *(Epilobium angustifolium)* | +.1 | 1.+ | +.1 | . | +.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *(Salix arctica)* | . | . | . | . | . | . | . | +.3 | +.2 | +.2 | . | . | . | . | . | . | . | . | . | . |
| *(Senecio lugens)* | +.1 | . | +.+ | +.+ | +.1 | +.1 | 1.+ | . | +.1 | +.1 | . | . | . | . | . | . | . | . | +.+ | . |
| *(Solidago decumbens)* | . | . | . | +.1 | +.1 | +.1 | 1.1 | +.1 | +.1 | +.1 | . | . | . | . | . | . | 1.1 | . | . | . |
| *Zygadenus elegans* | +.1 | 3.1 | 3.+ | 1.1 | 2.1 | 2.1 | 3.1 | 1.+ | +.1 | 3.1 | . | . | . | . | . | . | +.1 | . | . | +.+ |
| **Association 19 charac. species:** | | | | | | | | | | | | | | | | | | | | |
| (B) *Ledum palustre* | . | . | . | . | . | . | . | . | +.2 | . | 4.2 | 3.2 | 3.2 | 3.2 | 3.2 | 4.2 | 5.2 | +.1 | 2.2 | 3.2 |
| *Rhododendron lapponicum* | . | . | . | . | . | . | . | . | . | . | +.1 | . | +.2 | +.1 | +.1 | +.1 | 2.2 | . | 2.1 | +.2 |
| *Vaccinium uliginosum* | . | . | . | . | . | . | . | . | . | . | 3.2 | 3.1 | 4.2 | 2.1 | 2.1 | 5.2 | 4.2 | 2.2 | 5.5 | 4.2 |
| (C) *Arctagrostis latifolia* | . | . | . | . | . | . | . | . | . | . | . | . | 1.+ | +.2 | +.1 | . | +.1 | 2.+ | 1.+ | 3.1 |
| *(Cassiope tetragona)* | . | . | . | . | . | . | . | . | . | . | 7.3 | 5.2 | 3.2 | 4.3 | 4.2 | 5.2 | 3.2 | 4.4 | 3.5 | 2.2 |
| *Empetrum nigrum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2.2 | 1.2 | . | . | . |
| *(Kobresia myosuroides)* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | +.+ | 1.1 |
| *Pyrola asarifolia* | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | 1.1 | +.1 | +.1 | . | 1.1 | . | . |
| *Saussurea angustifolia* | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . | +.1 | . | . | . | . | . |
| (D)(*Cetraria tilesii*) | . | . | . | . | . | . | . | . | . | . | +.+ | +.+ | +.1 | . | . | +.+ | . | +.1 | . | . |
| *(Cladonia pocillum)* | +.1 | . | . | . | . | . | . | . | . | +.+ | +.1 | +.1 | . | +.1 | 1.1 | 1.1 | 1.1 | 1.1 | +.1 | . |
| *(Dactylina arctica)* | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | +.+ | . | . | . | . | . |
| *Orthothecium chryseum* | . | . | . | . | . | . | . | . | . | . | . | +.+ | +.1 | . | . | . | . | +.1 | . | . |
| **Companion species:** | | | | | | | | | | | | | | | | | | | | |
| (C) *Agropyron boreale* | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . |
| *Antennaria stolonifera* | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Calamagrostis purpurascens* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . |
| *Carex concinna* | . | . | . | . | . | +.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Carex petricosa* | . | . | . | . | +.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Elymus innovatus* | . | . | . | . | . | . | . | . | +.1 | . | . | . | . | . | . | . | . | . | . | . |
| *Lupinus arcticus* | . | . | . | . | . | . | 2.2 | . | . | . | . | . | . | . | . | +.1 | . | . | . | . |
| *Oxytropis viscida* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . |
| *Poa alpina* | . | . | . | . | . | . | +.1 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Polemonium pulcherrimum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.1 | . | . | . |
| *Polygonum viviparum* | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . |
| *Trisetum spicatum* | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | +.+ | . |
| (D) *Bryum sp.* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.1 | . | . |
| *Cetraria cucullata* | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . |
| *Lecanora epibryon* | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | +.+ | . | . | . | . | . |

Species in brackets are relatively less characteristic.

Table 45.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Order:** | 10. ARTEMISIETALIA ALASKANAE | | | | | | | | | |
| **Alliance:** | 12. Artemision alaskanae | | | | | 13. Artemisio (hyperboreae - alaskanae) - Salicion myrtillifoliae | | | | |
| **Association:** | 20. Artemisietum alaskanae | | | | | 21. Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae | | | | |
| **Plot number** | 196 | 171 | 187 | 185 | 174 | 195 | 181 | 173 | 183 | 175 |
| **Hygrotope** | 3+ | 2/3 | 2/3 | 3+ | 3 | 3+ | 3+ | 3+ | 3+ | 3+ |
| **Order charac. species:** | | | | | | | | | | |
| *Artemisia alaskana* | 2.1 | 3.1 | 2.2 | 4.2 | 3.2 | 2.1 | +.1 | +.1 | . | +.1 |
| (*Artemisia frigida*) | +.1 | . | . | . | . | +.1 | 3.1 | . | . | +.1 |
| (*Artemisia hyperborea*) | 2.1 | . | 2.1 | 3.1 | . | 3.1 | 3.2 | 2.1 | 3.2 | 2.1 |
| (*Aster sibiricus*) | . | +.+ | . | . | . | +.+ | . | . | . | . |
| (*Crepis nana*) | . | . | . | . | +.+ | +.+ | . | . | . | . |
| (*Epilobium latifolium*) | . | +.1 | . | . | . | +.+ | +.+ | . | . | . |
| (*Oxytropis huddelsonii*) | 2.1 | +.1 | 3.1 | 4.1 | . | 3.1 | . | +.1 | 3.1 | 4.1 |
| **Alliance 12 & association 20 charac. species:** | | | | | | | | | | |
| (*Anemone drummondii*) | +.+ | . | +.+ | . | . | . | . | . | . | . |
| (*Astragalus nutzotinensis*) | . | . | . | . | +.1 | . | . | . | . | . |
| *Cystopteris fragilis* | . | . | . | . | +.1 | . | . | . | . | . |
| (*Draba alpina*) | . | . | +.+ | . | . | . | . | . | . | . |
| (*Papaver macounii*) | . | +.1 | . | . | . | . | . | . | . | . |
| *Ranunculus pedatifidus*) | +.+ | . | . | +.+ | . | . | . | . | . | . |
| (*Smelowskia borealis*) | . | . | . | . | +.1 | . | . | . | . | . |
| *Stellaria monantha* | . | . | . | . | +.1 | . | . | . | . | . |
| **Alliance 13 & association 21 charac. species:** | | | | | | | | | | |
| (B)(*Potentilla fruticosa*) | . | . | . | . | . | 3.2 | 3.2 | 1.1 | 1.2 | 2.3 |
| (*Salix glauca*) | . | . | . | . | . | +.3 | +.3 | 1.4 | +.2 | 1.4 |
| *Salix myrtillifolia* | . | . | . | . | . | 4.4 | 5.4 | 5.4 | 5.4 | 4.4 |
| (*Shepherdia canadensis*) | . | . | . | . | . | . | . | 1.3 | . | . |
| (C)(*Anemone multifida*) | . | . | . | . | . | . | 1.+ | +.+ | 1.+ | +.+ |
| (*Antennaria media*) | . | . | . | . | . | . | . | . | . | +.+ |
| (*Artemisia dracunculus*) | . | . | . | . | . | . | +.1 | . | . | 1.1 |
| (*Calamagrostis purpurascens*) | . | . | . | . | +.+ | 1.1 | 1.1 | 1.1 | 2.1 | +.1 |
| (*Castilleja hyperborea*) | . | . | . | . | . | . | . | +.+ | . | . |
| (*Chamaerhodos erecta*) | . | . | . | . | . | . | +.+ | . | . | . |
| (*Erigeron caespitosus*) | . | . | . | . | . | +.+ | +.+ | . | . | +.+ |
| (*Gentiana propinqua*) | . | . | . | . | . | . | . | . | . | 1.+ |
| (*Oxytropis viscida*) | . | . | . | . | . | . | . | 2.1 | 1.1 | 2.1 |
| (*Pentstemon gormanii*) | . | . | . | . | . | . | +.1 | . | . | . |
| (*Potentilla hookeriana*) | . | . | . | . | . | +.+ | . | . | . | . |
| *Saxifraga tricuspidata* | . | . | . | . | . | . | . | 1.1 | . | . |
| (*Solidago decumbens*) | . | . | . | . | . | . | +.+ | . | 1.+ | 1.+ |

Species in brackets are relatively less characteristic.

Table 46.

Order: 11. DRYADETALIA INTEGRIFOLIAE

Alliance: 14. Carico (scirpoideae) - Dryadion integrifoliae | 15. Dryado (integrifoliae) - Cassiopion tetragonae

Association: 22. Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae | 23. Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae

| Plot number | 67 | 36 | 349 | 48 | 347 | 331 | 332 | 46 | 125 | 135 | 49 | 121 | 346 | 345 | 330 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hygrotope | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3/4 | 3/4 | 3/4 | 3/4 | 4+ |
| **Order charac. species:** | | | | | | | | | | | | | | | |
| (C)(*Anemone parviflora*) | +.+ | . | . | . | 1.+ | +.+ | +.+ | 1.+ | 2.+ | . | +.+ | 1.+ | +.+ | 1.+ | +.+ |
| *Arctostaphylos alpina* | . | . | +.1 | 3.1 | . | . | . | . | . | . | 3.1 | 2.2 | . | . | +.2 |
| *Astragalus alpinus* | . | +.+ | . | . | . | +.+ | +.+ | +.1 | . | . | . | . | +.+ | . | +.+ |
| *Carex scirpoidea* | 3.1 | 3.2 | 3.2 | 2.1 | 1.+ | 3.1 | 2.1 | 2.1 | 3.1 | 3.1 | . | +.+ | +.+ | +.+ | . |
| *Dryas integrifolia* | 8.5 | 6.3 | 8.5 | 8.4 | 8.4 | 8.5 | 8.5 | 8.3 | 7.4 | 7.4 | 5.3 | 7.3 | 6.2 | 6.3 | 6.3 |
| (*Lloydia serotina*) | . | . | . | . | +.+ | . | 1.+ | . | +.+ | . | . | . | . | . | +.+ |
| (*Parrya nudicaulis*) | . | . | . | . | 1.+ | +.1 | 1.1 | . | +.1 | . | . | . | . | +.+ | . |
| (*Pedicularis capitata*) | . | . | . | . | 1.+ | +.1 | 1.1 | . | . | . | . | . | +.+ | . | . |
| (*Pedicularis kanei*) | . | +.1 | . | . | . | . | . | . | 1.1 | . | . | +.+ | 1.1 | +.1 | . |
| (*Polygonum viviparum*) | . | . | . | +.+ | . | . | . | . | . | . | . | . | +.+ | +.+ | . |
| (*Salix reticulata*) | . | 4.2 | 2.1 | 5.3 | 4.2 | 3.2 | 4.2 | 4.2 | 4.2 | 4.1 | 4.2 | 3.2 | +.2 | +.1 | 3.1 |
| (*Saxifraga oppositifolia*) | 3.1 | 3.1 | +.1 | . | 1.1 | 1.1 | 2.1 | 1.1 | 1.1 | +.1 | . | 3.1 | 2.1 | 2.+ | 1.1 |
| (*Saussurea viscida*) | . | +.1 | . | . | 2.1 | 1.1 | 2.1 | +.1 | +.1 | . | +.1 | . | 1.1 | 1.1 | +.1 |
| (*Silene acaulis*) | +.1 | 1.2 | 2.1 | 1.2 | 3.2 | . | 1.1 | 2.2 | 1.1 | +.1 | . | 2.1 | 3.1 | 3.1 | 2.1 |
| (D)(*Caloplaca cirrochroa*) | . | . | +.+ | . | . | +.+ | . | +.+ | +.+ | . | . | +.+ | . | . | +.+ |
| (*Cetraria cucullata*) | +.1 | . | 3.1 | +.1 | 1.1 | +.1 | . | +.1 | . | 2.1 | 1.+ | . | . | . | . |
| (*Cetraria tilesii*) | +.1 | . | 3.1 | +.1 | 1.1 | +.1 | . | +.1 | . | 2.1 | . | . | 1.1 | 1.1 | +.1 |
| *Cladonia pocillum* | +.1 | . | . | . | 2.1 | 2.1 | . | 1.1 | 3.1 | 1.1 | +.+ | +.1 | +.1 | 1.1 | 3.1 |
| (*Dactylina arctica*) | . | +.1 | . | . | 1.1 | . | +.1 | 3.1 | 1.1 | . | +.+ | +.1 | 1.1 | 2.1 | +.1 |
| (*Dermatocarpon hepaticum*) | 1.1 | . | +.1 | 1.1 | 1.1 | 1.1 | 1.1 | 2.1 | 2.1 | 4.2 | . | 1.+ | 1.1 | 1.1 | +.+ |
| *Lecanora epibryon* | +.1 | +.+ | +.+ | +.+ | +.1 | 1.1 | +.+ | +.+ | 2.1 | 4.1 | . | 1.1 | . | +.1 | 1.+ |
| (*Peltigera canina*) | . | . | +.1 | . | +.1 | 1.1 | 1.1 | . | +.1 | 1.1 | . | . | . | | +.1 |
| *Stereocaulon glareosum* | . | . | . | . | 1.1 | 2.1 | 3.1 | . | . | . | +.+ | . | 3.1 | 4.2 | 3.2 |
| (*Thamnolia subuliformis*) | +.1 | +.+ | . | +.+ | +.1 | +.+ | +.+ | . | 2.1 | +.+ | . | . | +.1 | . | . |
| **Alliance 14 & association 22 charac. species:** | | | | | | | | | | | | | | | |
| (C)(*Antennaria monocephala*) | . | +.+ | +.+ | . | +.+ | . | . | +.+ | +.+ | . | . | . | . | . | . |
| (*Hedysarum alpinum*) | 3.1 | 2.1 | +.1 | 3.1 | 1.1 | 2.1 | 2.1 | . | . | 2.1 | . | . | . | . | . |
| (*Kobresia myosuroides*) | 2.1 | 3.1 | +.1 | 3.1 | +.1 | . | . | +.1 | +.1 | 1.1 | . | . | . | . | . |
| (*Oxytropis deflexa*) | +.1 | . | 2.+ | . | 2.1 | 1.+ | +.+ | 3.1 | 2.1 | 2.1 | . | . | +.+ | . | . |
| (*Oxytropis viscida*) | 2.1 | . | 1.1 | +.1 | 3.1 | . | . | . | . | +.1 | . | . | . | . | . |
| *Potentilla biflora* | +.1 | . | . | . | . | . | +.1 | . | . | . | . | . | . | . | . |
| (*Salix arctica*) | +.2 | 1.1 | 1.1 | 2.2 | . | . | . | . | . | . | . | . | . | . | . |
| (*Salix dodgeana*) | . | . | . | 1.2 | +.1 | . | . | +.1 | . | +.1 | . | . | . | . | . |
| (*Trisetum spicatum*) | . | . | . | 2.1 | +.+ | . | . | . | +.+ | . | . | . | . | . | . |
| (D)(*Buellia epigaea*) | . | . | . | . | . | +.1 | . | . | . | +.1 | . | . | . | . | . |
| (*Cetraria nivalis*) | . | . | +.1 | . | . | . | +.1 | . | . | . | . | . | . | . | . |
| (*Cetraria richardsonii*) | . | . | +.1 | . | +.1 | . | . | . | . | . | . | . | . | . | . |
| (*Cornicularia aculeata*) | . | . | +.+ | . | . | +.+ | . | +.+ | +.+ | . | . | . | . | . | . |
| (*Lecanora lentigera*) | +.1 | . | . | . | . | 1.1 | +.1 | . | 2.1 | +.+ | . | . | . | . | . |
| (*Lecidea decipiens*) | . | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | . |
| (*Physcia muscigena*) | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . |
| (*Solorina spongiosa*) | +.1 | . | . | . | . | 1.1 | +.1 | . | . | . | . | . | . | . | . |
| **Alliance 15 & association 23 charac. species:** | | | | | | | | | | | | | | | |
| (C) *Carex microchaeta* | . | . | . | . | . | . | . | . | . | . | 1.1 | 2.1 | 3.1 | 3.1 | 3.1 |
| *Cassiope tetragona* | . | . | . | . | . | . | . | . | . | . | 8.4 | 8.4 | 7.3 | 7.5 | 8.5 |
| (*Epilobium latifolium*) | . | +.1 | . | 2.1 | . | . | . | . | . | . | 1.1 | 1.1 | 1.1 | +.1 | 3.1 |
| (*Oxyria digyna*) | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | 2.1 | . |
| *Pyrola grandiflora* | . | . | . | . | . | . | . | . | . | . | 1.1 | . | . | . | +.1 |
| (*Salix polaris*) | . | . | . | . | . | . | 2.2 | . | +.2 | . | 3.2 | . | 2.1 | 2.1 | +.1 |
| (*Vaccinium uliginosum*) | . | . | . | . | . | . | . | . | . | . | 3.2 | +.1 | . | . | . |
| (D)(*Distichium capillaceum*) | . | . | . | . | . | . | . | . | . | . | +.+ | 2.1 | 2.1 | 2.1 | 1.+ |
| *Lecidea cuprea* | . | . | . | . | . | . | . | . | . | . | . | 2.1 | 2.+ | +.+ | . |
| *Solorina saccata* | . | . | . | . | . | . | . | . | . | . | . | +.1 | +.1 | . | . |
| (*Timmia austriaca*) | . | . | . | . | . | . | . | . | . | . | . | +.1 | +.1 | 1.1 | . |
| (*Tomentypnum nitens*) | . | . | . | . | . | . | . | . | . | . | . | +.1 | 1.1 | . | +.+ |
| **Companion species:** | | | | | | | | | | | | | | | |
| (B) *Salix alaxensis* | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . | . |
| (C) *Draba hirta* | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . |
| *Equisetum scirpoides* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1.+ |
| *Festuca altaica* | . | +.1 | +.1 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Festuca brachyphylla* | . | . | . | 2.1 | . | . | . | . | . | . | . | . | . | . | . |
| *Gentiana propinqua* | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . |
| *Mertensia paniculata* | . | . | . | 1.1 | . | . | . | . | . | . | . | . | . | . | . |
| *Myosotis alpestris* | . | . | . | +.+ | . | . | +.+ | . | . | . | . | . | . | . | . |
| *Parnassia kotzebuei* | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . |
| *Poa alpina* | . | . | . | 1.+ | . | . | . | . | . | . | . | . | . | . | . |
| *Poa glauca* | . | . | . | 1.+ | +.+ | . | . | . | . | . | . | . | . | . | . |
| *Poa lanata* | . | . | . | +.+ | . | . | +.+ | . | . | . | . | . | . | . | . |
| (D) *Hylocomium splendens* | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . |
| *Hypnum bambergeri* | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . |

Species in brackets are relatively less characteristic.

TABLE 47

**Order:** 12. OXYTROPO (VISCIDAE) - ARTEMISIO (HYPERBOREAE) - FESTUCO (BRACHYPHYLLAE) - TRISETETALIA SPICATI

**Alliance:** 16. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetion spicati

**Association:** 24. Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati; 25. Oxytropo (huddelsonii) - Salicetum dodgeanae

| Plot number | 329 | 328 | 327 | 28 | 29 | 47 | 338 | 350 | 27 | 30 | 57 | 122 | 58 | 123 | 59 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hygrotope | 2/3 | 2/3 | 2 | 2/3 | 2 | 2 | 2/3 | 2/3 | 2 | 2 | 2/3 | 2/3 | 2/3 | 3 | 2/3 |
| **Order & alliance charac. species:** | | | | | | | | | | | | | | | |
| (C) *Artemisia hyperborea* | 7.2 | 7.3 | 6.2 | 4.2 | 4.2 | 6.2 | 5.1 | 7.2 | 6.2 | 5.2 | +.1 | +.+ | . | 3.2 | 2.1 |
| (*Calamagrostis purpurascens*) | 3.1 | 2.1 | 3.1 | 1.1 | 3.2 | 2.2 | +.1 | . | . | . | . | . | . | 1.1 | 2.1 |
| *Draba cinerea* | . | . | . | +.+ | . | +.+ | . | . | +.+ | . | +.+ | . | +.+ | . | +.+ |
| *Festuca brachyphylla* | 1.1 | 1.1 | +.1 | +.+ | 3.1 | +.1 | +.+ | 2.1 | 1.1 | 2.1 | 1.1 | 1.1 | 2.1 | 3.1 | 2.1 |
| *Oxytropis huddelsonii* | +.1 | . | +.1 | . | . | . | 1.1 | 1.1 | . | 4.2 | 4.2 | 4.2 | 5.2 | 4.2 | 5.2 |
| *Oxytropis viscida* | 4.2 | 5.2 | 5.2 | 3.1 | 5.2 | 4.1 | 2.1 | 4.1 | 5.1 | 4.1 | 2.1 | 4.2 | 1.1 | 1.1 | . |
| *Poa glauca* | 2.1 | 2.1 | +.1 | +.1 | 5.1 | +.1 | 1.1 | 1.1 | 2.1 | 4.1 | 1.+ | . | 1.+ | 2.+ | 2.1 |
| *Salix dodgeana* | +.2 | . | . | 3.3 | . | . | +.2 | +.2 | . | . | 6.4 | 5.4 | 6.4 | 5.3 | 6.4 |
| *Senecio conterminus* | 2.1 | 1.+ | 1.+ | 1.+ | 4.1 | 1.+ | 1.1 | 2.1 | +.1 | 1.1 | +.+ | +.+ | 1.+ | +.+ | +.+ |
| *Silene acaulis* | 1.2 | +.2 | 1.2 | 3.2 | 2.2 | 3.2 | 1.2 | +.2 | +.2 | . | 1.1 | 2.2 | 3.2 | 1.1 | 3.1 |
| (*Stellaria longipes*) | . | +.+ | . | . | . | . | . | . | +.+ | +.+ | . | . | +.+ | . | +.+ |
| *Trisetum spicatum* | 3.1 | 3.1 | 3.1 | 4.1 | 5.1 | 2.+ | 2.1 | 3.1 | 5.1 | 2.1 | 1.+ | 2.1 | 2.+ | 3.1 | 3.1 |
| (D) *Alectoria ochroleuca* | . | . | +.+ | . | . | . | 1.+ | 1.+ | . | . | +.+ | 1.+ | +.+ | . | +.+ |
| (*Buellia epigaea*) | . | . | +.+ | . | . | . | . | +.+ | . | +.+ | . | . | 1.1 | . | +.1 |
| (*Caloplaca cirrochroa*) | +.+ | +.+ | 1.+ | . | +.+ | +.+ | +.+ | . | +.+ | . | +.+ | . | . | +.+ | . |
| *Cetraria cucullata* | . | 1.+ | 1.+ | 3.1 | +.+ | 2.1 | . | 2.1 | . | +.+ | 3.1 | 3.1 | 3.1 | . | 3.1 |
| *Cetraria nivalis* | . | +.+ | . | +.+ | . | . | . | . | . | +.+ | +.1 | . | +.1 | . | . |
| *Cetraria tilesii* | 1.+ | +.+ | +.+ | 4.1 | 1.+ | 2.+ | 2.1 | 2.1 | . | +.+ | 3.1 | 3.1 | 3.1 | 2.1 | 3.1 |
| *Dactylina madreporiformis* | +.+ | +.+ | . | . | . | +.+ | . | . | . | . | . | . | +.1 | . | +.1 |
| (*Dermatocarpon hepaticum*) | 1.+ | +.+ | +.+ | 4.2 | 1.+ | 2.2 | 2.1 | 2.1 | . | . | 2.1 | 3.1 | 2.+ | 2.1 | 2.1 |
| (*Hypnum vaucheri*) | 1.1 | 1.1 | . | +.1 | . | +.1 | . | . | +.1 | . | 1.+ | . | +.1 | . | 1.1 |
| (*Lecanora lentigera*) | . | . | 2.1 | +.+ | +.+ | . | +.+ | . | +.+ | +.+ | 4.1 | 4.1 | 4.1 | . | 2.1 |
| (*Lecidea decipiens*) | 1.+ | 1.+ | 2.1 | 2.1 | . | +.+ | 1.+ | . | . | . | 2.1 | +.+ | . | . | +.+ |
| (*Lecidea rubiformis*) | +.+ | 2.1 | 3.1 | +.+ | +.+ | +.+ | +.+ | . | +.+ | . | . | . | . | 1.1 | +.1 |
| *Tortula ruralis* | 1.1 | 1.1 | +.1 | . | . | . | 1.1 | +.1 | +.1 | 1.1 | 2.1 | +.1 | +.1 | . | 3.1 |
| *Thamnolia subuliformis* | 1.+ | +.+ | 3.1 | 2.1 | +.+ | 1.+ | 1.+ | 2.1 | . | +.+ | 2.1 | 3.1 | 3.1 | 2.+ | 3.1 |
| **Association 24 charac. species:** | | | | | | | | | | | | | | | |
| (C)(*Agropyron violaceum*) | 3.1 | 3.2 | 1.1 | . | +.+ | 2.1 | 1.1 | . | 2.1 | +.1 | . | . | . | 1.1 | . |
| *Anemone drummondii* | 2.1 | 2.+ | 3.+ | +.1 | +.2 | +.+ | 1.1 | 1.1 | 2.1 | +.1 | . | . | . | 1.1 | . |
| (*Anemone parviflora*) | . | . | . | +.+ | +.+ | . | . | . | 3.1 | . | . | 1.+ | . | . | . |
| (*Carex filifolia*) | 2.2 | 2.2 | 1.+ | 3.2 | +.2 | 3.2 | +.2 | +.2 | 2.2 | . | . | . | . | 1.2 | . |
| *Carex nardina* | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . |
| **(*Carex scirpoidea*)** | **1.1** | **3.1** | **+.1** | **2.1** | **+.1** | **1.1** | . | **+.1** | . | **3.1** | . | . | **+.1** | . | . |
| ***Castilleja hyperborea*** | 2.1 | 1.1 | 5.1 | +.+ | 1.1 | 2.+ | +.+ | +.1 | +.1 | . | . | . | . | . | . |
| *Erigeron compositus* | 2.1 | 2.1 | 2.1 | . | . | +.+ | 1.+ | 1.1 | 1.+ | . | . | . | . | . | +.1 |
| *Erysimum pallasii* | +.1 | +.1 | . | . | . | . | +.1 | +.+ | . | +.+ | . | . | . | . | . |
| *Festuca baffinensis* | +.1 | . | . | . | 3.1 | . | +.1 | . | . | . | . | . | . | . | . |
| (*Melandrium apetalum*) | +.1 | . | 1.+ | +.+ | . | . | . | +.1 | . | +.+ | . | . | . | . | . |
| *Minuartia obtusiloba* | . | . | . | . | . | 3.1 | 1.1 | . | . | . | . | . | . | . | . |
| *Polemonium pulcherrimum* | . | . | +.+ | . | 1.1 | . | . | . | 3.1 | . | . | . | . | . | . |
| (*Potentilla hookeriana*) | 1.1 | 1.1 | 2.1 | . | +.1 | +.1 | 3.1 | 4.1 | +.1 | +.1 | . | . | . | . | . |
| (*Potentilla virgulata*) | . | . | . | . | +.1 | . | +.+ | . | +.+ | . | . | . | . | . | . |
| (*Ranunculus pedatifidus*) | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . |
| (D)(*Lecanora epibryon*) | +.+ | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Association 25 charac. species:** | | | | | | | | | | | | | | | |
| (C) *Agrostis borealis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 |
| *Carex rupestris* | . | . | . | . | . | +.+ | . | . | . | . | 3.1 | 3.1 | 3.1 | 1.1 | 3.1 |
| (*Cerastium beeringianum*) | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | 1.1 |
| *Draba alpina* | . | . | . | . | . | . | . | . | . | . | +.+ | +.+ | +.+ | +.+ | 1.+ |
| (*Dryas integrifolia*) | . | . | . | . | . | . | . | . | . | . | . | 3.3 | . | . | +.2 |
| *Festuca "vivipara"* | . | . | . | . | . | +.+ | . | . | . | . | 3.1 | 3.1 | 4.1 | . | 2.1 |
| (*Kobresia myosuroides*) | . | . | . | . | . | . | . | . | . | . | 1.1 | . | . | 2.2 | 1.1 |
| (*Lloydia serotina*) | . | . | . | . | . | . | . | . | . | . | 1.+ | 3.+ | 3.+ | . | 3.+ |
| *Melandrium affine* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2.+ |
| (*Parrya nudicaulis*) | . | . | . | . | . | . | . | . | . | . | +.+ | . | +.1 | . | 1.1 |
| (*Pedicularis kanei*) | . | . | . | . | . | . | . | . | . | . | . | 1.+ | . | . | +.1 |
| *Poa arctica* | . | . | . | . | . | +.+ | . | . | . | . | +.+ | . | 1.+ | +.+ | +.+ |
| *Poa arctica f. vivipara* | . | . | . | . | . | . | . | . | . | . | +.+ | . | +.+ | . | +.+ |
| *Potentilla uniflora* | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | +.1 |
| *Salix arctica* | . | . | . | . | . | . | . | . | . | . | 1.1 | 2.3 | . | . | . |
| *Saxifraga oppositifolia* | . | . | . | +.1 | . | . | . | +.1 | . | . | 1.1 | 3.2 | 3.2 | 1.2 | 4.2 |
| *Saxifraga reflexa* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2.1 |
| (*Saussurea viscida*) | . | . | . | . | . | . | . | . | . | . | +.1 | . | 2.1 | . | . |
| *Senecio fuscatus* | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . | 1.1 |
| (D) *Cornicularia aculeata* | . | . | . | . | . | +.+ | . | . | . | . | +.+ | +.1 | +.+ | . | +.+ |
| (*Dactylina arctica*) | . | . | . | . | . | . | . | . | . | . | 1.1 | +.1 | +.1 | . | . |
| *Dactylina ramulosa* | . | . | . | . | . | . | . | . | . | . | +.1 | . | +.1 | . | +.1 |
| *Lecidea granulosa* | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | 2.1 |
| **Companion species:** | | | | | | | | | | | | | | | |
| (C) *Agropyron boreale* | . | . | . | . | +.1 | . | . | . | . | . | . | . | . | . | . |
| *Gentiana propinqua* | . | . | . | . | +.+ | +.+ | . | . | . | . | . | . | . | . | . |
| *Gentiana prostrata* | . | . | . | . | +.+ | +.+ | . | . | . | . | . | . | . | . | . |
| *Myosotis alpestris* | . | . | . | . | 1.1 | . | . | . | . | . | . | . | . | . | . |
| *Saxifraga tricuspidata* | +.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Senecio lugens* | . | . | . | . | . | +.+ | . | . | . | 1.1 | . | . | . | . | . |
| (D) *Cladonia pocillum* | . | . | . | . | . | . | . | . | . | . | +.1 | . | . | . | . |
| *Fulgensia bracteata* | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . |
| *Physcia muscigena* | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . |
| *Solorina spongiosa* | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . | . |

Table 48.

| | |
|---|---|
| Order: | 13. AGROPYRETALIA VIOLACEI |
| Alliance: | 17. Agropyrion violacei |
| Association: | 26. Agropyretum violacei |

| Plot number | 62 | 61 | 335 | 321 | 320 |
|---|---|---|---|---|---|
| Hygrotope | 2 | 2 | 2 | 2 | 2 |
| **Order, alliance & association charac. species:** | | | | | |
| *Agropyron violaceum* | 3.1 | 2.1 | 1.1 | +.+ | +.1 |
| (*Artemisia alaskana*) | . | . | . | +.1 | . |
| *Astragalus nutzotinensis* | +.1 | +.1 | . | . | +.1 |
| *Cerastium beeringianum* | 1.1 | 1.1 | 1.+ | . | +.+ |
| *Crepis nana* | 1.+ | 2.1 | +.1 | +.+ | . |
| (*Cystopteris fragilis*) | . | . | . | . | +.1 |
| *Erigeron purpuratus* | 2.1 | 3.1 | 1.1 | +.1 | 1.1 |
| (*Festuca brachyphylla*) | +.+ | +.+ | . | . | . |
| *Melandrium apetalum* | . | +.1 | +.1 | +.1 | . |
| (*Saxifraga tricuspidata*) | . | . | +.1 | . | . |
| *Smelowskia borealis* | 1.+ | +.+ | 1.1 | . | 1.+ |
| *Stellaria longipes* | 1.+ | 2.1 | +.+ | +.+ | 2.2 |
| (*Stellaria monantha*) | . | +.+ | . | . | . |
| **Companion species:** | | | | | |
| *Draba alpina* | . | . | +.+ | . | . |
| *Oxytropis huddelsonii* | . | . | +.1 | . | . |
| *Papaver macounii* | . | . | +.1 | . | . |
| *Saxifraga oppositifolia* | . | . | +.1 | . | . |
| *Trisetum spicatum* | . | +.+ | . | . | . |

Species in brackets are relatively less characteristic.

Table 49.

Order: 14. FESTUCETALIA ALTAICAE

Alliance: 18. Festucion altaicae

Association: 27. Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae

| Plot number | 317 | 37 | 301 | 40 | 316 | 318 | 319 | 130 | 131 | 133 |
|---|---|---|---|---|---|---|---|---|---|---|
| Hygrotope | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 |
| **Order, alliance & association charac. species:** | | | | | | | | | | |
| (C)(*Anemone parviflora*) | 2.+ | 1.+ | 2.+ | 1.+ | 2.+ | 3.+ | 2.+ | 2.+ | 3.+ | 3.+ |
| (*Antennaria monocephala*) | 1.+ | +.+ | 1.+ | +.+ | . | 1.+ | . | +.+ | +.+ | +.+ |
| (*Artemisia arctica*) | 3.1 | 2.1 | 3.2 | 4.1 | 4.2 | 3.1 | 4.2 | 3.1 | 4.1 | 2.1 |
| (*Aster sibiricus*) | . | . | . | +.1 | . | +.1 | 1.+ | . | . | . |
| (*Carex membranacea*) | . | . | 2.1 | +.+ | . | +.+ | +.+ | . | . | . |
| (*Carex scirpoidea*) | +.1 | 4.1 | . | . | 1.1 | 1.1 | 1.1 | +.+ | 1.+ | 1.1 |
| (*Castilleja hyperborea*) | . | 1.1 | 2.1 | . | . | 1.1 | +.1 | . | +.+ | +.1 |
| (*Claytonia sarmentosa*) | . | . | . | +.+ | . | . | . | . | +.+ | +.+ |
| *Delphinium brachycentrum* | . | . | . | . | 2.1 | . | 1.1 | . | . | . |
| *Draba lanceolata* | . | +.+ | . | . | . | . | . | . | . | . |
| (*Dryas integrifolia*) | 2.2 | . | 1.2 | +.2 | 2.2 | 1.2 | . | +.1 | 1.2 | 2.2 |
| (*Equisetum scirpoides*) | 1.+ | 1.+ | . | 3.+ | 1.+ | 1.+ | 1.+ | 1.+ | 2.+ | 2.+ |
| *Erigeron eriocephalus* | . | . | . | . | . | . | . | . | +.+ | . |
| (*Erigeron humilis*) | 1.+ | 1.+ | 1.+ | 1.+ | +.+ | 1.+ | +.+ | 1.+ | 2.+ | 1.+ |
| *Festuca altaica* | 8.3 | 7.2 | 8.3 | 8.2 | 8.3 | 8.3 | 8.3 | 8.4 | 8.3 | 8.4 |
| (*Gentiana propinqua*) | 2.+ | 1.+ | 2.+ | . | 2.+ | 1.+ | 2.+ | +.+ | +.+ | +.+ |
| (*Gentiana prostrata*) | 1.+ | . | 2.+ | . | 1.+ | 1.+ | . | . | . | . |
| *Hedysarum alpinum* | 4.1 | 2.+ | 3.2 | . | 4.1 | 4.2 | 3.1 | 3.1 | 4.1 | 3.1 |
| (*Kobresia myosuroides*) | 3.2 | . | 3.2 | 1.2 | +.1 | 1.2 | 1.2 | 3.3 | . | 2.2 |
| (*Mertensia paniculata*) | 1.1 | 2.1 | 3.2 | 2.1 | 2.1 | 1.1 | 2.1 | 3.2 | 3.1 | 2.1 |
| (*Minuartia rossii*) | . | . | +.+ | . | . | . | . | . | . | +.+ |
| *Myosotis alpestris* | . | 2.+ | . | 2.1 | 2.1 | +.+ | 1.+ | 1.+ | 1.+ | 2.+ |
| *Oxytropis deflexa* | +.+ | +.+ | 2.+ | . | 1.+ | +.+ | 1.+ | 2.+ | 3.+ | 2.+ |
| (*Parnassia kotzebuei*) | 1.+ | 1.+ | +.+ | +.+ | 1.+ | +.+ | +.+ | 1.+ | +.+ | 1.+ |
| (*Pedicularis capitata*) | +.1 | 1.1 | . | 2.1 | +.+ | +.+ | . | . | 1.1 | . |
| (*Poa alpina*) | . | +.+ | . | . | . | . | . | . | +.+ | +.+ |
| (*Poa arctica*) | . | +.+ | . | +.+ | . | +.+ | +.+ | 1.+ | . | 2.1 |
| *Polemonium boreale* | . | . | 2.2 | . | . | . | . | . | . | . |
| (*Polygonum viviparum*) | 1.+ | +.+ | . | +.+ | 1.+ | 1.+ | +.+ | . | +.+ | +.+ |
| (*Potentilla fruticosa*) | +.1 | . | . | . | +.1 | . | 1.1 | . | . | . |
| (*Salix polaris*) | . | 1.1 | 1.1 | . | . | +.1 | . | . | +.1 | . |
| (*Salix reticulata*) | 5.3 | 6.4 | 6.4 | 5.3 | 4.3 | 5.3 | 5.4 | 6.4 | 7.4 | 5.4 |
| (*Saussurea viscida*) | . | . | 1.1 | . | 1.1 | . | +.1 | +.1 | 1.1 | 2.1 |
| (*Sedum roseum*) | . | . | . | . | . | . | +.1 | . | +.1 | +.1 |
| (*Senecio lugens*) | +.1 | 2.+ | . | +.+ | 1.1 | 1.1 | 1.+ | 3.1 | 3.1 | 2.1 |
| (*Silene acaulis*) | +.+ | 1.2 | 2.2 | 1.2 | . | . | . | . | . | +.1 |
| *Solidago multiradiata* | 2.+ | +.1 | 2.1 | +.1 | 3.1 | 2.1 | 3.1 | +.1 | 1.1 | 1.1 |
| *Stellaria edwardsii* | . | 1.+ | . | +.+ | +.+ | 1.+ | . | +.+ | 1.+ | . |
| (*Trisetum spicatum*) | +.+ | 1.+ | 2.+ | +.+ | +.+ | +.+ | +.+ | 1.+ | 1.+ | 2.+ |
| (*Zygadenus elegans*) | 3.1 | . | 3.2 | . | 3.1 | 4.2 | 3.1 | +.1 | . | . |
| (D)(*Cladonia pocillum*) | +.+ | +.+ | . | . | . | . | . | +.+ | +.+ | +.+ |
| (*Distichium capillaceum*) | . | 1.1 | 2.1 | +.+ | . | . | 1.1 | 1.1 | . | 1.1 |
| (*Peltigera canina*) | 1.1 | 1.+ | . | . | . | +.+ | . | . | +.+ | . |
| (*Timmia austriaca*) | 1.1 | . | . | +.+ | 1.1 | . | . | . | . | . |
| **Companion species:** | | | | | | | | | | |
| (C) *Achillea borealis* | . | . | . | . | . | . | +.1 | . | . | . |
| *Arctostaphylos alpina* | 2.2 | . | . | . | . | . | . | . | . | . |
| *Arnica alpina* | . | +.1 | . | . | . | . | . | . | . | . |
| *Astragalus umbellatus* | . | +.+ | . | . | . | . | . | . | . | . |
| *Carex microchaeta* | . | . | . | . | 2.1 | . | . | . | . | . |
| *Dodecatheon frigidum* | . | 3.1 | . | 3.1 | . | . | . | . | . | . |
| *Festuca "vivipara"* | . | . | . | . | . | . | . | +.+ | +.+ | . |
| *Oxyria digyna* | . | . | . | +.+ | . | . | . | . | . | . |
| *Parrya nudicaulis* | . | . | . | . | +.1 | . | . | . | . | +.1 |
| *Poa lanata* | . | . | . | . | . | . | . | . | . | +.+ |
| *Potentilla diversifolia* | . | . | . | . | . | . | +.1 | . | . | . |
| *Saxifraga hieracifolia* | . | . | . | . | . | . | . | +.1 | . | . |
| *Valeriana capitata* | . | . | 2.1 | . | +.1 | . | . | . | . | . |
| (D) *Cetraria tilesii* | . | . | . | . | . | . | . | . | . | +.+ |
| *Dactylina arctica* | . | . | . | . | +.1 | . | . | . | . | . |
| *Stereocaulon glareosum* | . | . | 1.1 | . | . | . | . | . | . | . |

Species in brackets are relatively less characteristic.

Table 50.

Order: 15. SALICETALIA BARRATTIANAE

Alliance: 19. Salicion barrattianae

Association: 28. Salicetum barrattianae

| Plot number | 307 | 308 | 303 | 304 | 302 | 310 | 312 | 129 | 132 | 134 |
|---|---|---|---|---|---|---|---|---|---|---|
| Hygrotope | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ |
| **Order, alliance & association charac. species:** | | | | | | | | | | |
| (B) *Salix barrattiana* | 9.6 | 8.6 | 8.6 | 9.6 | 8.6 | 9.6 | 8.6 | 7.6 | 7.5 | 7.6 |
| *Salix niphoclada* | . | . | 3.2 | . | . | . | . | . | . | . |
| (C)(*Anemone parviflora*) | 1.1 | 3.1 | 2.1 | . | 1.1 | 1.1 | +.1 | 3.1 | 2.1 | 3.1 |
| (*Antennaria monocephala*) | . | 2.1 | . | +.+ | . | +.1 | +.+ | +.+ | 1.+ | 1.+ |
| (*Artemisia arctica*) | +.1 | 1.1 | 2.1 | 1.1 | 2.1 | 2.1 | 2.1 | 1.1 | 2.1 | 3.1 |
| (*Carex scirpoidea*) | 1.1 | 2.1 | 2.1 | 2.1 | 4.1 | 2.1 | 1.1 | 3.1 | 2.1 | 3.1 |
| (*Dryas integrifolia*) | . | 2.3 | 4.3 | 2.2 | . | . | 3.3 | . | . | . |
| (*Equisetum scirpoides*) | . | 2.+ | 1.+ | 1.+ | 2.+ | 1.+ | 1.+ | 1.+ | . | 1.+ |
| (*Erigeron humilis*) | . | . | +.+ | +.+ | . | +.+ | +.+ | . | . | +.+ |
| (*Festuca altaica*) | 4.2 | 4.2 | 3.2 | 2.2 | 3.2 | 4.3 | 4.2 | 4.3 | 4.3 | . . |
| (*Gentiana propinqua*) | +.+ | 2.+ | 2.+ | +.+ | +.+ | . | 1.+ | +.+ | +.+ | +.+ |
| *Gentiana prostrata* | 1.+ | 2.+ | 1.+ | 1.+ | 1.+ | 2.1 | 1.+ | . | . | . |
| (*Hedysarum alpinum*) | 3.1 | 4.2 | 1.1 | 2.1 | 2.1 | 2.1 | 4.1 | 2.1 | 3.1 | 1.1 |
| *Kobresia myosuroides* | 5.2 | 1.2 | 2.2 | 2.2 | 3.2 | 5.3 | 3.2 | 6.3 | 7.3 | 5.3 |
| (*Lupinus arcticus*) | . | . | . | . | . | 2.2 | . | . | . | . |
| (*Mertensia paniculata*) | 2.1 | 2.1 | 2.1 | 1.1 | 2.1 | 3.1 | +.1 | 3.1 | 3.1 | 2.1 |
| (*Myosotis alpestris*) | . | . | . | +.+ | . | 1.+ | . | . | . | +.+ |
| (*Oxytropis deflexa*) | 1.1 | . | 2.1 | +.+ | . | . | +.1 | 1.+ | 3.1 | 3.1 |
| (*Parnassia kotzebuei*) | . | . | 2.+ | . | 1.+ | . | . | +.+ | . | . |
| (*Pedicularis capitata*) | 1.1 | 1.1 | 2.1 | 1.1 | 2.1 | +.+ | 1.+ | +.+ | +.+ | . |
| (*Poa arctica*) | +.+ | . | +.+ | +.+ | . | . | . | . | 1.+ | +.+ |
| (*Polemonium boreale*) | . | . | . | . | 2.1 | . | . | . | . | . |
| (*Polygonum viviparum*) | . | 1.+ | +.+ | +.+ | +.+ | . | . | . | +.+ | . |
| (*Potentilla fruticosa*) | 2.2 | 1.2 | 2.2 | 1.2 | +.1 | 2.2 | . | . | 1.2 | . |
| (*Salix reticulata*) | 2.3 | 5.4 | 4.3 | 4.3 | 5.4 | 3.3 | 5.5 | 3.3 | +.1 | 2.2 |
| (*Saussurea viscida*) | . | +.1 | . | . | . | +.1 | . | 1.1 | 3.1 | 2.1 |
| (*Senecio lugens*) | +.1 | +.1 | 1.1 | 1.1 | 1.1 | +.1 | +.1 | 2.1 | 2.1 | 2.1 |
| (*Silene acaulis*) | . | 1.1 | . | . | . | . | +.1 | . | +.1 | 4.2 |
| (*Solidago multiradiata*) | . | +.1 | +.1 | 1.1 | +.1 | 2.1 | 2.1 | +.1 | 1.1 | 1.1 |
| *Stellaria laeta* | . | +.+ | . | . | . | . | +.+ | +.+ | +.+ | +.+ |
| (*Trisetum spicatum*) | . | +.1 | 2.1 | 1.1 | 2.1 | 1.1 | +.+ | 1.1 | +.1 | 1.1 |
| (*Valeriana capitata*) | . | 2.1 | . | 1.1 | 1.1 | . | . | . | . | . |
| (*Zygadenus elegans*) | 3.2 | 2.2 | 2.2 | 2.1 | 3.2 | 3.2 | +.1 | 2.1 | . | . |
| (D) *Cetraria islandica* | . | . | . | . | . | . | . | +.1 | . | . |
| (*Cladonia pocillum*) | 3.1 | . | . | +.1 | . | . | +.1 | +.+ | +.+ | +.+ |
| (*Distichium capillaceum*) | 1.1 | +.1 | . | +.1 | . | +.+ | +.1 | . | +.1 | . |
| (*Peltigera canina*) | 1.1 | . | +.1 | 1.1 | . | . | +.1 | +.1 | +.1 | +.1 |
| **Companion species:** | | | | | | | | | | |
| (C) *Arctostaphylos alpina* | 1.2 | +.2 | . | . | . | . | . | . | . | . |
| *Arnica alpina* | . | . | . | . | . | . | . | . | . | 1.+ |
| *Artemisia hyperborea* | . | . | . | . | . | . | . | . | . | +.1 |
| *Carex microchaeta* | . | . | . | . | 1.+ | . | . | . | . | . |
| *Castilleja hyperborea* | . | . | . | . | . | +.1 | . | . | . | +.1 |
| *Draba cinerea* | . | . | . | . | . | . | . | . | . | +.+ |
| *Epilobium latifolium* | . | . | . | . | . | . | . | . | +.+ | . |
| *Equisetum arvense* | . | . | . | . | 2.+ | . | . | . | . | . |
| *Festuca brachyphylla* | . | . | . | . | . | . | . | . | . | +.1 |
| *Festuca "vivipara"* | . | . | . | . | . | . | . | . | +.+ | 1.+ |
| *Minuartia rossii* | . | . | . | . | . | . | . | . | . | 1.+ |
| *Oxytropis viscida* | . | . | . | . | . | . | . | 2.1 | . | 1.1 |
| *Poa alpina* | . | . | . | . | . | . | +.+ | . | +.+ | . |
| *Poa lanata* | . | . | . | . | +.+ | . | . | . | . | . |
| *Salix dodgeana* | . | . | . | . | . | . | . | . | . | 2.2 |
| *Saxifraga reflexa* | . | . | . | . | . | . | . | . | . | +.+ |
| (D) *Solorina spongiosa* | 1.1 | . | . | . | . | . | . | . | . | . |

Species in brackets are relatively less characteristic.

TABLE 51

Order: 16. SALICETALIA POLARIS

Alliance: 20. Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicion polaris | 21. Senecione (lugentis) - Salicion polaris - reticulatae

Association: 29. Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris | 30. Senecione (lugentis) - Salicetum polaris - reticulatae

| Plot number | 315 | 41 | 323 | 42 | 325 | 324 | 333 | 326 | 334 | 43 | 38 | 39 | 309 | 313 | 311 | 322 | 314 | 305 | 45 | 136 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hygrotope | 4 | 3/4 | 3/4 | 4+ | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 4+ | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 4 | 3/4 | 3/4 | 3/4 |
| **Order charac. species:** | | | | | | | | | | | | | | | | | | | | |
| (C) *Anemone parviflora* | 2.+ | 2.+ | 2.+ | +.+ | 2.+ | 2.+ | 1.+ | 2.1 | 2.+ | +.+ | 4.1 | 3.1 | 2.+ | 3.1 | 2.+ | 2.1 | 2.1 | 2.+ | 2.+ | 2.+ |
| *Antennaria monocephala* | 3.+ | +.+ | 2.+ | +.+ | 2.+ | 2.+ | 2.+ | 2.+ | 1.+ | +.+ | +.+ | +.+ | . | 2.+ | 1.+ | 1.+ | . | 1.+ | +.+ | . |
| (*Artemisia arctica*) | 2.1 | 4.2 | 2.1 | +.1 | 3.1 | 2.1 | 1.+ | 2.1 | +.+ | +.+ | 1.1 | 3.2 | 4.2 | 3.2 | 3.2 | 4.3 | 3.1 | 4.2 | 1.1 | 3.1 |
| (*Carex membranacea*) | +.+ | +.+ | 3.1 | . | 3.1 | 3.1 | 3.1 | 3.1 | 4.1 | 2.+ | +.1 | 1.1 | 1.1 | 4.3 | +.+ | 1.1 | +.+ | 5.2 | 1.1 | . |
| (*Carex scirpoidea*) | 1.1 | +.+ | +.+ | +.+ | 3.1 | 2.1 | . | 2.+ | . | . | +.1 | +.+ | 2.1 | 1.1 | 2.1 | . | 3.1 | +.+ | +.+ | 3.1 |
| (*Dodecatheon frigidum*) | . | +.1 | . | . | . | . | . | . | . | . | . | 2.2 | . | 2.2 | . | . | 2.1 | . | . | . |
| *Draba hirta* | . | . | . | +.+ | . | . | . | +.+ | +.+ | . | . | . | . | . | . | . | . | . | +.+ | . |
| (*Dryas integrifolia*) | . | . | . | . | +.1 | . | +.2 | . | . | 1.1 | . | . | . | . | . | . | . | . | +.2 | 2.2 |
| *Erigeron humilis* | 3.+ | +.+ | 3.+ | +.+ | 1.+ | 1.+ | +.+ | 1.+ | 2.+ | +.+ | . | +.+ | +.+ | +.+ | 1.+ | +.+ | 2.1 | 1.1 | 1.+ | 1.+ |
| *Equisetum variegatum* | . | 1.+ | 2.+ | +.+ | . | . | . | . | . | . | . | . | +.+ | . | +.+ | . | . | 1.+ | . | . |
| *Gentiana propinqua* | . | . | +.+ | . | 1.+ | 1.+ | . | . | . | . | . | +.+ | 2.+ | 2.+ | 2.+ | 1.+ | 2.+ | 2.+ | +.+ | +.+ |
| (*Gentiana prostrata*) | . | . | . | . | +.+ | . | . | 1.+ | . | . | . | . | +.+ | . | 1.+ | . | . | . | +.+ | . |
| *Lloydia serotina* | 2.+ | 4.+ | 1.+ | . | 1.+ | 2.+ | 2.+ | 2.+ | 2.+ | 1.+ | +.+ | . | 1.+ | 1.+ | 1.+ | 1.+ | . | 3.+ | +.+ | . |
| (*Mycosotis alpestris*) | . | 1.1 | +.1 | . | . | . | +.1 | . | +.+ | . | . | +.+ | . | . | 1.1 | 1.1 | 1.1 | 3.+ | 2.+ | +.+ |
| (*Oxyria digyna*) | 1.1 | 4.2 | 2.1 | 3.2 | 4.2 | 4.2 | 4.2 | 3.1 | 3.1 | 3.1 | 4.1 | 3.1 | 2.1 | 3.1 | . | . | . | . | +.+ | +.1 |
| (*Oxytropis deflexa*) | . | . | +.1 | . | +.+ | . | 1.1 | . | +.+ | +.+ | . | . | . | 1.1 | +.1 | 1.2 | . | +.+ | 2.1 | 1.1 |
| *Parnassia kotzebuei* | +.+ | +.+ | 1.+ | . | 1.+ | 2.+ | +.+ | 1.+ | . | . | 1.+ | +.+ | 1.+ | 2.+ | 2.+ | 3.+ | 2.+ | 3.+ | 1.+ | +.+ |
| (*Pedicularis capitata*) | . | 1.1 | . | . | +.+ | +.+ | . | 1.1 | . | . | 2.1 | 2.1 | 1.+ | . | 2.1 | 3.1 | 2.+ | +.+ | . | . |
| (*Petasites frigidus*) | 3.2 | 4.2 | . | . | +.2 | 1.2 | . | 3.2 | . | . | 3.3 | 3.3 | 2.1 | 3.2 | 2.1 | . | 3.2 | +.1 | . | . |
| (*Poa alpina*) | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | 1.+ | +.+ | 2.1 | 3.1 | . | . |
| (*Polemonium acutiflorum*) | . | . | . | . | . | . | . | +.1 | . | . | . | . | . | +.1 | . | +.+ | +.1 | +.1 | . | . |
| (*Polygonum viviparum*) | . | . | . | . | 1.+ | 1.+ | 3.+ | 1.+ | 1.+ | . | . | +.+ | 2.+ | 2.+ | . | . | 3.+ | 1.+ | +.+ | +.+ |
| *Salix polaris* | 9.6 | 8.4 | 8.4 | 8.4 | 8.5 | 8.4 | 8.4 | 9.5 | 8.4 | 7.3 | 3.2 | 5.3 | . | 3.2 | 5.3 | 4.3 | 3.2 | 4.3 | 1.2 | 2.2 |
| *Salix reticulata* | 2.3 | 3.3 | 2.3 | . | +.2 | . | +.2 | 1.3 | +.2 | 1.3 | 8.6 | 7.4 | 8.4 | 8.4 | 9.4 | 8.5 | 9.5 | 8.4 | 8.4 | 8.5 |
| *Saussurea viscida* | +.+ | +.1 | . | . | 3.1 | 2.1 | 1.1 | 3.1 | 2.1 | +.+ | +.1 | +.1 | +.1 | . | 1.+ | . | . | +.+ | 1.+ | 2.1 |
| (*Silene acaulis*) | 1.2 | +.2 | 1.2 | 1.2 | 2.2 | 1.+ | 1.1 | 2.2 | 1.2 | . | +.1 | 2.2 | . | . | . | +.2 | . | . | +.2 | 1.2 |
| (*Trisetum spicatum*) | . | +.+ | +.+ | +.+ | +.+ | +.+ | 2.1 | 1.1 | 1.1 | +.1 | +.+ | +.+ | 2.1 | 1.+ | +.+ | 3.1 | 1.+ | 3.1 | 2.1 | 1.+ |
| (D) *Distichium capillaceum* | 4.2 | 2.1 | 4.2 | +.1 | 3.2 | 4.2 | +.1 | 1.2 | +.1 | +.1 | +.1 | 2.1 | +.1 | +.2 | 2.1 | 1.2 | +.1 | . | . | . |
| (*Lecanora epibryon*) | . | . | . | . | . | 2.+ | 1.+ | . | . | . | +.+ | +.1 | . | . | . | . | . | . | . | +.+ |
| (*Peltigera canina*) | 2.1 | . | 3.2 | . | 2.1 | 1.1 | 1.1 | +.1 | 2.1 | . | . | +.+ | . | . | +.1 | . | . | . | . | +.1 |
| *Solorina spongiosa* | . | . | +.+ | . | +.+ | +.+ | +.1 | . | +.1 | . | +.+ | +.1 | . | . | . | . | . | . | . | +.1 |
| (*Timmia austriaca*) | +.1 | 1.+ | 2.1 | . | 2.1 | 2.1 | 1.+ | +.+ | +.+ | . | +.1 | . | +.+ | +.1 | . | . | +.1 | . | . | . |
| **Alliance 20 & association 29 charac. species:** | | | | | | | | | | | | | | | | | | | | |
| (C) *Arnica lessingii* | . | . | . | +.1 | +.1 | +.1 | . | 1.1 | . | . | . | . | . | . | . | . | . | . | . | . |
| (*Carex podocarpa*) | . | . | . | . | +.1 | +.1 | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . |
| *Papaver macounii* | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (*Parrya nudicaulis*) | . | +.+ | . | . | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | . | . | . | . | . | . | . | . | . | +.1 | . |
| (*Pedicularis kanei*) | . | . | . | 2.1 | 1.1 | 1.1 | +.+ | 3.1 | . | . | . | . | . | . | . | . | . | . | . | . |
| (*Poa arctica*) | +.+ | +.+ | . | . | +.+ | +.+ | +.+ | . | +.+ | . | . | . | . | . | . | . | . | . | . | . |
| *Ranunculus nivalis* | . | . | . | 1.+ | +.+ | . | . | . | 1.+ | . | . | . | . | . | . | . | . | . | . | . |
| *Ranunculus pygmaeus* | . | . | . | 1.+ | +.+ | . | . | . | . | 1.+ | . | . | . | . | . | . | . | . | . | . |
| (*Saxifraga davurica*) | . | +.+ | . | . | . | +.+ | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . |
| (*Saxifraga oppositifolia*) | 2.2 | +.1 | +.2 | 5.2 | 2.2 | 1.1 | 1.1 | 2.2 | 2.1 | 5.2 | . | . | . | . | . | . | . | . | . | +.1 |
| *Senecio atropurpureus* | . | . | . | . | +.1 | 1.1 | 1.1 | 1.1 | 1.1 | . | . | . | . | . | . | . | . | . | . | . |
| *Taraxacum alaskanum* | 1.+ | . | +.+ | +.1 | . | +.1 | . | +.+ | 1.1 | . | . | . | . | . | . | . | . | . | . | . |
| (D) (*Cladonia pocillum*) | . | . | . | . | 1.1 | . | +.1 | . | +.1 | . | . | . | . | . | . | . | . | . | . | . |
| (*Dermatocarpon hepaticum*) | . | . | 1.1 | . | 2.+ | 2.+ | 1.+ | . | 1.1 | . | . | . | . | . | . | . | . | . | . | . |
| (*Stereocaulon glareosum*) | 2.1 | +.+ | 2.2 | . | 2.1 | 3.2 | 3.1 | 1.1 | 2.1 | . | . | . | . | . | . | . | . | . | . | . |
| **Alliance 21 & association 30 charac. species:** | | | | | | | | | | | | | | | | | | | | |
| (C) (*Achillea borealis*) | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . | . | . | +.1 | . | . |
| (*Anemone richardsonii*) | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . |
| (*Carex microchaeta*) | . | . | . | . | . | . | +.+ | . | . | . | +.1 | +.1 | +.1 | 1.1 | +.+ | 2.1 | . | . | . | . |
| (*Castilleja hyperborea*) | . | +.+ | . | . | . | . | . | . | . | . | . | . | +.+ | 1.1 | 2.1 | 3.1 | . | 1.1 | 1.1 | +.+ |
| (*Epilobium latifolium*) | . | . | . | . | . | . | . | . | . | . | +.1 | 1.1 | . | . | . | . | . | . | 1.1 | 1.1 |
| (*Equisetum arvense*) | . | . | . | . | . | . | . | . | . | . | . | . | 1.+ | . | 1.+ | +.1 | 2.+ | . | . | . |
| (*Equisetum scirpoides*) | . | 1.+ | . | . | . | . | . | . | +.+ | . | 3.+ | 4.1 | 1.+ | 2.1 | 1.+ | 2.+ | 2.1 | 2.+ | 1.+ | 1.+ |
| (*Festuca altaica*) | . | . | . | . | . | . | . | . | . | . | 1.2 | 2.2 | 3.2 | 2.2 | +.1 | 1.1 | 1.1 | . | . | . |
| (*Hedysarum alpinum*) | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . | +.1 | 1.1 | . | . | 3.1 |
| (*Hertensia paniculata*) | . | . | . | . | . | . | . | . | . | . | +.1 | . | 2.1 | 1.1 | 2.2 | 1.1 | . | . | +.1 | 1.1 |
| *Minuartia biflora* | . | . | . | . | . | . | . | . | . | . | . | 1.1 | . | . | 1.1 | . | . | . | . | . |
| (*Poa lanata*) | . | . | . | . | . | . | . | . | . | . | +.1 | +.1 | 1.+ | 2.1 | +.+ | +.1 | . | 3.1 | 3.1 | 3.1 |
| (*Potentilla diversifolia*) | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2.1 | . | . |
| *Senecio lugens* | . | . | +.1 | . | . | . | . | . | . | . | +.1 | +.1 | +.1 | 2.1 | 1.1 | 3.1 | 2.1 | 3.1 | 2.1 | 1.1 |
| (*Solidago multiradiata*) | . | . | . | . | . | . | . | . | . | . | . | . | 1.1 | +.+ | +.+ | +.1 | . | +.+ | +.+ | +.+ |
| *Valeriana capitata* | . | . | . | . | . | . | . | . | . | . | . | . | 1.1 | 1.1 | 1.1 | 1.1 | 2.1 | . | . | . |
| (D) *Tortula norvegica* | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ | +.1 | . | +.1 | . | . | +.1 |
| Companion species: | | | | | | | | | | | | | | | | | | | | |
| (C) *Astragalus nutzotinensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2.1 | . |
| *Cardamine purpurea* | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Claytonia sarmentosa* | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.+ |
| *Draba stenoloba* | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Eriophorum angustifolium* | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sedum roseum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | +.1 | . | . |
| *Zygodenus elegans* | . | . | . | . | . | . | . | . | . | . | . | . | 1.1 | . | 1.1 | . | . | . | . | . |
| (D) *Brachythecium turgidum* | . | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Cetraria cucullata* | . | . | . | . | . | . | . | . | . | . | . | +.+ | . | . | . | . | . | . | . | . |
| *Rhium blythii* | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Pohlia* sp. | . | . | . | +.+ | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

Species in brackets are relatively less characteristic.

Table 52

Order: 17. PETASITETALIA FRIGIDI

Alliance: 22. Oxyrio (digynae) - Artemision arcticae - tilesii | 23. Saxifrago (hirculi) - Caricion membranaceae

Association: 31. Oxyrio (digynae) - Artemisietum arcticae - tilesii | 32. Saxifrago (hirculi) - Caricetum membranaceae

| Plot number | 340 | 63 | 64 | 65 | 344 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|---|---|---|
| Hygrotope | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 4 | 4+ | 4 | 4+ | 4 |
| **Order charac. species:** | | | | | | | | | | |
| (C)(*Anemone parviflora*) | 2.+ | 3.1 | 2.+ | 1.+ | 3.1 | +.+ | +.+ | . | . | 1.+ |
| *Anemone richardsonii* | +.+ | . | . | . | . | . | . | . | +.1 | . |
| *Artemisia arctica* | 3.2 | 4.2 | 3.2 | 4.2 | 6.3 | 1.1 | 1.1 | . | . | 3.1 |
| *Astragalus umbellatus* | +.+ | . | . | . | . | . | +.+ | . | . | . |
| *Carex podocarpa* | +.1 | . | . | 2.+ | 2.+ | . | +.1 | +.+ | +.1 | +.+ |
| *Draba praealta* | +.+ | . | +.+ | . | . | . | +.+ | +.+ | . | +.+ |
| *Equisetum arvense* | 1.1 | 4.1 | . | 1.1 | . | 3.1 | 2.+ | +.+ | 4.1 | 2.+ |
| (*Equisetum scirpoides*) | . | +.+ | +.+ | . | . | . | . | . | +.+ | . |
| (*Myosotis alpestris*) | . | . | 1.1 | 2.1 | 2.1 | . | +.+ | . | . | . |
| (*Pedicularis capitata*) | . | . | . | . | +.+ | . | . | . | . | +.1 |
| *Petasites frigidus* | 4.3 | 4.2 | 4.3 | 4.3 | . | 5.2 | 6.2 | 5.2 | 4.2 | 4.2 |
| *Poa alpina* | 2.+ | 1.+ | 1.+ | 2.+ | 1.+ | . | 1.+ | +.+ | . | +.+ |
| *Polemonium acutiflorum* | +.1 | . | +.1 | 1.1 | . | 1.1 | 2.1 | 2.1 | +.+ | 3.1 |
| *Polygonum viviparum* | 2.+ | 1.+ | +.+ | +.+ | +.+ | . | +.+ | +.+ | +.+ | +.+ |
| (*Salix polaris*) | . | 1.2 | 1.2 | . | 1.2 | 1.2 | 1.2 | 1.2 | 4.3 | 3.2 |
| (*Salix reticulata*) | 3.2 | 2.2 | +.2 | 1.2 | 3.2 | 7.3 | 5.3 | 3.2 | 6.3 | 3.2 |
| (*Senecio lugens*) | +.1 | 1.1 | 2.1 | +.1 | 1.1 | 2.1 | +.1 | +.1 | 1.1 | 2.1 |
| (*Valeriana capitata*) | 3.1 | . | . | 1.1 | . | 1.1 | 1.1 | . | . | . |
| (D) *Timmia austriaca* | +.1 | . | +.1 | . | +.1 | 2.2 | 3.2 | 2.1 | 3.2 | 2.1 |
| *Tomentypnum nitens* | +.+ | . | . | . | +.1 | +.1 | +.1 | 1.1 | 2.1 | 2.+ |
| **Alliance 22 & association 31 charac. species:** | | | | | | | | | | |
| (B)(*Salix alaxensis*) | . | +.1 | +.2 | . | . | . | . | . | . | . |
| (C) *Achillea borealis* | +.1 | 1.1 | . | 2.1 | 2.1 | . | . | . | . | . |
| *Aconitum delphinifolium* | 1.2 | 2.2 | +.1 | 4.2 | . | . | . | . | . | . |
| (*Agropyron violaceum*) | +.1 | +.1 | . | . | . | . | . | . | . | . |
| *Alopecurus alpinus* | . | . | . | 1.+ | . | . | . | . | . | . |
| *Arnica alpina* | . | +.1 | . | . | . | . | . | . | . | . |
| *Artemisia tilesii* | 7.3 | 6.3 | 5.3 | 5.3 | 7.4 | . | . | . | . | . |
| *Aster sibiricus* | 1.1 | 1.1 | +.+ | . | 2.1 | . | . | . | . | . |
| (*Castilleja hyperborea*) | . | +.+ | 2.1 | +.+ | +.+ | . | . | . | . | . |
| *Delphinium glaucum* | 1.1 | . | +.1 | 4.2 | . | . | . | . | . | . |
| *Epilobium latifolium* | 3.3 | 6.3 | 5.4 | 3.2 | 4.2 | . | . | . | . | . |
| (*Erigeron humilis*) | 1.+ | +.1 | 1.+ | 1.+ | 2.1 | . | . | . | . | . |
| (*Festuca altaica*) | . | 1.1 | +.1 | +.1 | 1.2 | . | +.2 | . | . | . |
| (*Gentiana propinqua*) | +.+ | +.+ | 1.+ | +.+ | 2.+ | . | +.+ | . | . | . |
| (*Hedysarum alpinum*) | 1.1 | . | . | . | +.1 | . | . | . | . | . |
| *Hierochloe odorata* | . | +.+ | . | . | . | . | . | . | . | . |
| *Mertensia paniculata* | 5.3 | 4.3 | 5.3 | 4.2 | 5.2 | . | . | . | . | . |
| (*Minuartia biflora*) | . | +.1 | . | . | . | . | . | . | . | . |
| *Oxyria digyna* | 1.2 | 5.4 | 4.2 | 4.3 | 2.2 | . | . | . | . | . |
| (*Parnassia kotzebuei*) | 1.+ | 2.1 | 2.1 | +.+ | +.+ | . | +.+ | . | . | . |
| (*Poa arctica*) | . | +.+ | +.+ | . | . | . | . | . | . | . |
| *Poa lanata* | 3.+ | 3.+ | 2.+ | 2.+ | 1.+ | . | . | . | . | . |
| *Poa paucispicula* | . | +.+ | +.+ | . | . | . | . | . | . | . |
| *Potentilla diversifolia* | . | . | . | +.1 | 1.1 | . | . | . | . | . |
| *Ranunculus sulphureus* | 1.+ | . | . | 1.+ | . | . | . | . | . | . |
| *Sedum roseum* | 3.2 | 1.2 | 2.2 | 3.2 | 3.2 | . | . | . | . | . |
| (*Solidago multiradiata*) | +.1 | . | . | 2.1 | +.+ | . | . | . | . | . |
| (*Trisetum spicatum*) | 1.+ | 1.+ | 3.+ | 2.+ | 2.+ | . | 1.+ | . | . | . |
| (*Zygadenus elegans*) | 2.1 | +.1 | . | +.1 | 3.1 | . | . | . | . | . |
| (D) *Philonotis tomentella* | +.1 | . | . | +.1 | . | . | . | . | . | . |
| *Plagiomnium rostratum* | +.1 | +.1 | . | +.+ | . | . | . | . | . | . |
| **Alliance 23 & association 32 charac. species:** | | | | | | | | | | |
| (C) *Cardamine purpurea* | . | . | . | . | . | 2.1 | +.1 | 3.1 | 2.1 | 2.1 |
| *Carex membranacea* | . | . | . | . | . | 6.2 | 7.4 | 7.4 | 7.4 | 8.3 |
| *Claytonia bostockii* | . | . | . | +.+ | . | 2.+ | 1.1 | 2.1 | +.+ | 2.+ |
| *Claytonia sarmentosa* | . | . | . | . | . | +.+ | 1.+ | +.+ | +.+ | 1.1 |
| *Dodecatheon frigidum* | . | . | . | . | . | 1.1 | +.1 | . | +.1 | 2.1 |
| (*Dryas integrifolia*) | . | . | . | . | . | +.2 | . | 2.2 | 3.2 | 3.2 |
| (*Equisetum variegatum*) | . | . | . | . | . | . | +.+ | . | 1.+ | . |
| *Eriophorum angustifolium* | . | . | . | . | . | 3.1 | 2.1 | 3.1 | 2.1 | 3.2 |
| *Parrya nudicaulis* | . | . | . | . | . | 2.1 | +.1 | +.1 | . | 2.1 |
| *Pedicularis kanei* | . | . | . | . | . | +.1 | +.1 | +.1 | +.+ | 1.1 |
| *Saxifraga caespitosa* | . | . | . | . | . | . | . | +.1 | . | +.+ |
| *Saxifraga davurica* | . | . | . | . | . | . | . | +.1 | 1.1 | 1.1 |
| *Saxifraga hieracifolia* | . | . | . | 2.1 | . | 2.1 | 2.1 | +.1 | +.1 | 1.1 |
| *Saxifraga hirculus* | . | . | . | . | . | 2.1 | 3.1 | 2.2 | 1.1 | 1.1 |
| (D) *Cetraria richardsonii* | . | . | . | . | . | . | . | . | +.1 | +.1 |
| (*Cladonia pocillum*) | . | . | . | . | . | . | . | +.1 | . | +.+ |
| *Dactylina arctica* | . | . | . | . | . | +.1 | . | +.1 | +.1 | +.1 |
| (*Peltigera canina*) | . | . | . | . | . | . | . | +.1 | . | +.1 |
| (*Stereocaulon glareosum*) | . | . | . | . | . | +.1 | . | +.1 | . | . |
| (*Plagiomnium rugicum*) | . | . | . | . | . | +.1 | . | +.+ | . | . |
| **Companion species:** | | | | | | | | | | |
| (C) *Antennaria monocephala* | . | . | +.+ | . | . | . | . | . | . | . |
| *Carex microchaeta* | . | . | . | . | . | . | . | . | +.+ | . |
| *Carex scirpoidea* | . | . | . | . | . | . | +.+ | . | . | . |
| *Potentilla fruticosa* | . | . | . | . | +.2 | . | . | . | . | . |
| *Salix arctica* | . | +.2 | . | . | . | . | . | . | . | . |
| *Saussurea viscida* | . | . | . | +.1 | . | . | . | . | . | . |
| (D) *Bryum* sp. | . | . | . | . | . | +.+ | . | . | . | . |
| *Ceratodon purpureus* | . | . | +.+ | . | . | . | . | . | . | . |
| ?*Hypnum bridelianum* | . | . | . | . | . | +.+ | . | . | . | . |
| *Thamnolia subuliformis* | . | . | . | . | . | . | . | . | +.+ | . |
| *Tortula norvegica* | . | . | +.+ | . | . | . | . | . | . | . |

Species in brackets are relatively less characteristic.

*LYCOPODIACEAE*

*Lycopodium selago* L. ssp. *selago*

*EQUISETACEAE*

*Equisetum arvense* L.
*Equisetum palustre* L.
*Equisetum pratense* L.
*Equisetum scirpoides* Michx.
*Equisetum variegatum* Schleich.
*Equisetum variegatum* Schleich. ssp. *variegatum*

*ATHYRIACEAE*

*Cystopteris fragilis* (L.) Bernh.
*Cystopteris fragilis* (L.) Bernh. ssp. *dickieana* (Sim) Hyl.

*PINACEAE*

*Picea glauca* (Moench) Voss
*Picea mariana* (Mill.) Britt., Sterns & Pogg.

*CUPRESSACEAE*

*Juniperus communis* L. ssp. *nana* (Willd.) Syme
*Juniperus horizontalis* Moench

*SPARGANIACEAE*

*Sparganium hyperboreum* Laest.

*POTAMOGETONACEAE*

*Potamogeton filiformis* Pers.
*Potamogeton perfoliatus* L. ssp. *richardsonii* (Bennett) Hult.

*JUNCAGINACEAE*

*Triglochin maritimum* L.
*Triglochin palustre* L.

*POACEAE (=GRAMINEAE)*

*Agropyron boreale* (Turcz.) Drobov ssp. *alaskanum* (Scribn. & Merr.) Melderis
*Agropyron boreale* (Turcz.) Drobov ssp. *boreale*
*Agropyron boreale* (Turcz.) Drobov ssp. *hyperarcticum* (Polunin) Melderis

*Agropyron subsecundum* (Link) Hitchc.
*Agropyron violaceum* (Hornem.) Lange ssp. *andinum* (Scribn. & Sm.) Melderis
*Agropyron violaceum* (Hornem.) Lange ssp. *violaceum* var. *alboviride* (Hult.) Melderis
*Agropyron yukonense* Scribn. & Merr.
*Agrostis borealis* Hartm.
*Agrostis scabra* Willd.
*Alopecurus alpinus* Sm.
*Arctagrostis latifolia* (R.Br.) Griseb. var. *angustifolia* (Nash) Hult.
*Arctagrostis latifolia* (R.Br.) Griseb. var. *latifolia*

*Arctophila fulva* (Trin.) Anderss.
*Bromus pumpellianus* Scribn. var. *arcticus* (Shear) Pors.
*Bromus pumpellianus* Scribn. var. *villosissimus* Hult.
*Calamagrostis canadensis* (Michx.) Beauv. ssp. *langsdorfii* (Link) Hult.
*Calamagrostis inexpansa* Gray
*Calamagrostis neglecta* (Ehrh.) Gaertn., Mey. & Schreb.
*Calamagrostis purpurascens* R.Br. ssp. *purpurascens*
*Deschampsia caespitosa* (L.) Beauv. ssp. *caespitosa* var. *glauca* (Hartm.) Sam.
*Elymus glaucus* Buckl. var. *glaucus*
*Elymus innovatus* Beal.
*Festuca altaica* Trin.
*Festuca baffinensis* Polunin
*Festuca brachyphylla* Schult.
*Festuca rubra* L.
*Festuca "vivipara"* (probably a viviparous hybrid between *F. baffinensis* and *F. brachyphyl*
*Glyceria pulchella* (Nash) Schum.
*Hierochloe odorata* (L.) Wahlenb.
*Hordeum jubatum* L.
*Muhlenbergia richardsonis* (Trin.) Rydb.
*Phleum alpinum* L.
*Poa abbreviata* R.Br.
*Poa alpina* L.
*Poa arctica* R.Br. ssp. *arctica*
*Poa arctica* R.Br. ssp. *longiculmis* Hult.
*Poa arctica* R.Br. ssp. *williamsii* (Nash) Hult.
*Poa arctica* R.Br. forma *vivipara*, forma nova
*Poa glauca* M. Vahl
*Poa glauca* M. Vahl var. *conferta* (Blytt) Nannf.
*Poa lanata* Scribn. & Merr.
*Poa paucispicula* Scribn. & Merr.
*Poa pratensis* L.
*Puccinellia deschampsioides* Sørens
*Trisetum spicatum* (L.) Richter ssp. *spicatum*

*CYPERACEAE*

*Carex aquatilis* Wahlenb. ssp. *aquatilis*
*Carex aurea* Nutt.
*Carex bicolor* All.
*Carex buxbaumii* Wahlenb.
*Carex capillaris* L.
*Carex concinna* R.Br.
*Carex dioica* L. ssp. *gynocrates* (Wormsk.) Hult.
*Carex filifolia* Nutt.
*Carex hassei* Bailey var. *bifaria* Fern. [=*Carex garberi* Fern. ssp. *bifaria* (Fern.) Hult.]
*Carex heleonastes* Ehrh.
*Carex krausei* Boeck.
*Carex lachenalii* Schkuhr
*Carex lugens* Holm
*Carex maritima* Gunn.
*Carex membranacea* Hook.
*Carex microchaeta* Holm
*Carex microglochin* Wahlenb.
*Carex nardina* E. Fries
*Carex nesophila* Holm

*Carex parryana* Dew.
*Carex petricosa* Dew.
*Carex podocarpa* C. B. Clarke
*Carex rossii* Boott
*Carex rostrata* Stokes
*Carex rupestris* All.
*Carex saxatilis* L. ssp. *laxa* (Trautv.) Kalela
*Carex scirpoidea* Michx.
*Carex scopulorum* Holm
*Carex stenophylla* Wahlenb. ssp. *eleocharis* (Bailey) Hult.
*Carex supina* Willd. ssp. *spaniocarpa* (Steud.) Hult.
*Eleocharis acicularis* (L.) Roem. & Schult.
*Eleocharis palustris* (L.) Roem. & Schult.
*Eriophorum angustifolium* Honck.
*Eriophorum angustifolium* Honck. ssp. *triste* (T. Fries) Hult.
*Eriophorum brachyantherum* Trautv. & Mey.
*Eriophorum scheuchzeri* Hoppe var. *scheuchzeri*
*Eriophorum vaginatum* L.
*Kobresia myosuroides* (Vill.) Fiori & Paol. [should be correctly named *Kobresia bellardii* (All.) Degland]
*Trichophorum caespitosum* (L.) Hartm.
*Trichophorum pumilum* (M. Vahl) Schinz & Thell. var. *rollandii* (Fern.) Hult

*JUNCACEAE*

*Juncus alpinus* Vill.
*Juncus arcticus* Willd. ssp. *ater* (Rydb.) Hult.
*Juncus castaneus* Sm. ssp. *castaneus*
*Juncus triglumis* L. ssp. *albescens* (Lange) Hult.
*Luzula confisa* Lindeb.
*Luzula spicata* (L.) DC.

*LILIACEAE*

*Allium ascalonicum* L.
*Lloydia serotina* (L.) Rchb.
*Tofieldia coccinea* Richards.
*Tofieldia pusilla* (Michx.) Pers.
*Zygadenus elegans* Pursh

*ORCHIDACEAE*

*Amerorchis rotundifolia* (Banks) Hult.
*Corallorhiza trifida* Chatelain
*Cypripedium passerinum* Richards.
*Platanthera dilatata* (Pursh) Lindl.
*Platanthera hyperborea* (L.) Lindl.
*Platanthera obtusata* (Pursh) Lindl.
*Platanthera saccata* (Greene) Hult.
*Spiranthes romanzoffiana* Cham.

*SALICACEAE*

*Populus balsamifera* L. ssp. *balsamifera*
*Populus tremuloides* Michx.

*Salix alaxensis* (Anderss.) Cov. ssp. *alaxensis*
*Salix alaxensis* (Anderss.) Cov. ssp. *longistylis* (Rydb.) Hult.
*Salix arbusculoides* Anderss.
*Salix arctica* Pall. ssp. *torulosa* (Trautv.) Hult.
*Salix barclayi* Anderss.
*Salix barrattiana* Hook.
*Salix bebbiana* Sarg. *[=S. depressa* L. ssp. *rostrata* (Anderss.) Hiitonen*]*
*Salix brachycarpa* Nutt. ssp. *brachycarpa*
*Salix commutata* Bebb.
*Salix dodgeana* Rydb.
*Salix glauca* L.
*Salix glauca* L. ssp. *acutifolia* (Hook.) Hult.
*Salix glauca* L. ssp. *desertorum* (Richards.) Anderss.
*Salix glauca* L. ssp. *glabrescens* (Anderss.) Hult.
*Salix lanata* L. ssp. *richardsonii* (Hook.) A. Skvortz
*Salix myrtillifolia* Anders.
*Salix niphoclada* Rydb. *[=S. brachycarpa* Nutt. ssp. *niphoclada* (Rydb.) Argus*]*
*Salix novae-angliae* Anderss. (identified by Argus)
*Salix pedicellaris* Pursh
*Salix planifolia* Pursh ssp. *planifolia [=S. phylicifolia* L. ssp. *planifolia* (Pursh) Hiitor
*Salix polaris* Wahlenb. ssp. *pseudopolaris* (Flod.) Hult.
*Salix reticulata* L. ssp. *reticulata*

*Salix scouleriana* Barr.
*Salix setchelliana* Ball
*Salix stolonifera* Cov.

*BETULACEAE*

*Alnus crispa* (Ait.) Pursh ssp. *crispa*
*Betula glandulosa* Michx.
*Betula papyrifera* Marsh. ssp. *humilis* (Regel) Hult.

*SANTALACEAE*

*Comandra umbellata* (L.) Nutt. ssp. *pallida* (DC.) Piehl
*Geocaulon lividum* (Richards.) Fern.

*POLYGONACEAE*

*Oxyria digyna* (L.) Hill
*Polygonum bistorta* L. ssp. *plumosum* (Small) Hult.
*Polygonum viviparum* L.
*Rumex arcticus* Trautv.

*CHENOPODIACEAE*

*Chenopodium capitatum* (L.) Aschers.
*Eurotia lanata* (Pursh) Moq.

*PORTULACEAE*

*Claytonia bostockii* Pors.
*Claytonia parviflora* Moq. ssp. *flagellaris* (Bong.) Hult.
*Claytonia sarmentosa* C.A. Mey.

*CARYOPHYLLACEAE*

*Cerastium beeringianum* Cham. & Schlecht. var. *beeringianum*
*Cerastium beeringianum* Cham. & Schlecht. var. *grandiflorum* (Fenzl) Hult.
*Melandrium affine* J. Vahl
*Melandrium apetalum* (L.) Fenzl ssp. *arcticum* (E.Fries) Hult.
*Minuartia biflora* (L.) Schinz & Thell.
*Minuartia obtusiloba* (Rydb.) House
*Minuartia rossii* (R. Br.) Graebn.
*Silene acaulis* L. ssp. *acaulis*
*Silene douglasii* Hook.
*Stellaria edwardsii* R. Br.
*Stellaria laeta* Richards.
*Stellaria longipes* Goldie
*Stellaria monantha* Hult.

*RANUNCULACEAE*

*Aconitum delphinifolium* DC. ssp. *paradoxum* Hult.
*Anemone drummondii* S. Wats.
*Anemone multifida* Poir.
*Anemone parviflora* Michx.
*Anemone richardsonii* Hook.
*Caltha palustris* L. ssp. *asarifolia* (DC.) Hult.
*Delphinium brachycentrum* Ledeb.
*Pulsatilla patens* (L.) Mill. ssp. *multifida* (Pritz.) Zamels
*Ranunculus cymbalaria* Pursh
*Ranunculus eschscholtzii* Schlecht.
*Ranunculus gmelinii* DC. ssp. *gmelinii*
*Ranunculus hyperboreus* Rottb. ssp. *hyperboreus*
*Ranunculus nivalis* L.
*Ranunculus pedatifidus* Sm. ssp. *affinis* (R. Br.) Hult.
*Ranunculus pygmaeus* Wahlenb.
*Ranunculus reptans* L.
*Ranunculus sceleratus* L. ssp. *multifidus* (Nutt.) Hult.
*Ranunculus sulphureus* Soland.
*Ranunculus sulphureus* Soland. var. *sulphureus*
*Ranunculus trichophyllus* Chaix. var. *trichophyllus*

*PAPAVERACEAE*

*Papaver lapponicum* (tolm.) Nordh. ssp. *occidentale* (Lundstr.) Knaben
*Papaver macounii* Greene

*FUMARIACEAE*

*Corydalis aurea* Willd.

*BRASSICACEAE (=CRUCIFERAE)*

*Arabis holboellii* Hornem.
*Barbarea orthoceras* Ledeb.
*Cardamine purpurea* Cham. & Schlecht.
*Descurainia sophia* (L.) Prantl

*Draba alpina* L.
*Draba aurea* Vahl
*Draba cinerea* Adams
*Draba exalata* Ekman
*Draba hirta* L.
*Draba incerta* Dayson
*Draba lactea* Adams
*Draba longipes* Raup
*Draba macrocarpa* Adams
*Draba nivalis* Liljebl.
*Draba praealta* Greene
*Draba stenoloba* Ledeb.
*Erysimum angustatum* Rydb.
*Erysimum cheiranthoides* L. ssp. *altum* Ahti
*Erysimum pallasii* (Pursh) Fern.
*Eutrema edwardsii* R. Br.
*Lesquerella arctica* (Wormsk.) S. Wats.
*Parrya nudicaulis* (L.) Regel
*Rorippa islandica* (Oeder) Borb.
*Smelowskia borealis* (Greene) Drury & Rollins

*CRASSULACEAE*

*Sedum lanceolatum* Torr.
*Sedum roseum* (L.) Scop. ssp.*integrifolium* (Raf.) Hult.

*SAXIFRAGACEAE*

*Chrysoplenium tetrandrum* (Lund.) T. Fries
*Parnassia kotzebuei* Cham. & Schlecht.
*Parnassia palustris* L. ssp. *neogaea* (Fern) Hult.
*Saxifraga adscendes* L. ssp. *oregonensis* (Raf.) Bacigalupi
*Saxifraga bronchialis* L. ssp. *funstonii* (Small) Hult.
*Saxifraga caespitosa* L.
*Saxifraga caespitosa* L. ssp. *sileneflora* (Sternb.) Hult.
*Saxifraga cernua* L.
*Saxifraga davurica* Willd.
*Saxifraga flagellaris* Willd. ssp. *platysepala* (Trautv.) Pors.
*Saxifraga hieracifolia* Waldst. & Kit.
*Saxifraga hirculus* L.
*Saxifraga oppositifolia* L.
*Saxifraga punctata* L. ssp. *porsildiana* Calder & Savile
*Saxifraga radiata* Small (=*S. exilis* Steph.)
*Saxifraga reflexa* Hook.
*Saxifraga rivularis* L.
*Saxifraga rivularis* L. var. *flexuosa* (Sternb.) Engler & Irmsch.
*Saxifraga serpyllifolia* Pursh

*ROSACEAE*

*Amelanchier alnifolia* (Nutt.) Nutt.
*Chamaerhodos erecta* (L.) Bunge ssp. *nuttallii* (Torr. & Gray) Hult.
*Dryas drummondii* Richards.
*Dryas integrifolia* M. Vahl ssp. *integrifolia*
*Fragaria virginiana* Duchesne ssp. *glauca* (S.Wats.) Staudt

*Geum macrophyllum* Willd. ssp. *perincisum* (Rydb.) Hult.
*Luetkea pectinata* (Pursh) Ktze.
*Potentilla anserina* L.
*Potentilla biflora* Willd.
*Potentilla diversifolia* Lehm.
*Potentilla diversifolia* Lehm. var. *glaucophylla* Lehm.
*Potentilla flabelliformis* Lehm.
*Potentilla fruticosa* L.
*Potentilla hookeriana* Lehm. ssp. *chamissonis* (Hult.) Hult.
*Potentilla hookeriana* Lehm. ssp. *hookeriana*
*Potentilla hookeriana* Lehm. ssp. *hookeriana* var. *hookeriana*
*Potentilla hookeriana* Lehm. ssp. *hookeriana* var. *furcata* (Pors.) Hult.
*Potentilla hyparctica* Malte
*Potentilla multifida* L.
*Potentilla palustris* (L.) Scop.
*Potentilla pennsylvanica* L.
*Potentilla pennsylvanica* L. var. *glabrata* S. Wats.
*Potentilla uniflora* Ledeb.
*Potentilla virgulata* Nels.
*Rosa acicularis* Lindl.
*Rubus arcticus* L. ssp. *acaulis* (Michx.) Focke
*Sanguisorba stipulata* Raf.

*FABACEAE (=LEGUMINOSAE* p.p.*)*

*Astragalus aboriginum* Richards.
*Astragalus alpinus* L. ssp. *alpinus*
*Astragalus nutzotinensis* Rousseau
*Astragalus umbellatus* Bunge
*Astragalus williamsii* Rydb.
*Hedysarum alpinum* L. ssp. *americanum* (Michx.) Fedtsch.
*Hedysarum mackenzii* Richards.
*Lupinus arcticus* S. Wats.
*Oxytropis borealis* DC.
*Oxytropis campestris* (L.) DC. ssp. *gracilis* (Nels.) Hult.
*Oxytropis deflexa* (Pall.) DC. var. *foliolosa* (Hook.) Barneby
*Oxytropis huddelsonii* Pors.
*Oxytropis nigrescens* (Pall.) Fisch. ssp. *bryophila* (Greene) Hult.
*Oxytropis splendens* Dougl.
*Oxytropis viscida* Nutt.

*LINACEAE*

*Linum perenne* L. ssp. *lewisii* (Pursh) Hult.

*ELAEAGNACEAE*

*Elaeagnus commutata* Bernh.
*Shepherdia canadensis* (L.) Nutt.

*ONAGRACEAE*

*Epilobium angustifolium* L. ssp. *angustifolium*
*Epilobium latifolium* L.

*HALORAGACEAE*

*Hippuris vulgaris* L.
*Myriophyllum spicatum* L.

*APIACEAE (=UMBELLIFERAE)*

*Conioselinum cnidifolium* (Turcz.) Pors.

*CORNACEAE*

*Cornus canadensis* L.
*Cornus stolonifera* Michx.

*PYROLACEAE*

*Moneses uniflora* (L.) Gray
*Pyrola asarifolia* Michx. var. *purpurea* (Bunge) Fern.
*Pyrola grandiflora* Radius
*Pyrola secunda* L. ssp. *secunda*

*EMPETRACEAE*

*Empetrum nigrum* L. ssp. *hermaphroditum* (Lange) Böcher

*ERICACEAE*

*Andromeda polifolia* L.
*Arctostaphylos alpina* (L.) Spreng.
*Arctostaphylos rubra* (Rehd. & Wils.) Fern.
*Arctostaphylos uva-ursi* (L.) Spreng.
*Arctostaphylos uva-ursi* (L.) Spreng. var. *adenotricha* Fern. & Macbr.
*Cassiope stelleriana* (Pall.) DC.
*Cassiope tetragona* (L.) D.Don ssp. *tetragona*
*Ledum palustre* L. ssp. *groenlandicum* (Oeder) Hult.
*Phyllodoce empetriformis* (Sm.) D.Don
*Phyllodoce glanduliflora* (Hook.) Cor.
*Rhododendron lapponicum* (L.) Wahlenb.
*Vaccinium caespitosum* Michx.
*Vaccinium uliginosum* L. ssp. *alpinum* (Bigel.) Hult.
*Vaccinium vitis-idaea* L. ssp. *minus* (Lodd.) Hult.

*PRIMULACEAE*

*Androsace chamaejasme* Host ssp. *lehmanniana* (Spreng.) Hult.
*Androsace septentrionalis* L.
*Dodecatheon frigidum* Cham. & Schlecht.
*Primula egaliksensis* Wormsk.
*Primula sibirica* Jacq.
*Primula stricta* Hornem.

*GENTIANACEAE*

*Gentiana algida* Pall.
*Gentiana barbata* Froel.
*Gentiana propinqua* Richards.
*Gentiana prostrata* Haenke
*Lomatogonium rotatum* (L.) E. Fries

*POLEMONIACEAE*

*Phlox sibirica* L. ssp. *sibirica*
*Polemonium acutiflorum* Willd.
*Polemonium boreale* Adams ssp. *boreale*
*Polemonium boreale* Adams ssp. *boreale* var. *villosissimum* Hult.
*Polemonium pulcherrimum* Hook.

*HYDROPHYLLACEAE*

*Phacelia franklinii* (R. Br.) Gray

*BORAGINACEAE*

*Lappula myosotis* Moench.
*Mertensia paniculata* (Ait.) G. Don var. *paniculata*
*Myosotis alpestris* F.W. Schmidt ssp. *asiatica* Vestergr.

*SCROPHULARIACEAE*

*Castilleja hyperborea* Pennell
*Castilleja villosissima* Pennell
*Castilleja yukonis* Pennell
*Pedicularis capitata* Adams
*Pedicularis kanei* Durand ssp. *kanei*
*Pedicularis labradorica* Wirsing
*Pedicularis sudetica* Willd. ssp. *interior* Hult.
*Pedicularis verticillata* L.
*Pentstemon gormanii* Greene
*Pentstemon procerus* Dougl.
*Veronica wormskjoldii* Roem. & Schult. ssp. *wormskjoldii*

*OROBANCHACEAE*

*Boschniakia rossica* (Cham. & Schlecht.) Fedtsch.
*Orobanche fasciculata* Nutt.

*PLANTAGINACEAE*

*Plantago canescens* Adams
*Plantago major* L. var. *major*

*RUBIACEAE*

*Galium boreale* L.

*CAPRIFOLIACEAE*

*Linnaea borealis* L. ssp. *americana* (Forbes) Hult.
*Viburnum edule* (Michx.) Raf.

*VALERIANACEAE*

*Valeriana capitata* Pall.

*CAMPANULACEAE*

*Campanula lasiocarpa* Cham. ssp. *lasiocarpa*
*Campanula uniflora* L.

*COMPOSITAE*

*Achillea borealis* Bong.
*Achillea lanulosa* Nutt.
*Antennaria friesiana* (Trautv.) Ekman ssp. *alaskana* (Malte) Hult.
*Antennaria friesiana* (Trautv.) Ekman ssp. *compacta* (Malte) Hult.
*Antennaria friesiana* (Trautv.) Ekman ssp. *friesiana*
*Antennaria media* Greene
*Antennaria monocephala* DC.ssp. *monocephala* var. *exilis* (Greene) Hult.
*Antennaria monocephala* DC. ssp. *monocephala* var. *monocephala*

*Antennaria pallida* E. Nels.
*Antennaria pulcherrima* (Hook.) Greene
*Antennaria rosea* Greene
*Antennaria rosea* Greene var. *nitida* (Greene) Breitung
*Antennaria stolonifera* Pors.
*Arnica alpina* (L.) Olin ssp. *angustifolia* (M.Vahl) Maguire
*Arnica frigida* C.A. Mey.
*Arnica lessingii* Greene ssp. *lessingii*
*Artemisia alaskana* Rydb.
*Artemisia arctica* Less. ssp. *arctica*
*Artemisia dracunculus* L.
*Artemisia frigida* Willd.
*Artemisia furcata* Bieb.
*Artemisia hyperborea* Rydb.
*Artemisia rupestris* L. ssp. *woodii* Neilson
*Artemisia tilesii* Ledeb. ssp. *elatior* (Torr. & Gray) Hult.
*Artemisia tilesii* Ledeb. ssp. *tilesii*
*Aster alpinus* L. ssp. *vierhapperi* Onno
*Aster sibiricus* L.
*Aster yukonensis* Cronq.
*Crepis elegans* Hook.
*Crepis nana* Richards. var. *nana*
*Erigeron acris* L. ssp. *politus* (E.Fries) Schinz & Keller
*Erigeron ceaspitosus* Nutt.
*Erigeron compositus* Pursh
*Erigeron compositus* Pursh var. *discoideus* Gray
*Erigeron elatus* Greene
*Erigeron eriocephalus* J. Vahl
*Erigeron grandiflorus* Hook. ssp. *grandiflorus*
*Erigeron humilis* Graham
*Erigeron purpuratus* Greene
*Hieracium triste* Willd.
*Petasites frigidus* (L.) Franch.
*Petasites hyperboreus* Rydb.
*Saussurea angustifolia* (Willd.) DC.
*Saussurea viscida* Hult. var. *yukonensis* (Pors.) Hult.
*Senecio atropurpureus* (Ledeb.) Fedtsch. ssp. *atropurpureus*
*Senecio atropurpureus* (Ledeb.) Fedtsch. ssp. *frigidus* (Richards.) Hult.
*Senecio atropurpureus* (Ledeb.) Fedtsch. ssp. *tomentosus* (Kjellm.) Hult.
*Senecio congestus* (R. Br.) DC.
*Senecio conterminus* Greenm.
*Senecio fuscatus* (Jord. & Fourr.) Hayek
*Senecio lugens* Richards.
*Senecio pauciflorus* Pursh
*Senecio resedifolius* Less.
*Solidago decumbens* Greene var. *oreophila* (Rydb.) Fern.
*Solidago multiradiata* Ait. var. *arctica* (DC.) Fern.
*Solidago multiradiata* Ait. var. *scopulorum* Gray
*Taraxacum alaskanum* Rydb.
*Taraxacum ceratophorum* (Ledeb.) DC.
*Taraxacum lacerum* Greene
*Taraxacum officinale* Weber
*Townsendia hookeri* Beaman

*Acarospora oxytona* (Ach.) Mass.
*Alectoria ochroleuca* (Hoffm.) Mass.
*Buellia epigaea* (Hoffm.) Tuck.
*Buellia stelluata* (Tayl. in Mack.) Mudd
*Caloplaca cirrochroa* (Ach.) Th. Fr.
*Cetraria cucullata* (Bell) Ach.
*Cetraria hepatizon* (Ach.) Vain.
*Cetraria islandica* (L.) Ach.
*Cetraria nivalis* (L.) Ach.
*Cetraria richardsonii* Hook.
*Cetraria tilesii* Ach.
*Cladonia amaurocraea* (Flörke) Schaer.
*Cladonia gonecha* (Ach.) Asah.
*Cladonia gracilis* (L.) Willd. var. *dilatata* (Huds.) Vain.
*Cladonia lepidota* Nyl.
*Cladonia pocillum* (Ach.) O. Rich.
*Cladonia sylvatica* (L.) Hoffm.
*Collema coccophorum* Tuck.
*Cornicularia aculeata* (Schreb.) Ach.
*Dactylina arctica* (Hook.) Nyl.
*Dactylina madreporiformis* (Wulf.) Tuck.
*Dactylina ramulosa* (Hook.) Tuck.
*Dermatocarpon hepaticum* (Ach.) Th. Fr.
*Evernia divaricata* (L.) Ach.
*Evernia esorediosa* (Mull. Arg.) DuRietz
*Fulgensia bracteata* (Hoffm.) Ras.
*Lecanora caesiocinerea* Nyl.
*Lecanora candida* (Anzi) Nyl.
*Lecanora epibryon* (Ach.) Ach.
*Lecanora lentigera* (G. Web.) Ach.
*Lecanora melanopthalma* (Ram.) Ram.
*Lecanora rubina* (Vill.) Ach.
*Lecidea atromarginata* Magn.
*Lecidea cuprea* Somm.
*Lecidea decipiens* (Hedw.) Ach.
?*Lecidea granulosa* (Hoffm.) Ach.

*Lecidea marginata* Schaer.

*Lecidea rubiformis* (Wahlenb. ex Ach.) Wahlenb.

*Lecidea tesselata* (Ach.) Flörke

*Parmelia taractica* Kremph.

*Peltigera aphthosa* (L.) Willd.

*Peltigera aphthosa* (L.) Willd. var. *leucophlebia* Nyl.

*Peltigera canina* (L.) Willd. var. *rufescens* (Weis.) Mudd

*Peltigera canina* (L.) Willd. var. *spuria* (Ach.) Schaer.

*Physcia muscigena* (Ach.) Nyl.

*Ramalina roesleri* (Hochst.) Nyl.

*Rhizocarpon geographicum* (L.) DC.

*Solorina saccata* (L.) Ach.

*Solorina spongiosa* (Sm.) Anzi

*Stereocaulon alpinum* Laur.

*Stereocaulon glareosum* (Sav.) Magn.

*Stereocaulon paschale* (L.) Hoffm.

*Stereocaulon rivulorum* Wagn.

*Thamnolia vermicularis* (Sw.) Ach.

*Thamnolia subuliformis* (Ehrh.) Culb.

*Toninia caeruleonigricans* (Lighf.) Th. Fr.

*Umbilicaria havaasii* Llano

*Xanthoria elegans* (Link) Th. Fr.

*Abietinella abietina* (Hedw.) Fleisch.

*Asterella lindenbergiana* (Corda) Lindb.

*Aulacomnium acuminatum* (Lindb. & Arn.) Par.

*Barbula icmadophila* Schimp. ex C. Müll.

?*Barbula tophacea* (Brid.) Mitt. *[=Didymodon tophaceus* (Brid.) Garov.*]*

?*Brachythecium groenlandicum* (C. Jens.) Schljak.

?*Brachythecium turgidum* (C.F. Hartm.) Kindb.

?*Bryum alpinum* With.

*Bryum pallens* Sw.

*Bryum* sp.

*Campylium stellatum* (Hedw.) C. Jens.

*Catoscopium nigritum* (Hedw.) Brid.

*Ceratodon purpureus* (Hedw.) Brid.

*Cinclidium stygium* Sw.

*Cratoneuron filicinum* (Hedw.) Spruce

*Cyrtomnium hymenophyllum* (B.S.G.) Holmen

*Distichium capillaceum* (Hedw.) B.S.G.

*Ditrichum flexicaule* (Schwaegr.) Hampe

*Drepanocladus procerus* (Ren. & Arn.) Warnst.

*Funaria hygrometrica* Hedw.

*Hylocomium splendens* (Hedw.) B.S.G.

*Hypnum bambergeri* Schimp.

*Hypnum bridelianum* Crum, Steere & Anderson

*Hypnum cupressiforme* Hedw.

*Hypnum procerrimum* Mol.

*Hypnum vaucheri* Lesq.

*Marchantia polymorpha* L.

*Meesea uliginosa* Hedw.

*Mnium blyttii* B.S.G.

*Orthothecium chryseum* (Schwaegr.) B.S.G.

*Philonotis tomentella* Mol.

*Plagiomnium rostratum* (Schrad.) Koponen (Hazen & Turner, 1886)

*Plagiomnium rugicum* (Laur.) Koponen

*Pohlia* sp.

*Preissia quadrata* (Scop.) Nees

*Sauteria alpina* Nees

*Scorpidium turgescens* (T. Jens.) Loeske

? *Sphagnum nemoreum* Scop.

*Splachnum luteum* Hedw.

*Tetraplodon mnioides* (Hedw.) B.S.G.

*Timmia austriaca* Hedw.

*Tomentypnum nitens* (Hedw.) Loeske

*Tortula norvegica* (Web.) Wahlenb.

*Tortula ruralis* (Hedw.) Gaertn., Meyer & Scherb.

GENERAL DESCRIPTION I :

| Plot No.: | Plot size: | Extent of type: |
|---|---|---|
| Date: | Locality: | |

Vegetation Type (biogeocoenosis):

a) provisional name:

b) definite name:

| Latitude: | Longitude: | Distribution code: |
|---|---|---|
| Altitude: | Exposure: | Slope gradient: |

Macroclimate:

| Wind influence: | Approximate snow cover time: |
|---|---|

Topographic location:

a) Land type: b) Land form:

History3 (fire, disturbance, grazing):

Vegetational stratification:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Coverage of | Tree layer | $A_1$ | % | $A_2$ | % | $A_3$ % | Total A | % |
| | Shrub layer | $B_1$ | % | $B_2$ | % | | Total B | % |
| | Herb layer | $C_1$ | % | $C_2$ | % | | Total C | % |
| | Moss Lichen layer | $D_h$ | % | $D_{dw}$ | % | $D_r$ % | Total D | % |
| | Epiphytes | $E_A$ | % | $E_B$ | % | $E_C$ % | Total E | % |

Groundsurface covered by:

| Humus: % | Mineral soil: % | Decaying wood % |
|---|---|---|
| | Rock: % | |

Remarks:

GENERAL DESCRIPTION II:

| Plot No.: | Date: |
|---|---|
| Tentative soil subgroup: | |
| Definite soil subgroup: | |
| Hygrotope: | Edaphotope: |

Relief shape:

| Cross section: | Profile: | Contour line: |
|---|---|---|
| Erosion: | Runoff: | Drainage: |

Parent material:

| Soil depth: | Coarse fragments in soil: |
|---|---|
| Rockiness: | Stoniness: |

Root distribution:

| Humus: Thickness: | Form: |
|---|---|

Melanized mineral soil depth:

| Soil concretions: | Soil pan: |
|---|---|
| Location in profile | Location in profile |
| size | size |
| type | type |

| Ground water: | Depth from surface: | pH: |
|---|---|---|
| a) moving | | |
| b) stagnant | | |

| Permeable layer depth: | Salt or alkali: |
|---|---|

Permafrost:

| a) depth | b) thickness |
|---|---|

Remarks:

DESCRIPTION III:

Plant community analysis for Vegetation Map:

| Plot No. | Plot Size: | Date: | Locality: |
|---|---|---|---|

| Stratification | Species: | Species significance: | Sociability: | Vigor: | Phenology: | Life form: |
|---|---|---|---|---|---|---|
| | | | | | | |

Table LIII in pocket in v.2

# PART II

# ECOLOGICAL INVESTIGATION OF A POPULATION OF DALL SHEEP (*OVIS DALLI DALLI*, NELSON)

by

MANFRED HOEFS

INTRODUCTION:

The analysis presented is part II of an investigation dealing with the ecology of a population of Dall sheep (Ovis dalli dalli Nelson) and their habitat.

The first part deals in detail with the location, geology, physiography, climate and vegetation cover of the study area and includes a vegetation map. Further information along these lines is therefore limited to a description of the range of this sheep population and to the environmental parameters as they directly affect sheep.

The emphasis is on range use and forage selection which is documented in detail over an annual cycle. To do this it was necessary to frequently make reference to the phytosociological analysis and vegetation map of part I of this investigation.

Population data are presented for a five-year period as well as whatever historical information exists about this population. However, this investigation must not be considered as a "population study" per se since some important factors as rates of emigration and immigration and mortality on summer ranges could not be assessed. Conclusions drawn as to the factors which "regulate" this population will therefore be of necessity tentative.

The general life history of Dall sheep has been presented in detail in earlier works by Dixon (1938) and Murie (1944) and their social behaviour has recently been dealt with by Geist (1971). The following analysis therefore deals only with ecological parameters of this population which were compared to data abstracted through an intensive literature review about other "northern" sheep populations. "Northern" sheep in this connection means populations living in sub-arctic latitudes like Dall sheep, Stone sheep (Ovis dalli stonei) and Siberian Snow sheep (Ovis nivicola). It is felt that only

these species are exposed to similar environmental factors. Wherever appropriate, however, reference is made to Bighorn sheep as well as other ungulates.

While the following analysis is based primarily on data collected by the writer, personal communication with a number of people, particularly on historical aspects, is included and it is, therefore, appropriate that these people are introduced here.

Mr. John Haden, now living at Whitehorse, resided in Silver City on Kluane Lake from 1930 to 1937, where his parents were managing a fox farm. Mr. Haden had Sheep Mountain under almost constant surveillance during those years.

Mr. Gus Lolan, a prospector now living in Whitehorse, worked a number of placer operations in various creeks in the area, including Sheep Creek in 1937.

Mr. Joe Langevin, now living at Dawson City, was forest ranger and game warden for the Kluane Game Sanctuary from 1950 to 1961. He occupied a cabin near Mile 1057, Alaska Highway, and held Sheep Mountain under constant surveillance during those years.

Mr. and Mrs. F. Sais have been living at Silver City on Kluane Lake for the past two years. Mrs. Sais is a daughter of Mr. Jacquot, who outfitted in the Kluane Game Sanctuary prior to its establishment and founded the settlement of Burwash in 1910.

Neil Olson, formerly with the Faculty of Forestry, University of British Columbia, now living at Haines Junction, started a research project on sheep. He marked a number of sheep in 1970 and 1971 to be able to evaluate such factors as migration distances, rates of emigration, initial breeding age and age-specific mortality rates. Unfortunately, this study was

discontinued. However, the presence of a considerable number of marked sheep in this population helped the writer to evaluate such parameters as dispersal, early lamb mortality and extent of range of this population.

Dr. N. Simmons, research scientist with the Canadian Wildlife Service at Fort Smith, N.W.T., has been studying Dall sheep in the MacKenzie Mountains for the past seven years. The writer has been corresponding frequently with Dr. Simmons.

Dr. V. Geist, University of Calgary, studied the behaviour of this sheep population in 1965 and returned to the area several times subsequently. The writer has had many rewarding discussions with Dr. Geist.

Methods and Materials:

The writer was present on the study area during the following time intervals: from May 16th, 1969 to September 14th, 1969; from April 10th, 1970 to November 14th, 1971; from May 4th, 1972 to September 14th, 1972; subsequently the writer took up a position with the Yukon Game Branch at Whitehorse, but the gathering of population data was continued during short stays at the area throughout 1973.

Counts were made throughout this 5-year period (1969-1973) to evaluate the dynamics of this population; detailed range utilization analyses, as well as evaluations of forage selection and of the response of sheep to snow, temperature and wind were limited to the one-year period from October 1970 to September 1971.

By this time the writer was familiar with the flora of the area through complete plant collections at various phenological stages, a preliminary vegetation map had been constructed, and a 'pilot study' on a semi-captive band of Dall sheep was well under way (Hoefs, 1974). At this

pilot study techniques used to determine forage selection were established.

A) Population dynamics and range utilization:

During the period of intensive study, total counts were made on the average for 20 days per month for range use determination. During half of these observation days (about 10 per month) sheep were classified, their elevations were determined, and their response to snow depth, temperatures, and wind was recorded. The other half of the observation days (about 10 days per month) were spent with the gathering of feeding observations.

To obtain population statistics the following classification was used: lambs, yearlings, ewes, 2 year old rams, 3 year old rams, 4 and 5 year old rams, rams 6 years and older, and rams whose horn curl significantly exceeded 360°. This type of classification for ram varies considerably from the one developed by Geist (1971). It was used because of the ease with which rams could be classified even over larger distances and because of practical considerations to be discussed later. Whenever a large portion of the ram segment of the population could be approached close enough Geist's classification was also used, and comparisons between the two systems will be discussed later.

For aging sheep the method utilizing annual growth rings of horns as applied by Cowan (1940) was used. This method was later experimentally verified by Geist (1966) for Bighorn sheep and by Hemming (1969) for Dall sheep. To determine 'degree curl' of horns, a modification of Erickson's (1970) procedure was applied.

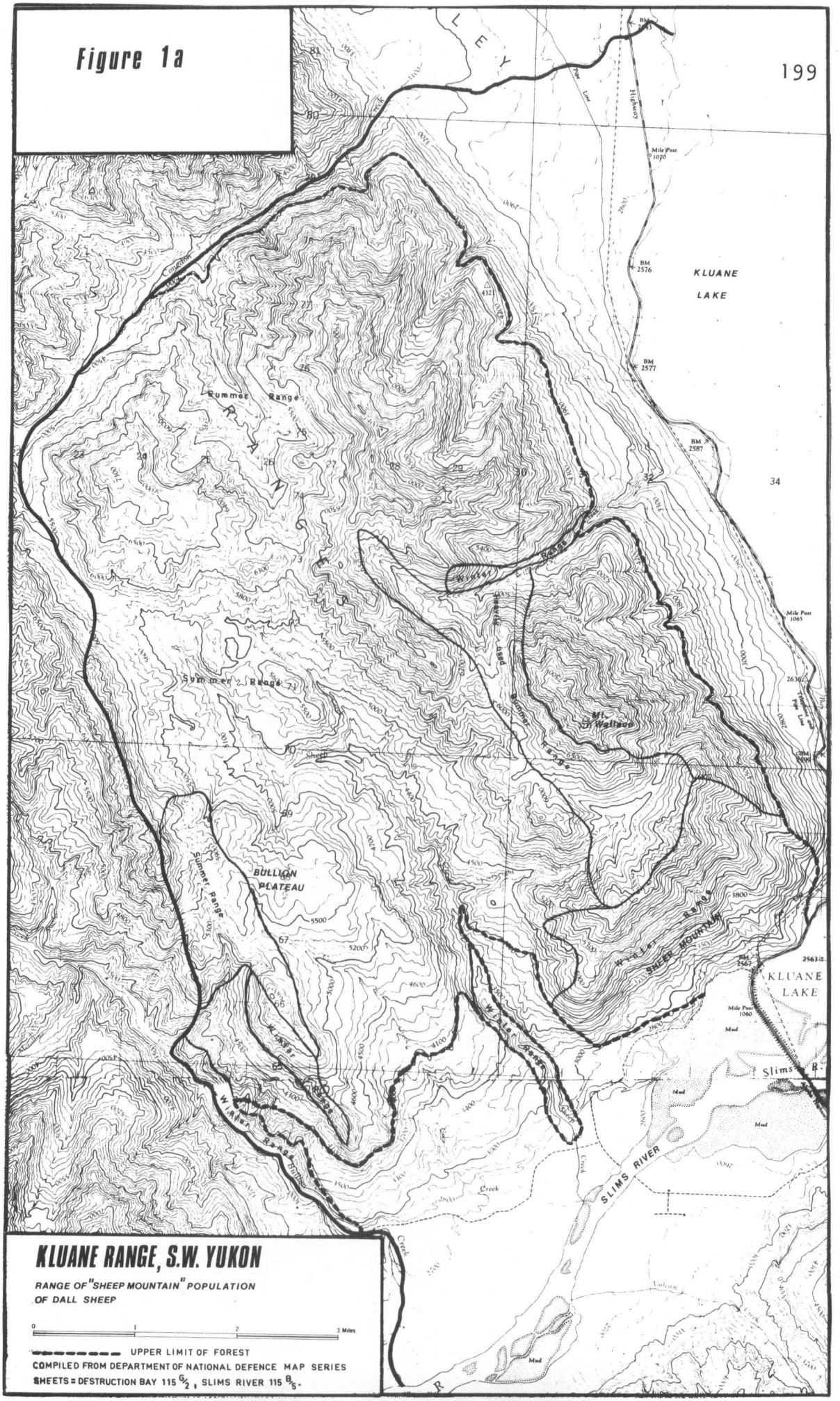
The writer carried continuously with him a LEITZ "Trinovid 8 x 32" binocular, and when classified counts were made a BUSHNELL "Spacemaster II" spotting scope (20 to 45x by 60mm) was used.

To evalute intensities of grazing pressure, strategies of range utilization, and use of the various plant associations over the annual cycle the distribution of sheep was mapped on a preliminary vegetation map, which was a miniature version (scale 1: 20 000) of the large map, which is part of the vegetation analysis of part I of this thesis.

Inspection of that map will show that it is divided into 45 'sections' and each section is divided into 100 'quadrats'. Bands of feeding sheep were observed for about 20 minutes each, individuals were observed for 5 minutes, and the location of their feeding was recorded as section and quadrat numbers. Bands which were resting at the time were returned to later when they were feeding. Range use was subsequently expressed as 'sheep days per acre' or 'sheep per square mile per time interval', as well as proportional utilization of plant associations. Since some quadrats included more than one association, notes were also made as to whether sheep were feeding in herbaceous cover, in shrub, or in forest. Where boundaries were not distinct, as between adjacent grassland associations, or where continuous snow covered the ground, the allocation of sheep to various associations within a quadrat was proportional to the sizes of the different associations within that quadrat.

As already pointed out, the range use study was limited to Sheep Mountain, which is only a portion of the total range of this population. While this mountain has been described in great detail in the first part of this thesis, it will here only be necessary to briefly recall its boundaries (Figure 1 and vegetation map, Part I of thesis): Its northern boundary is the 1000 foot depression between Sheep Mountain and Mt. Wallace to the north of it. An unnamed creek coming down that depression to the east reaches the Alaska Highway near Mile 1064.1 (Goose Bay Campsite). Another creek, Forty-eight Pup, follows that depression to the west and flows into Sheep Creek,

**Figure 1a**




## KLUANE RANGE, S.W. YUKON

*RANGE OF "SHEEP MOUNTAIN" POPULATION OF DALL SHEEP*

0 1 2 3 Miles

UPPER LIMIT OF FOREST

COMPILED FROM DEPARTMENT OF NATIONAL DEFENCE MAP SERIES SHEETS = DESTRUCTION BAY 115 $G/2$, SLIMS RIVER 115 $B/5$.

Figure 1b: "Sheep Mountain", the most important wintering area of this population, and the site of intensive range use and forage selection studies.

which in turn enters the Slims River. The other boundaries of Sheep Mountain are clearly defined by Kluane Lake, Slims River and Sheep Creek (Figure 1).

Comparisons to counts made by previous investigators are difficult to interpret, since these people did not describe the boundaries of "their" Sheep Mountain nor did they state the exact locations from which counts were made. Our experiences show that it is very important to count from several strategic locations if the numbers obtained are to be fairly reliable.

Since the Alaska Highway as well as portions of the old Alaska Highway follow the outline of Sheep Mountain on the east and south sides directly at the base, many areas on the mountain can not be observed from here.

To get the best impression of the total numbers as well as of the distribution of sheep over the mountain, counts should be started at the south side of the Slims River. Three locations were used here, first at Mile 1056.4, Alaska Highway, from which the east and portions of the large south east slopes can be surveyed very well; next at Mile 1059.2, Alaska Highway, from where the large south east face can be scanned, and lastly the end of the old Alaska Highway at the burnt bridge, from where the south west side of the mountain can be viewed. This old route of the Alaska Highway follows the south shore of the Slims River for a distance of perhaps three miles.

This overall count from a large distance, for which a good spotting scope is essential, was followed by more detailed classified counts at close range from the base of the mountain. As already pointed out, the northern boundary of Sheep Mountain can be viewed from the Goose Bay Campsite (Mile 1064.1) and it was here where detailed surveys started. These were continued from several locations along the Alaska Highway, usually where parking space

was available along the road [Mile 1063.8 (Bayshore Inn), 1063.6, 1062.7, 1062.2, 1062.0 and 1060.5]. Subsequently, the old Alaska Highway was followed along the base of Sheep Mountain. Good counts of the large south east slope can be made from the Slims River flood plain. The south west side of the mountain can be most accurately surveyed from the small rock outcrop cut off from the mountain proper by the old Alaska Highway. This small hill is perhaps 150 feet high and located half the way between the present Alaska Highway in the east and Sheep Creek in the west. The west side of Sheep Mountain and the slopes along Sheep Creek can only be surveyed by walking up along Sheep Creek's east bank for a distance of about two miles to a knob which has an elevation of about 3500'.

If a survey is done in this manner, which may take 3 to 4 hours, it is estimated that 95% or more of the sheep on this mountain can be accounted for. These counts do not include the alpine north face of Sheep Mountain, which is summer range and which can only be viewed by actually climbing to the peak. Counts made of Sheep Mountain in the above manner are listed in Table 1 in the appendix.

Counts used in the discussion on population dynamics are usually higher than the numbers listed for Sheep Mountain. This mountain is only a portion of the total range of this population (Figure 1) and not all sheep are on Sheep Mountain at the same time. Even in late winter, winter ranges along Williscroft Creek and Bullion Creek are used by members of this population. However, if all those ranges are surveyed and if repeated classifications are done, the total number of sheep in this population can be established with a fair degree of accuracy.

The greatest difficulty is encountered when trying to establish the total number of rams in this population and their age structure. Only in

May 1973 were we able to determine the latter. Sheep Mountain is essentially a ewe wintering area and probably not more than 50% to 60% of rams are on this mountain at any one time. The rams dispersed over a much larger area and a portion of them mixes with members of other populations both in winter and in summer. However, throughout May it is possible to come up with a total number by repeated classifications and by making long excursions along Sheep Creek to locate all ram bands.

Another difficulty arises when trying to establish the number of lambs actually born. This can only be done by surveying the lambing grounds daily throughout the lambing period as well as by keeping track of the other nursery bands. Ewes separate from nursery bands before they give birth. The location of such isolated ewes must be mapped and checked every day. After giving birth they remain isolated for another day or two before they rejoin the nursery bands. By keeping track of such isolated ewes, their newly-born lambs as well as the total number of lambs in nursery bands, it is possible to establish the total number of lambs actually born as well as the early mortality. This was done for 1971 and 1972. A number of marked ewes in the population greatly aided in this exercise.

Summer counts of the population, the extent of their year round range and their migration routes were established concurrently with summer range studies and feeding observations on summer ranges. For this purpose a camp was maintained on Sheep Mountain's alpine north slope from June 1, 1971 to September 15, 1971.

B) Forage utilization:

Two methods were used to determine which plants were utilized as forages by sheep: first, direct observations, and second, rumen sample

analyses.

a) direct observations:

An average of 9 days per month was spent with direct observations of feeding sheep. Prior to the initiation of this work in October 1970, complete plant collections had been made to familiarize the writer with all potential food plants at various phenological stages. Preliminary work had also been completed with the floristic description of various plant associations on the range of this sheep population. This knowledge of which species grow in what associations greatly reduced the number of potential forage plants per site through elimination and increased the number of successful observations. To clarify this statement, let us use the genus Calamagrostis as an example. Plant collections had documented that four Calamagrostis spp. grow on the mapped area (C. canadensis, C. inexpansa, C. neglecta, and C. purpurascens), all of which are similar in external appearance. However, only the latter species (Calamagrostis purpurascens) was known to grow in grassland associations, and therefore only this species had to be recognized when the feeding of sheep in such grassland associations was monitored.

A serious attempt was made to distribute the direct observation of sheep proportionally to the various associations as well as altitudinal levels that were utilized at that time of the month. Since days spent with direct observations alternated with days on which the distribution of sheep over the various altitudinal zones and plant communities was documented, the statistics of the day prior to the observation day served as the respective reference. For instance, when it was found that 80% of the sheep fed in grassland associations and 20% in willows, then 4 hours were spent watching sheep feeding in grasslands, and 1 hour watching sheep browse in willow stands.

In order not to disturb the natural feeding behaviour of sheep,

initially observations were made from a distance of 200 to 300 feet. The procedure was to get to a 'strategic' location above the sheep, sit or lie down and watch them through a spotting scope, recording the observations on a tape recorder or note book. It is much easier to recognize individual plant species if observations are made from above. After some time, however, the sheep were so accustomed to the daily presence of the investigator that they often could be approached as closely as 100 or even 50 feet before they paid any attention to the writer.

The feeding observations were meant to report the forage utilization of this population, therefore observations of rams and ewes alternated proportionally to their ratios at the time. Occasionally attempts were made to stay with the same animals over an entire day.

The feeding was recorded as 'interactions' or bites per plant species. Initial work by the writer with semi-captive sheep (Hoefs, 1974) had indicated that the variations between these 'interactions' are much smaller than in the often-used 'animal minutes'. It was found that during one minute the number of bites may be as low as 2 or 3 and as high as 50. On the other hand, an interaction is determined by the capacity of the animal's mouth and the nature of the forage (height and density of forage, size and thickness of leaves). It was never observed to be less than a single leaf or bud and cannot be more than the animal can grasp at a time.

While most feeding took place in areas with little or no snow, allowing direct observation of food selection, it was occasionally necessary to inspect feeding craters in deep snow.

b) rumen sample analyses:

Over the past 5 years a total of 43 rumen samples became available from the study population and from surrounding arears with comparable

ecological conditions. The reliability of rumen contents for determining forage utilization of a population as well as the various methods of rumen content analyses have often been criticized, nor does the writer consider this method as perfect. But since such a large number was available and since the samples were nicely spaced over the entire year, they were considered a valuable supplement to direct feeding observations.

Approximately half the samples came from sheep that died from natural causes, usually during the winter months. The other half came from sheep that were collected for a variety of reasons by the Canadian Wildlife Service, the Yukon Game Branch, and the University of British Columbia. Additional sheep died during trapping and transplanting operations and a few were illegally taken by poachers.

Whenever the writer was personally involved with the collections, sheep were only taken after extensive feeding periods during which notes were made on the plant associations utilized and the forages taken. This procedure greatly aided in subsequent rumen analyses.

Approximately one quart (1.136 liters) was kept from each rumen, after the content was thoroughly mixed, and was kept frozen until analyses started. The samples were later thawed, washed, seived and oven-dried. A modification of Chamrad and Box's (1964) method of point analysis was used to determine % (percent) frequency of various species. A complete plant collection was available for reference, plus the fact that the plant associations as well as the forages used at the time were known through direct observations. Unidentifiable fragments were classified into the broad categories: grasslike, browse, forbs and mosses or lichens.

Snow conditions:

Snow cover duration in days as well as average and maximum depths

per plant association were determined during the 1970/71 winter through the establishment of 160 permanent snow posts. These posts were distributed in all three altitudinal zones and in all communities utilized by sheep over the annual cycle. These measurements were supplemented by frequent sampling of the snow depths with a ruler. Measurements were recorded at least at weekly intervals, plus immediately after every snow fall and major removal (chinook) period.

Measurements were also taken of the snow depths in the area in which sheep were feeding. Anatomical features of the sheep themselves were used as a scale as described by Geist (1971:265). An attempt was made to obtain these data twice every week during the period with snow cover. Between 80 and 150 sheep were observed per day, and for those that were feeding on ground vegetation, the snow depth was recorded. Periodically such estimations of snow depth done through a spotting scope were checked by trailing sheep feeding in different snow depths and measuring the depths of the feeding craters.

Temperatures:

To record the temperatures of the three biogeoclimatic zones (boreal, sub-alpine and alpine), to detect correlations between temperatures and plant phenological changes, as well as to analyse possible responses of sheep to temperatures, four weather stations were maintained at 2800, 3610, 5380 and 6380 feet elevations. Except for the station at 6380 feet, which was not serviced during December, January and February, all stations were maintained from June 1970 to September 1971. The stations consisted of weekly recording thermographs (Model T-9158, Cassela Instrument Ltd., London, England), and they were set up in Stevenson screens according to Department of Transport standards (Meteorological Branch, D.O.T., 1966).

The stations were serviced at weekly intervals and occasionally more frequently during very cold weather. The temperatures at the elevations of sheep were computed through interpolations of the graphs of adjacent stations, assuming linear relationship between altitude and temperature between such stations.

Wind:

To record the wind speeds the study area is exposed to over the annual cycle and to possibly detect any response of sheep to winds of different intensities or of different directions three permanent weather stations were maintained from May 1970 to August 1971 at 2600 feet, 3600 feet and 5400 feet elevations. These stations were equipped with totalizing anemometers (Counter type Mark II, R.W. Munro Ltd., London, England) and were serviced at weekly intervals.

Since only three instruments were available a decision had to be made as to where it was most desirable to determine wind speeds. Since previous experience had indicated that the study area is subject to particularly strong winds blowing from the southwest down the Kaskawulch Glacier and the Slims River valley, and since it was known that most sheep winter on the large southeast-facing slope of Sheep Mountain which is exposed to such winds, it was here that the weather stations were established. In doing so, however, it was not possible to measure the full force of winds blowing from the north, which, even though much less frequent than southwest winds, are important in mid-winter.

These three stations provided average wind velocities per week, which were useful in detecting differences in altitude and for comparisons with other areas, but which were of little help in determining the wind speeds

sheep were exposed to at any one time. To accomplish this a hand anemometer (#444, Science Associates Inc., Princeton, N.J., U.S.A.) was used. Direct readings from this instrument were supplemented by observing standard airport weather hoses (socks), twenty of which were distributed over the mountain at various altitudes. These hoses indicate the wind direction directly, and the velocities could be estimated by considering the angle, between the extended hose and the vertical supporting post.

Plant Phenology

In order to quantify the advance of plant development during the growing period in spring and summer as well as during the drying-up period in fall both with respect to altitude as well as aspect a number of investigations were carried out.

a) Dates of first flowering: Since studies by the writer (Hoefs, 1974) on a semi-captive herd of Dall sheep had demonstrated that the flowers of certain plant species are preferred forage plants, it was useful to know at what dates such flowers came into bloom. For this reason about 60 species of flowering plants, including all important forage plants, were mapped and the dates at which those plants first developed fully opened flowers were recorded during the 1970, 1971 and 1972 seasons.

b) Rates of growths and drying-up of important forage plants: Several investigators have shown that sheep and other ungulates prefer green and succulent vegetation to old, dried-up plants (Karaer, 1961; Arnold, 1964; Martin, 1964; Eadie, 1970; Hoefs, 1974). To document this selection for the study population the rates of growth and drying up of the five most important winter range plants (Artemisia frigida, Agropyron yukonense,

Calamagrostis purpurascens, Oxytropis viscida, and Carex filifolia) were measured at weekly intervals from early May to late October. Ten "clumps" or clones of these species were selected with respect to exposure to wind and sunshine but which were protected from grazing through exclosure fences or grew in sites not utilized by sheep. Weekly measurements included determination of lengths of leaves and flowering culms, percentage of green matter with regard to total standing crop, onset of flowering and fruiting, and rates of drying up. Estimations of these phenological phenomena were also done for a number of other forage plants.

c) Altitudinal phenological advance during spring: A number of factors have been used to explain the vertical seasonal movements of sheep, these include snow conditions and other weather factors, avoidance of blood-sucking insects, protection of winter ranges, and advantages with respect to forage (Dixon, 1938; Murie, 1944; Blood, 1963: Egorov, 1967; Hebert, 1972; and Nasimovich, undated). Some of these potential causes of vertical migration have also been investigated in this study. Some indications of the vertical march of phenology can be obtained from the dates of first flowering of plant species at different altitudes. However, a more accurate quantification is possible by observation of the performance of the same species of plant at various altitudes. Perhaps no other species in the study area is more suitable for such an investigation than Carex filifolia. It has the following advantages:

a) It is a fairly abundant plant in all dry grassland associations in the boreal, sub-alpine and alpine biogeoclimatic zones.

b) It is one of the most preferred Dall sheep forage plants.

c) It is an "early bird" in a phenological sense, flowering earlier and reaching the annual maximum of growth before any of the other important forage plants.

Ten bundles of this species were selected at each of five altitudinal sites (3080', 3310', 4400', 5260' and 6300') and measurements of growth, flowering, fruiting and rate of drying up were performed at weekly intervals from early May to late October. The selected bunches were protected from grazing by exclosure fences.

NUMBERS:

As has been outlined in the section on "methods and materials", two types of counts were made in this study: one was confined to "Sheep Mountain" proper and was meant to evaluate such parameters as intensity of use of various plant associations, while the other extended over the entire range of this population with the aim to establish statistics for an evaluation of the dynamics of the population.

Table 1 in the appendix lists the numbers obtained on Sheep Mountain proper from various locations along its base. The May and June counts do not include newly-born lambs. Counts which are thought to be incomplete because of poor visibility or other reasons have been ommitted.

The pattern of use of Sheep Mountain was similar during each of the five years of observation. In no year were sheep present during the month of July. Most migration off the mountain took place in the first half of June while sheep began to come back in the second half of August. Sheep Mountain is most heavily used in April and May, since during these months most nursery bands as well as the largest percentage of mature rams are found here. A second time of heavy use is observed in September and October when almost all nursery bands are on the mountain, but usually none or very few mature rams.

Fluctuation from day to day as well as between years must not be interpreted as "population trends". They simply reflect the artificiality of using Sheep Mountain as the boundaries of a study area, when it is only a portion of the total range of this population, as will be discussed in the next chapter. Fluctuations also reflect observational errors in that the north slope of Sheep Mountain cannot be observed from the base. A band of sheep using the peaks and high ridge of Sheep Mountain may therefore only be

partially accounted for.

From these factors it is apparent that counts on Sheep Mountain are not too useful, and single counts may even be misleading. However, if repeated counts are made in April/May as well as in September/October and if the "highs" or averages of these counts are used, some index of intensity of use of winter range is obtained, which may reflect the trend in this population.

The following table lists the highest counts obtained on Sheep Mountain in spring and in fall over the past 5 years.

TABLE: 2

Highest numbers of sheep observed on Sheep Mountain.

| | Spring Count * | | Fall Count ** | |
|---|---|---|---|---|
| Year | Date | Number | Date | Number |
| 1969 | May 18 | 90 | Sept. 11 | 114 |
| 1970 | April 23 | 157 | Oct. 5 | 151 |
| 1971 | April 9 | 164 | Oct. 6 | 151 |
| 1972 | May 28 | 155 | Sept. 12 | 113 |
| 1973 | May 21 | 136 | Oct. 6 | 133 |

* These spring counts include a large percentage of mature rams but no new-born lambs.

** These fall counts consist almost entirely of nursery bands.

The low counts in 1969 are a reflection of the writer not being familiar with the study area and with the most strategic places to do counts. Otherwise these counts have remained fairly stable even though there is some indication of a downward trend in fall 1972 and throughout 1973.

TABLE: 3

COMPOSITION OF THE POPULATION

(Observed data during lambing time (May) )

a) Numbers observed

| | RAMS 2 years and older | EWES 2 years and older | YEARLINGS 12 months | LAMBS new-born | TOTAL ADULTS | TOTAL POPULATION |
|---|---|---|---|---|---|---|
| 1969 | 65 | 69 | 30 | (40)* | 164 | 204 |
| 1970 | 81 | 90 | 24 | (45) | 195 | 240 |
| 1971 | 85 | 89 | 32 | 59 | 206 | 265 |
| 1972 | 82 | 86 | 36 | 50 | 204 | 254 |
| 1973 | 77 | 84 | 36 | (35) | 197 | 232 |

* ( ) Brackets indicate estimates, as will be discussed in text.

b) Percentages of total population (a) before and (b) after lambing

| | RAMS 2 years and older | | EWES 2 years and older | | YEARLINGS | | LAMBS* |
|---|---|---|---|---|---|---|---|
| | (a) | (b) | (a) | (b) | (a) | (b) | |
| 1969 | 40% | 32% | 42% | 37% | 18% | 15% | 20% |
| 1970 | 42% | 34% | 46% | 38% | 12% | 10% | 19% |
| 1971 | 41% | 32% | 43% | 39% | 16% | 12% | 22% |
| 1972 | 40% | 32% | 42% | 39% | 18% | 14% | 20% |
| 1973 | 39% | 33% | 43% | 36% | 18% | 16% | 15% |

* Percentage of total population

The numbers obtained by repeated classified counts over the entire range of this population are listed in Table 3. Subsequent chapters will deal in detail with such population parameters as productivity and sex ratios; we are here only interested in total numbers.

The total numbers of adult sheep have fluctuated very little, with 206 in May 1971 being the highest observed and 195 in May 1970 the lowest. The low count of 164 in 1969 is again accounted for by unfamiliarity with the total range of this population. The Williscroft Creek area, where thirty to sixty animals may be observed in spring was not surveyed at all, since it was not known at the time that this area is used by Sheep Mountain animals. The total numbers of sheep including lambs varies more because of great fluctuations in the lamb crops.

This table reveals that the population has been stable over the 5 year observation period, by whatever criteria "stable" may be defined. A slight downward trend was observed in 1973 and this will continue at least into 1974 because of the unusually poor lamb crop in May 1973.

That the 1969 data are not a true population estimate is revealed in the progress report by the writer (Hoefs, 1969). A survey flight was made on July 15, 1969, covering Sheep Mountain and the Mt. Wallace areas north to Williscroft Creek. A total of 192 sheep (including lambs) was observed. As will be discussed in the next chapter, this area is a heavily used summer range (Figure 1) where 70 to 80% of the sheep spend late June, July and August. This has been the case for the past 4 summers and there is no reason to believe that it was different in summer 1969. Since 192 sheep were counted here the total number at that time will have been between 240 and 270 which falls within the range of total summer counts in subsequent years.

Range of the population

For practical purposes the range of this population is bordered approximately by Kluane Lake in the west, Slims River in the south, Congdon Creek in the north, lower Bullion Creek and the height of land between lower Bullion Creek and the headwaters of Congdon Creek in the west (Figure 1a). Sheep Mountain, the most important winter range of this population and the site of intensive range use study, is shown in Figure 1b.

Not all of this 64 square mile area is sheep habitat, but wildlife managers often use physical boundaries like rivers, lakes, mountain peaks as borders of wildlife ranges, if they do not know the exact extent of the habitat.

Forests make up 19.3 square miles and flood plain vegetation 1.3 square miles of the total range. These vegetation types are never used by sheep, leaving (64.0 - 19.3 - 1.3) 43.4 square miles of actual sheep range.

Sheep Mountain and Sheep Creek are the most important wintering areas in this total range, and all sheep in the population come to it - at least for a short time - every winter. A small winter range occurs along the north side (south-facing) of Williscroft Creek and 30 to 60 sheep spend the fall and late winter there, however it is not used in January and February. There are two additional wintering areas along Bullion Creek, which are part of a larger range during winter of the "Bullion Creek population". However, some rams of the "Sheep Mountain population" wander back and forth between Sheep Creek and Bullion Creek particularly in late winter and spring. These areas are therefore included into the total range of the "Sheep Mountain population".

The large portion of the population (up to 90% of the nursery bands and about 50% of the rams) spends the summer along the west flank of Mount Wallace, the north slope of Sheep Mountain and the headwaters of

Williscroft Creek. (Figure 1)

Another important summer range is the area west of "Bullion Plateau" (Figure 1). The area is used at times by up to 20% of the "Sheep Mountain" rams; they share this range with part of the "Bullion Creek population". The remaining sheep, up to 30% of the mature rams and perhaps 10% of the nursery sheep, use the large summer range further north. They may be found anywhere, but "preferred" sites are the headwaters of Sheep and Fisher Creek and the extensive alpine plateaus adjacent to the north. Some sheep have been observed as far north as Congdon Creek and the headwaters of the Duke River, where they mix with members of another population.

Some Sheep Mountain sheep may at times go beyond the boundary as outlined here; this is compensated for by sheep of neighbouring populations "coming in", particularly in the Bullion Creek area. Therefore, it is reasonable to say that the density does not change significantly and is representative for this population.

Migration pattern

Studies have been conducted through U.B.C.'s Faculty of Foresty with emphasis on this aspect of sheep ecology, and I will therefore only describe it in general terms.

Most sheep are on winter ranges throughout the month of May. Of an adult population of approximately 200 at the time, 140 may be on Sheep Mountain, 30 along Williscroft Creek and 30 (rams) may use alternatingly the Sheep Creek or Bullion Creek areas.

Migration from winter to summer range is a very gradual process, which takes place throughout the month of June. Nursery bands and ram bands take different routes. During this migration both groups make extensive use

of the sub-alpine shrub zone, which is becoming "green" at this time, while the alpine zone lies for the most part still "dormant" and may be even partially covered by snow. The nursery sheep migrate along the east side of Sheep Mountain and Mount Wallace and gradually ascend through a number of creeks and gullies until they reach the summer range along the west side of Mount Wallace. This migration is not a "determined" procedure. There are many "back and forth" movements involved, and unfavourable weather, particularly snow, may force them to return to winter range overnight. A small band of rams (up to 20) also takes this route, while the majority gradually ascends along Sheep Creek. Some cross over to "Bullion Plateau", but most of them work their way up to the headwaters of Sheep and Fisher Creek, where they break up into smaller bands. Some continue in a northerly direction, utilizing the extensive alpine plateaus and many scree slopes in this area, until they come to the headwaters of Congdon Creek or at times even to the headwaters of Bullion Creek and the Duke River, which are beyond the boundary of Figure 1. The others move in an easterly direction and eventually utilize the summer range along the west slope of Mount Wallace, where they occasionally mix with nursery bands in mid-summer.

Perhaps the greatest "dispersion" (or distance from winter ranges) is reached in late July. This appears to be similar in Alaska since Jones (1963) writes: "The distribution of the sheep from mid July to the 5th of August probably represents the maximum dispersal of sheep into the high country during the summer". Once on summer range (in July and most of August) the daily movements are more or less random with respect to migration patterns. The heavily used area along the west side of Mount Wallace is grazed over from north to south several times, but these movements of sheep at this time is primarily determined by different phenological stages in

the mosaic of plant communities on their alpine range. Plant communities utilized early in the summer may be neglected later when others, formerly set back by shady aspects or waterlogging during spring run-off, become "green". This selection applies at the community as well as at the individual species level, as will be discussed in the section on range use and food selection.

In the second half of August some nursery bands are moving back to the winter range. At this time the north slope of Sheep Mountain is heavily used. By mid September most nursery bands have returned to winter ranges, utilizing the highest portions of them as well as neighbouring willow stands. Not all these sheep stay on winter ranges from now on. If snow conditions permit many move up again and utilize "summer ranges" immediately adjacent to winter ranges on parts of Sheep Mountain's north and west slopes. An occasional ram may return to the winter range and mix with ewes in October, or even in September, but the majority do not return until the rutting season, in November. After the rut most sheep stay on winter ranges, gradually moving lower, until May. The migration pattern must be very similar in Mt. McKinley Park since Murie (1944) writes: "The movements to the summer range take place during much of June and sometimes as late as July. The return to winter range begins in August, but most of the fall migration takes place in September. Stragglers have been seen migrating in early October".

As will be discussed in detail in the section on range use and food selection, winter and summer ranges have to be defined in terms of plant associations and not in terms of altitude. Some sheep may be observed at great heights and yet they are on <u>winter range</u>.

Vertical migration will be discussed in a separate section, after

the various environmental factors associated with it have been analysed.

A review of the literature shows that the horizontal distance between summer and winter range is very short for most members of this population. If the 4500 foot contour in the middle of Sheep Mountain's south slope is regarded as the starting point ("centre of dispersion"), then 75% of the population using Mount Wallace west slope as summer range migrates a maximum of 5 to 6 miles from their winter range and spends most of the summer at an average distance of not more than three miles from their winter range. The few sheep that move as far as the headwaters of Congdon Creek are 8 to 9 miles from their winter range. Individual rams have been seen in the headwaters of the Duke River, some 15 miles from Sheep Mountain; but we have so far no evidence that this is an annual event. Table 4 lists published migration distances for comparison. Most sheep populations looked at in other areas migrate a greater distance than the Sheep Mountain population. Nichol's (Nichol & Heimer, 1972) three study populations on the Kenai Peninsula in Alaska are each confined to ranges of some 80 square miles or less, and I assume that their migration distance will be very similar to that of the Sheep Mountain population. Asiatic snow sheep appear to traverse much greater distances in their annual migrations. Egorov (1967) describes the patterns in several populations in Yakutia, one of which supposedly migrated as far as 60 to 75 miles (100 to 120 km.) annually.

TABLE 4 :

Migration distances of northern * sheep

| Location | Species | Average distance in miles | Maximum distance in miles | Author |
|---|---|---|---|---|
| Kluane Range Kluane Park, Yukon | Ovis dalli | 3.0 | 8 to 9 ** | Hoefs present study |
| Dry Creek Alaska | O. dalli | 6.5 | 16.6 | Nichols & Smith (1971) |
| Dry Creek Alaska | O. dalli | | 8 | Erickson (1970) |
| Tonzona River Alaska | O. dalli | | 30 | Jones et al (1965) |
| McKinley Park Alaska | O. dalli | | 15 to 20 | Dixon (1938) |
| Yakutia U.S.S.R. | O. nivicola | | 15 to 20<br>30 to 40<br>60 to 75 | Egorov (1967) |

* northern sheep refers to Dall and Snow Sheep

** individual rams may go as far as 15 miles, however, we do not know whether this is an annual event.

POPULATION CHARACTERISTICS:

Densities:

In the last chapter it has been shown that the total range of this population is approximately 64 square miles. About 90% of this population spends the entire annual cycle in this area, while 10% (mainly mature rams) may on occasion go farther in mid summer (July, August); however, this is compensated for by members of other populations coming in at that time, so that the "density" remains fairly stable.

Forests and Slims River flood plain communities, two vegetation types not used by sheep, cut the "potential" total range of this population from 64 to an "effective one" of about 43.4 square miles, which can be divided up into the following "habitat types", showing different degrees of usuage over the year.

Winter ranges of Sheep Mountain, Sheep Creek, and Williscroft Creek make up a total of 5.1 square miles. These are utilized from mid-August to mid-June the following year, but most heavily from January to late May.

The sub-alpine shrub zone comprises a total of 11.9 square miles, 6.7 of which are "Salix glauca" type, which is used heavily in June and again in September and October; the other 5.2 square miles are "Salix lanata - glauca" type, which is used during the same months but to a lesser degree.

The remaining 26.4 square miles are alpine summer range; of which about 1.7 square miles are mountain peaks above the 7000 foot contour. These and an undetermined, but significant, acreage of steep walls, boulder fields and scree slopes with practically no vascular vegetation are of use only as escape terrain and bedding sites.

The entire summer range is used from late June to September by

nursery bands and up to November by rams, but 4.2 square miles of heavily-used summer range on the north side of Sheep Mountain and along the west flank of Mount Wallace (Figure 1) receive very heavy utilization from early July to late August.

Now that animal numbers and range sizes are known, densities can be calculated.

A summer population of about 250 sheep uses 64 square miles of "potential" range. This gives a year-round density of about 4 sheep per square mile. A study of Table 5 reveals that this density is higher than most densities reported. Only in other areas of the Kluane Game Sanctuary (Hoefs, 1973) and in the Mt. Hayes area of Alaska (Palmer, 1941) have greater densities been observed. The greatest year-round density observed by the writer (Hoefs, 1973) was found in the Steele Creek area, Kluane Game Sanctuary. However, this exceptionally high value of 8 sheep per square mile is based on only one summer and one winter survey and needs to be further studied.

As mentioned earlier, 70 to 80% of the Sheep Mountain population or about 175 animals utilize almost exclusively Sheep Mountain and the adjacent heavily-used summer range to the north of it. This works out to a density as high as 19.5 sheep per square mile, which to my knowledge has never been reported for any northern sheep population. Much higher values will of course be found on winter ranges, as will be discussed later; however in this particular context only year-round densities are relevant.

TABLE: 5

Densities of northern* sheep

| | Location | Sheep Type | Date | Sheep Number | Total "potential" range in square miles | "Year round" Density Sheep/sq.mile | Authors |
|---|---|---|---|---|---|---|---|
| 1 | Kluane Range Kluane Park,Yukon | Dall sheep | 1969-1973 | 250 | 64 | 3.9 | Hoefs (present study) |
| 2 | Donjek Range Kluane Park,Yukon | Dall sheep | 1972-1973 | 1,200 | 250 | 4.8 | Hoefs, 1973 |
| 3 | Steele Creek Kluane Park,Yukon | Dall sheep | 1972-1973 | 400 | 50 | 8.0 | Hoefs, 1973 |
| 4 | Crescent Mt., Kenai Alaska | Dall sheep | 1970 | 287 | 82 | 3.5 | Nichols & Smith (1971) |
| 5 | Cooper Landing closed area, Alaska | Dall sheep | 1970 | 311 | 81 | 3.8 | Nichols & Smith (1971) |
| 6 | Mt. McKinley Park, Alaska (total) | Dall sheep | 1941 | 1000 to 1500 | about 2500 | 0.4 to 0.6 | Murie, 1944 |
| 7 | Mt. McKinley Park, Alaska (total) | Dall sheep | 1928 | 5000 to 10,000 | about 2500 | 2.0 to 4.0 | Murie, 1944 |
| 8 | Mt. Hayes area, Alaska | Dall sheep | 1940 | 915 | 265 | 3.5 | Palmer, 1941 |
| 9 | Mt. Hayes area, Alaska | Dall sheep | 1940 | - | - | 5.23 | Palmer, 1941 |
| 10 | Yakutia (total) U.S.S.R. | Snow sheep | 1959 ? | 80 to 100,000 | 90,000 | about 1.0 | Egorov, 1967 |
| 11 | Verkhoyansk Range U.S.S.R. | Snow sheep | 1959 ? | - | - | 3 to 4 | Egorov, 1967 |
| 12 | Koryak Upland U.S.S.R. | Snow sheep | 1960/61 | - | - | 2.1 to 3.2 | Egorov, 1967 |

* northern sheep in this connection means Dall and Snow sheep.

SEX RATIOS:

Limited data indicate that the sex ratio at birth is close to equality. Table 6 lists the information available for Dall sheep. Nichols (1972) inspected 21 embryos of ewes collected in southern Alaska, 12 were males and 9 were females. During the present study the carcasses of five winter-killed ewes could be secured in time to inspect the embryos. Four ewes were pregnant with two embryos being males and two females. Considerable information on the sex ratio at birth became available through the capture of newly-born lambs on Sheep Mountain for the Yukon Game Farm and through births of lambs at the Farm. A total of 39 lambs could be classified of which 19 were males and 20 were females. Nichols and Heimer (1972) caught 17 lambs in nets in the Dry Creek area of Alaska. The sex ratio was 8 males to 9 females. Information on a total of 81 lambs, with a sex ratio of 41 males to 40 females, therefore indicates that this ratio is around equality at birth. Data available for Bighorn sheep and summarized by Geist (1971) also indicate an equal sex ratio at birth.

The sex ratios observed among adult sheep is also given in Table 6. It varied from 90 ♂♂:100 ♀♀ in spring 1970 to 96 ♂♂:100 ♀♀ in spring 1971. The average sex ratio observed during the five year period is 93 ♂♂:100 ♀♀. Because of the great difficulty of locating all ram bands, I doubt very much that the actual sex ratio among adult sheep varies significantly from equality. An equal sex ratio is generally assumed in unhunted populations, this is reported for Dall sheep populations in Mt. McKinley Park in Alaska. Murie (1944) states "...The data from the skull collection indicates that the sex ratio among the sheep is about 50:50". Recent observations in Mt. McKinley Park (Nichols and Erickson, 1969) documented a sex ratio of 98 rams to 100 ewes among adult sheep.

TABLE: 6

SEX RATIO OF DALL SHEEP

A. PRE-NATAL SEX RATIO

| YEAR OBSERVED | SAMPLE SIZE | MALE | : | FEMALE | AREA | AUTHORITY |
|---|---|---|---|---|---|---|
| 1970/71 | 21 | 12 | : | 9 | Alaska | Nichols (1972 |
| 1970/71 | 4 | 2 | : | 2 | Yukon | Hoefs (present study) |

B. POST-NATAL SEX RATIO

| | | | | | | |
|---|---|---|---|---|---|---|
| 1970 | 2 | 1 | : | 1 | Yukon | Hoefs (present study) Lambs born at Yukon Game Farm, Whitehorse. |
| 1971 | 2 | 1 | : | 1 | Yukon | |
| 1972 | 7 | 2 | : | 5 | Yukon | |
| 1973 | 5 | 2 | : | 3 | Yukon | |
| 1968 | 5 | 3 | : | 2 | Yukon | Hoefs (present study) Lambs caught on Sheep Mountain for Yukon Game Farm. |
| 1969 | 6 | 2 | : | 4 | Yukon | |
| 1970 | 4 | 2 | : | 2 | Yukon | |
| 1971 | 8 * | 6 | : | 2 | Yukon | |
| 1970 | 10 | 4 | : | 6 | Alaska | Nichols & Heimer (1972) Lambs caught in net. |
| 1971 | 7 | 4 | : | 3 | Alaska | |
| Summary: | 81 | 41 | : | 40 | | |

C. SEX RATIO OF ADULT DALL SHEEP

| YEAR | SAMPLE SIZE | RAMS 2 years and older | EWES 2 years and older | RATIO | AUTHORITY |
|---|---|---|---|---|---|
| 1969 | 134 | 65 | 69 | 94 : 100 | Hoefs (present study) |
| 1970 | 171 | 81 | 90 | 90 : 100 | |
| 1971 | 174 | 85 | 89 | 96 : 100 | |
| 1972 | 168 | 82 | 86 | 95 : 100 | |
| 1973 | 161 | 77 | 84 | 92 : 100 | |
| | | | $\bar{x}$ | 93 : 100 | |

* These lambs were released again

In populations exposed to hunting, the sex ratios among adult sheep varies greatly in favour of ewes. N. Simmons (personal communication) working with Dall sheep populations in the MacKenzie Mountains (Northwest Territories) which are under moderate hunting pressure observed a sex ratio of 85 ♂♂:100 ♀♀ among adult sheep. His total sample size was 553 animals. A great deal of work has been done on sheep censuses by personnel of the Alaska Fish and Game department. Only a few ratios observed will be listed here to demonstrate the range of variations.

Jones (1963) reported a sex ratio of 74 ♂♂:100 ♀♀ in areas of central Alaska, of a total of 1223 sheep classified. Pitzman (1969) observed sex ratios of 33 ♂♂:100 ♀♀ and 39 ♂♂:100 ♀♀ during two years of research in the Kenai National Moose range of southern Alaska. Nichols and Heimer (1972) found a sex ratio of only 13 ♂♂:100 ♀♀ on Surprise Mountain in southern Alaska. This is the lowest sex ratio documented for Dall sheep. Such a discrepancy among sexes cannot be explained by hunting pressure alone, since under existing legislation only about 50% of adult rams are subject to "legal" hunting; one suspects bias in the sample.

Breeding Age and Longevity:

Our observations support the general concensus that ewes breed first as 2½ year olds in the wild and have their first lamb as 3 year olds (Allan, 1939; Palmer, 1941; Honess and Frost, 1942; Spencer, 1943; Murie, 1944; Buechner, 1960; Cherniavski, 1962; Moser, 1962; Geist, 1971; and Luckhurst, 1973).

All ewes with newly-born lambs that could be approached close enough for positive identification were three years old or older. At close range such classification is still possible by taking into consideration the slightly smaller body size, juvenile facial characteristics and, primarily, horn lengths. The average horn length of two year old ewes is 15 cm. compared to 21 cm. for three year old ewes (Table 41). In the older age groups of ewes such separation is no longer possible because of great variation in horn growth and considerable overlap between age classes. Personal communication with N. Simmons who works on Dall sheep in the MacKenzie Mountains, Northwest Territories, reveals that he doubts that a significant portion of 2 year old ewes have lambs.

On the other hand we have evidence that ewes are potentially capable of reaching sexual maturity as 1½ year olds and of having their first lambs as 2 year olds. Of the lambs caught on Sheep Mountain immediately after birth, a number were retained by the Yukon Game Farm for breeding and exhibition purposes. These included 4 ewes, two of which had lambs at 2 years of age. Two yearlings caught on Sheep Mountain and in the Ruby Range had their first lambs as 3 year olds. The better reproductive performance of these captive ewes can perhaps be explained by better nutrition during winter, which is also reflected in faster horn growth and larger body sizes.

There is also some evidence that ewes in wild populations reach sexual maturity at 1½ years of age. Nichols & Heimer (1972) report that 75% (sample size 4) of the yearling ewes collected on Crescent Mountain, southern Alaska, were pregnant. Egorov (1967) reporting on Snow Sheep, states: "...ewes in Yakutia reach maturity at the age of one year and a half and usually begin to reproduce at that age".

Perhaps these two documentations came from "expanding populations", in the terminology of Geist (1971), who also made reference to the Bighorn sheep introduced on Wildhorse Island, Montana, whose females reached maturity at 18 months of age (Woodgerd, 1964).

We have so far no evidence of sterility because of old age. In contrast to observations by Murie (1944), the maximum length of life of ewes on Sheep Mountain is just as high as that for rams. Out of a total of 110 skulls of rams, which died from natural causes, only two were between 12 and 13 years old. Out of a total of only 7 skulls of ewesobtained, also two were in the 12 to 13 year old age class. The aging of ewes by counting the annual increments in horn growth is sometimes difficult and its reliability has been questioned. However, its accuracy has been verified for Dall sheep by Hemming (1969). Even Geist (1971) who has his reservations about the value of this technique for aging ewes, assumes that the age derived for old ewes may be an underestimation.

During the study period the carcasses of five winter-killed ewes could be secured before they were too badly damaged. Four of these ewes were pregnant and one of them was in her 13th year. Nichols and Heimer (1972) collected sheep on Crescent Mountain, southern Alaska, in mid-winter. Their collection included two ewes in their 13th year which were pregnant and one ewe over fifteen years old which had given birth before dying.

The reproductive age of rams can be assessed much more easily. There is a good correlation between length and massiveness of horns and the age of rams (Table 39 in appendix). While I have observed on several occasions that 1½ year old rams take part in chasing estrous ewes, the subsequent mounting was always performed by older rams. We know, however, from observations at the Whitehorse Game Farm that 1½ year old rams can be sexually mature. Two lambs were born at the farm in May, 1970, whose fathers were two year old rams. We have no indications of sterility in old rams; on the contrary, the old rams appear to be the most active. However, we did not capture rams during the rutting period to collect sperm. The conclusion that old rams are not sterile is based entirely on the observations of their behaviour during the rutting season.

The maximum length of life obtained by members of the Sheep Mountain population is not as high as that reported for other areas. So far our evidence indicates that 13 years is the maximum for rams and ewes. Murie (1944) found 3 ram skulls in the 13 to 14 year age class during his extensive collections in Mt. McKinley Park; Hemming (1969) used three 14 year old and two 15 year old skulls from the Brooks Range in his research on age determination. Nichols and Heimer (1972) caught two 14 year old ewes in nets in the Dry Creek area of Alaska. They also reported on collecting an ewe over 15 years old on Crescent Mountain in Alaska. Simmons (1968) reported 4 rams in the 13 to 14 year age class and one in the 14 to 15 year age class out of 159 skulls inspected from hunter-killed rams in the MacKenzie Mountains of the Northwest Territories. No research on other Dall sheep populations has been done in the Yukon, but in 1973, the Yukon Game Branch began to inspect the horns of rams killed by hunters in various areas of the Yukon Territory. A 14 year old ram was shot in the Snake River area and

the percentage of 13 year old rams in the hunter kill of certain areas was higher than could be expected from the life table (Table 12) of the Sheep Mountain population. Outfitter Werner Koser informed us that his hunters shot 2 rams in the past few years which had 15 annual rings and were therefore at least 15 if not 16 years old, since the first year's ring usually is not visible in old rams. These rams were shot in the Selwyn Mountain range.

It therefore appears that the maximum length of life of members of the Sheep Mountain population is at least one year shorter than that of other Dall sheep populations which were studied. Speculations on possible reasons for this will be dealt with later.

REPRODUCTIVE PERFORMANCE:

1) Pregnancy Rate; Twinning

No special collections were made to determine the pregnancy rate, but the carcasses of five winter-killed ewes could be secured in time to check for pregnancy. Four of these five ewes had embryos, or 80% of them.

Collections were made of Dall ewes in other areas of their range. N. Simmons (personal communication) collected 107 ewes during March in the MacKenzie Mountains, Northwest Territories. Of these ewes 80 (or 75%) were pregnant. Even higher pregnancy rates are reported by Nichols and Heimer (1972), who collected 25 ewes from Crescent Mountain in southern Alaska. They found that 100% of the ewes over two years old and 75% of the yearlings were pregnant.

Neither Simmons (personal communication) nor Nichols and Heimer (1972) observed twins. During the present study the writer had an opportunity to watch lambs shortly after birth on more than a hundred occasions, but no twins were seen. Detailed studies on small populations (Woodgerd, 1964, Pitzman, 1969, Luckhurst, 1973) did not reveal any twinning. Jones (1963), after counting and classifying 2619 sheep in various areas in Alaska stated: "We have no records of twins being born." There are, however, some exceptions to this rule. Dixon (1938) reports "...As a rule each ewe gives birth to but one lamb per season, although at times there are twins." Palmer (1941) classified 915 sheep, including 214 lambs in the Mt. Hayes region of Alaska and reported: "...Twins are only occasionally born; we recorded but five sets." Murie (1944) states: "...Twins are a rarity. Only one pair was noted." Occurences of twinning are also reported from Siberian Snow sheep. Cherniavski (1962) states: "The Snow sheep mostly bring forth one lamb, but 2 cases of twins are known." Egorov (1967) reported: "Twin births were

observed in July and August of these two years in 17% of all births."

Limited observations suggest that the quality of nutrition during ovulation time and the subsequent winter has no influence on the incidence of twinning in the Dall sheep population under study. A total of 16 single lambs have been born so far at the Yukon Game Farm, whose dams originated from Sheep Mountain. Better nutrition of these sheep reflected itself in earlier sexual maturity, faster horn growth and larger body sizes. If twinning does occur in this population, it is with these captive ewes where it would be expected first.

It is therefore concluded, that twinning -- if it does occur at all — is of no consequence to the dynamics of this population.

2) Lamb to Ewe Ratios; Mortality During the First Year of Life

Exact determination of the number of lambs born in this population was only possible for the 1971 and 1972 lambing periods. In 1969 and 1970 the writer was not yet familiar with all the lambing sites and with subsequent migration routes from lambing grounds, in 1973 only a small portion of the month of May could be spent in the field. However, for all five years the number of lambs present after completion of the lambing period in June and July was established.

Most investigators count lambs at that time of the year and use such counts to determine the birth rate in a population. Only a few very detailed studies on small populations (Woodgerd 1964, Pitzman 1969) could establish the number of lambs actually born and therefore the true natality rate of the herd. The total number of lambs born was estimated, however, for 1969 and 1970 and 1973, by using the numbers obtained after the lambing period and making adjustments for an early mortality of about 18% (average)

and for lambs removed from the population for the Yukon Game Farm. An early mortality of 18% during the lambing period was established for 1971 and 1972 (Tables 7a, 7b), and we have no reason to believe that early mortality did not occur during the other three years (1969, 1970, 1973).

The lambing period extends over the entire month of May, with most lambs born in the second half of that month. In 1972 one lamb was already born on April 30, 1972 and, in both 1971 and 1972 the last lambs were born on June 2 (Tables 7a, 7b).

Reports on Alaskan Dall sheep indicate that their lambing period begins later.

Palmer (1941) states: "...Most of the lambs appeared to have been dropped between June 1 and June 15." Dixon (1938) reported: "The lambs are born from early in May, while there is still considerable snow on the ground, until late in June." Jones (1963) observed the first new-born lamb on May 18, 1962. Nichols and Erickson (1969) reported that: "... lambing in Peters Creek commenced between May 17 and May 20, 1968... and appeared to be completed on June 4, 1968. An exception was noted on Surprise Mountain in the Kenai Peninsula where several ewes were observed alone on high cliffs above Skilak Glacier on a June 19 flight. They appeared to just have had lambs." Murie (1944) makes reference to considerable variation in lambing period between different years. We have so far not observed this on Sheep Mountain. It is likely that the later beginnings of the lambing periods in certain areas of Alaska are an adaption to a delayed plant development of such more northern latitudes. Lambs will be born at a time of year which is most advantageous for them.

During the five year observation period the number of lambs born on Sheep Mountain varied greatly. The best lamb crop observed was in 1971,

TABLE 7a :

Survival of the 1971 lamb crop to yearling's age

| Date | May 2/71 | May 4/71 | May 5/71 | May 6/71 | May 8/71 | May 9/71 | May 13/71 | May 14/71 | May 15/71 | May 16/71 | May 17/71 | May 18/71 | May 19/71 | May 20/71 | May 21/71 | May 23/71 | May 24/71 | May 25/71 | May 26/71 | May 27/71 | May 30/71 | June 2/71 | Sept. 24/71 | May 16/72 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lambs born | 2 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 3 | 4 | 2 | 5 | 6 | 6 | 3 | 4 | 4 | 5 | 4 | 2 | 1 | 1 | 0 | 0 |
| Lambs dead | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 13 |
| Total numbers of lambs present | 2 | 2 | 1 | 1 | 2 | 3 | 4 | 5 | 8 | 12 | 13 | 18 | 23 | 27 | 30 | 34 | 38 | 43 | 46 | 48 | 49 | 50 | 49 | 36 |
| Sum of lambs born | 2 | 2 | 2 | 3 | 4 | 5 | 7 | 9 | 12 | 16 | 18 | 23 | 29 | 35 | 38 | 42 | 46 | 51 | 55 | 57 | 58 | 59 | 59 | 59 |
| Sum of lambs dead | 0 | 0 | 1 | 2 | 2 | 2 | 3 | 4 | 4 | 4 | 5 | 5 | 6 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 * | 10 | 23 ** |

** 39% died during first year of life

* 15% died during first month of life

TABLE : 7b

Survival of the 1972 lamb crop to yearling's age

| Date | April 30/72 | May 4/72 | May 8/72 | May 9/72 | May 10/72 | May 11/72 | May 12/72 | May 15/72 | May 16/72 | May 17/72 | May 18/72 | May 19/72 | May 20/72 | May 21/72 | May 24/72 | May 25/72 | May 26/72 | May 27/72 | May 28/72 | May 30/72 | June 2/72 | July 10/72 | Sept.12/72 | April 21/73 | May 20/73 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lambs born | 1 | 1 | 0 | 3 | 4 | 1 | 2 | 6 | 3 | 3 | 3 | 4 | 1 | 2 | 2 | 2 | 4 | 3 | 3 | 1 | 1 | 0 | 0 | 0 | 0 |
| Lambs dead | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 0 |
| Total numbers of lambs present | 0 | 1 | 0 | 3 | 7 | 8 | 10 | 14 | 16 | 17 | 20 | 24 | 25 | 27 | 27 | 29 | 33 | 35 | 38 | 39 | 40 | 40 | 38 | 36 | 36 |
| Sum of lambs born | 1 | 2 | 2 | 5 | 9 | 10 | 12 | 18 | 21 | 24 | 27 | 31 | 32 | 34 | 36 | 38 | 42 | 45 | 48 | 49 | 50 | 50 | 50 | 50 | 50 |
| Sum of lambs dead | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 4 | 5 | 7 | 7 | 7 | 7 | 7 | 9 | 9 | 9 | 10 | 10 | 10 | 10 * | 10 | 12 | 14 | 14 ** |

** 28% died during first year of life

* 20% died during first month of life

when an estimated 78 ewes in reproductive age gave birth to 59 lambs for a ratio of 76:100 (Tables 8a, 8b). This ratio was never observed, since by the time all of the 59 lambs were born 9 had already succumbed (Table 7a). The ratio during summer was therefore 64:100 (Table 8b). The poorest lamb crop was observed in 1973, when an estimated 68 ewes in reproductive age gave birth to an estimated 35 lambs. Only 28 lambs were actually counted in June, giving a summer lamb to ewe ratio of 41:100. It is possible that the lamb crop for 1969 was just as low, however, we do not know the total number of ewes in reproductive age for that year to establish ratios. The years 1970 and 1972 were "average" as far as lamb crops go with 36 and 40 counted on summer range, giving summer ratios of 47:100 and 57:100 lambs to ewes in reproductive age respectively. We have so far not found any correlation between lamb crop and climatic parameters. The 1972/73 winter has been one of the mildest on record, both with respect to temperatures as well as snowfall, and yet the 1973 lamb crop has been the poorest so far observed.

A number of methods have been used in various investigations to convey an index of "reproductive performance" of a population. Such indices have been in the way of ratios, percentages or actual numbers. An attempt has been made to work out many of these indices so that our data can be compared to those obtained from other studies. Table 3 gives the numbers of rams, ewes, yearlings, lambs (at birth), the total numbers in the population before and after lambing and the percentages that each of these population segments contributes to the total population before and after lambing. Tables 8a, 8b deal specifically with the reproductive performance of this population. It gives the composition of the nursery bands as young rams (2 to 3 years old), ewes (2 years and older), yearlings and lambs, as well as an estimation of ewes in reproductive age (3 years and older). Further-

TABLE: 8a

REPRODUCTIVE PERFORMANCE

a) Observed Composition of Nursery Bands

| OBSERVATION TIME | | 1 NURSERY SHEEP* Σ 2 + 3 + 4 | 2 RAMS 2 to 3 years old | 3 EWES 2 years and older | 4 YEARLINGS ♂ & ♀ 1 to 2 years old | 5 LAMBS ♂ & ♀ 0 to 1 year old | 6 EWES** 3 years and older |
|---|---|---|---|---|---|---|---|
| 1969 | a. Lambing time (May) | 99 | -- | 69 | 30 | (40)*** | ? |
| | b. Summer, early fall | 102 | 2 | | 100**** | 28 | |
| 1970 | a. | 114 | -- | 90 | 24 | (45)*** | 77 |
| | b. | 120 | 5 | | 115 | 36 | |
| 1971 | a. | 125 | 4 | 89 | 32 | 59 | 78 |
| | b. | 122 | -- | | 122 | 50 | |
| 1972 | a. | 122 | -- | 86 | 36 | 50 | 71 |
| | b. | 117 | 1 | | 118 | 40 | |
| 1973 | a. | 123 | 3 | 84 | 36 | (35)*** | 68 |
| | b. | 118 | 2 | | 116 | 28 | |

* Nursery Sheep means an adult member of a nursery band which is composed of ewes, yearlings, and a few 2 to 3 year old rams.

** Ewes in reproductive age (3 years and older) are calculated as follows: Number of ewes (2 years and older) minus 45% of the number of previous years' yearlings. This 45% is based on assumed equal sex ratio (100% : /2 = 50% ♀♀) and an assumed 10% mortality during the second year of life (50% - 5% = 45%). The following example will demonstrate the calculation: In May 1971 there were 89 ewes of age 2 years and older in the population. In May 1970 there were 24 yearlings present. Assuming an equal sex ratio and 10% mortality in that year, the 45% of 24 or 11 female sheep are now among the adult females, but are not yet in reproductive age. These 11 are subtracted from 89 to give 78 ewes in reproductive age during the 1971 lambing period.

*** The total number of lambs born could only be ascertained for the 1971 and 1972 lambing period (See tables 7a and 7b ). The lamb crops for 1969, 1970 and 1973 were estimated by considering the actual numbers seen, the numbers trapped for the Yukon Game Farm and an assumed early mortality of about 18% as established for the years 1971 and 1972 (Tables 7a and 7b ).

**** At the end of their second growing season, yearlings (particularly males) have reached the size of adult ewes and are often difficult to distinguish from them when counts are made from a distance. To avoid the introduction of errors, these two groups are lumped here.

? The number of ewes in reproductive age could not be calculated for May 1969, since the number of yearlings in May 1968 was not known.

TABLE: 8b

b) Calculated Ratios

## REPRODUCTIVE PERFORMANCE

| OBSERVATION TIME | | LAMBS 100 ewes* 3 years and older | YEARLINGS 100 ewes* 3 years and older | LAMBS 100 nursery sheep** |
|---|---|---|---|---|
| 1969 | a. | | | 40 : 100 |
| | b. | | | 27 : 100 |
| 1970 | a. | 59 : 100 | 34 : 100 | 40 : 100 |
| | b. | 47 : 100 | | 30 : 100 |
| 1971 | a. | 76 : 100 | 41 : 100 | 47 : 100 |
| | b. | 64 : 100 | | 41 : 100 |
| 1972 | a. | 71 : 100 | 51 : 100 | 41 : 100 |
| | b. | 57 : 100 | | 34 : 100 |
| 1973 | a. | 51 : 100 | 53 : 100 | 28 : 100 |
| | b. | 41 : 100 | | 24 : 100 |

a. lambing period (May)
b. summer, early fall
* Ewes in reproductive age as listed in Table 8a
** Adult members of nursery bands as listed in Table 8a

more, the most commonly used ratios, lambs per 100 ewes (in reproductive age), yearlings per 100 ewes (in reproductive age), and lambs per 100 nursery sheep (ewes, yearlings and some young rams) are reproduced here. The last ratio is a poor indication of reproduction in a population, but it is often used for practical reasons. During aerial surveys in late summer, for instance, it is often difficult to separate yearlings of both sexes from ewes. Therefore all "adults" are lumped and only lambs are separated from them. The ratios as well as the actual numbers are given for a) during lambing time and b) during summer and early fall.

A survey of the literature indicates that there is great variation in the reproductive performance in different populations of northern sheep and in the same populations in different years. It is therefore not possible to generalize on this topic. In the following brief review some examples from the literature are given, arranged in an order of decreasing natality rates.

One of the highest birth rates observed is that of a Stone sheep population in northern British Columbia. Luckhurst (1973) reported an average lamb:ewe ratio of 74%, in which 2 year old ewes were included. He estimates that the ratio of lambs to ewes in reproductive age may be as high as 91%. Egorov (1967) observed a 74% ratio in Snow sheep of Yakutia. Simmons (personal communication) found a lamb to ewe ratio of 69% in the MacKenzie Mountains. Scott et. al. (1950) reported a ratio of 70% for sheep populations on the Kenai Peninsula in Alaska. Palmer (1941) observed a 66.9% ratio in the Mt. Hayes area of Alaska. Erickson (1970) and Jones (1963) found ratios of 63.5% and 50% respectively in the Dry Creek area of Alaska. A number of investigators observed ratios of around 50%: Murie (1944) in Mt. McKinley Park, Alaska, 50% and 49% in 1939 and 1940 respectively; Jones (1965) on

the Kenai Peninsula, 54%; Nichols and Smith (1971) in the Dry Creek area, 55% and Jones (1965) in the same area, only 39%.

The range of variation between different years in the same population can be appreciated from Rausch and Jones (1966), who observed a ratio of 50.2% and 67.4% in 1962 and 1963, respectively in the Chisana - Nabesna area of Alaska, and from Pitzman (1969), who reported 64% and 43.8% for 1966 and 1967, respectively, for a sheep population on the Kenai National Moose Range. Pitzman's (1969) percentages are a true indication of natality rates, since he did not include 2 year old ewes in the calculation.

The lowest ratios observed came from Cherniavski (1962) with 28.8% for snow sheep from the Koryak Highlands (Siberia), and from Nichols and Heimer (1972) for two areas in southern Alaska. They observed on Surprise Mountain ratios of 14% and 18% in 1970 and 1971, respectively, and in "Copper Landing Closed Area" 21% and 38% in the same years.

Comparisons with these data would classify the Sheep Mountain population as "average" in reproductive performance, with ratios -- based on summer counts of nursery sheep -- varying from 64% in 1971 to 41% in 1973.

Mortality during the first year of life was accurately determined for 1971 and 1972 cohorts (Tables 7a, 7b). The mortality rates were 39% for the 1971 lamb crop and 28% for the 1972 lamb crop. For lambs born in 1969 and 1970 an accurate determination of first year mortality was not possible, firstly because the total number of lambs born could only be estimated, and secondly removal of 6 lambs in 1969 and 4 in 1970 by the Yukon Game Farm greatly complicated the issue. If removals are considered as "mortalities" and if early mortality during the lambing period was similar to that observed in 1971 and 1972, then about 40% of the 1969 lamb crop and 29% of the 1970 lamb crop died during the first year of life. Our observations indicate that

mortalities during the first year of life are concentrated around the lambing period (the first few weeks of life) and then again during the first winter. There is little if any mortality from mid June to October.

For the construction of a life table an average mortality of 34% was used. This is based on the 1971 and 1972 evidence and it is also a fair estimate for 1969 and 1970. These mortality rates are shown in Tables 7a and 7b. They cannot be calculated from the lamb to ewe and yearling to ewe ratios in Table 8b, since the number of ewes did not remain constant.

Many mortality rates from the literature can be criticized on two accounts: firstly — as mentioned above — if ratios are used, it is essential that the number of ewes is constant. This is an unrealistic assumption unless one is dealing with a very stable population in which mortality of ewes (about 13% annually in the Sheep Mountain population) is replaced by an equal amount of yearling recruitment. Secondly, as already pointed out, ratios established in summer after the lambing period, are already reduced because of early mortality during the first few weeks of life. The use of ratios is particularly misleading if lamb to ewe and yearling to ewe ratios from the same year are used, under the assumption that the lamb crop was probably comparable to the previous year. Evidence has been presented to show that there can be great variation in lamb crops between years.

Our observations, that there is little mortality during summer, are supported by Murie (1944). Also Luckhurst (1973) observed that the greatest mortality of the lamb crop occurred in winter. However, Cherniavski (1962) states: "These data show the lamb mortality proceeds fairly evenly and apparently by the end of September about 30 to 35% of the lambs that

were born have perished". Cherniavski (1962) estimated that 50% die during their first year of life.

First year mortality rates vary greatly. Simmons (personal communication) estimated it for sheep populations in the MacKenzie Mountains, Northwest Territories, at 50%. Murie (1944) assumed a mortality rate of 50% for the 1938 lamb crop, and 61% for the 1939 lamb crop, after a very severe winter in Mt. McKinley Park. Heavy losses are also reported by Nichols and Heimer (1972) who demonstrated 50% and 38% mortalities for the 1970 lamb crops on Surprise Mountain and Copper Landing Closed Area, Alaska, respectively. Jones (1963) observed a 50% mortality rate in the Tonzana River area, Alaska; and Luckhurst (1973) reported a 40% rate for the Nevis Mt. population in northern British Columbia.

Lighter mortality rates have been reported by Jones (1965) for the Dry Creek area of Alaska, with 20.4% and 36.2% for the 1962 and 1963 lamb crops, respectively. Egorov (1967) observed a 30% in Siberia Snow sheep; and Pitzman (1969) found 12% and 34% losses of the 1966 and 1967 lamb crops, respectively, on the Kenai National Moose Range in Alaska.

Losses observed in the Sheep Mountain population of 29% and 38% can therefore be considered as light.

Our data do not support observations made by Geist (1961:291) in that there is a direct significant relationship in cold climates between the lamb crop and their survival. In 1971, the year with the largest lamb crop, 59 lambs were born, 50 were still alive during the summer, but only 36 survived to yearling age. On the other hand, in 1969 twenty-eight lambs were alive during the summer and 24 of them made it to yearling age, and in 1972, 50 lambs were born, forty of them were alive during July, and 36 of them made it to yearling age.

These observations would therefore more appropriately support Cowan's "compensatory mortality", in that there was a higher mortality rate, when more lambs were born (Cowan, 1950 ).

3) Yearling to Ewe Ratios; Mortality During the Second Year of Life

The number of yearlings in the population was accurately determined for all five years (Tables 3, 8a). These total counts were only possible during May when the "nursery" component of this population was concentrated on winter ranges close to lambing areas. At this time the yearlings were almost exactly one year old. Their numbers ranged from a high of 36 in 1973 and 1972 (reflecting the good lamb crops of 1972 and 1971) to a low of 24 in 1970 (reflecting artifical removal of lambs from the mountain, most likely superimposed on an already poor lamb crop). In 1969 and 1971, 30 and 32 yearlings were counted, respectively. The ratios of yearlings to ewes in reproductive age are given in Table 8b; they vary from a high of 53:100 in 1973 to a low of 34:100 in 1970.

A review of the literature indicates that the percentages of yearlings in a population or the yearling to ewe ratios vary even more than the lamb to ewe ratios discussed earlier. This is to be expected since variations in lamb crops are expanded by different mortality rates during the first year of life.

Only some of the data available in the literature will be reproduced here to show the range of variation observed. Good yearling to ewe ratios, indicative of an expanding population (Geist, 1971), were reported by Egorov (1967) with 50% for Snow sheep in Yakutia; Luckhurst (1973) with 46.2% for Stone sheep in Northern B.C.; Pitzman (1969) with 38% and 49% for 1966 and 1967 respectively, for a Dall sheep population on the Kenai

National Moose Range, Alaska; Jones (1963) with 41% for Dall sheep in the Dry Creek area, Alaska; and by Simmons (personal communication) with 36% for Dall sheep populations in the MacKenzie Mountains, Northwest Territories.

Average ratios, sufficient to keep a population stable, were observed by Cherniavski (1962) with 25% and 33% in 1960 and 1961 respectively, for Snow sheep populations on the Koryak Highlands, Siberia; Erickson (1970) with 31.4% for a Dall sheep population in the Dry Creek area, Alaska; Jones (1963) with 29% for a Dall sheep population in the Tonzona River area, Alaska; and Murie (1944) with 26% for Dall sheep in Mt. McKinley Park, Alaska.

Yearling counts, of a size insufficient to replace adult mortality, were observed by Nichols and Heimer (1972) with 4% and 7% for 1970 and 1971 respectively, for a Dall sheep population on Surprise Mountain, Alaska; Nichols and Erickson (1969) with 2.6% to 8.6% for Dall sheep populations in various areas of Alaska; and Murie (1944) with only 0.5% to 4% for Dall sheep in Mt. McKinley Park, Alaska.

This comparison to data obtained from other northern sheep populations shows that the yearling counts obtained from Sheep Mountain are average to good. As will be discussed later, recruitment of 25 to 30 yearlings is necessary to replace adult mortality, while yearling numbers as high as 36 should result in a slow buildup of that population unless emigration takes place.

Our experience shows that the likelihood of error in classifying sheep is much greater for yearlings than for lambs or for adult sheep. Particularly if counts are made in late summer and subsequently, many yearlings, particularly rams, have reached the size of adult ewes or at least of 3 year old ewes, and are easily misidentified from a distance. The bias introduced is of the nature to always underestimate the number of

yearlings, since, while yearlings can be misidentified as adults, it is hardly possible to misidentify adult sheep or lambs as yearlings. For this reason, yearling counts must be considered as conservative.

In our studies we were not able to accurately determine the number of yearlings subsequently to the May counts mentioned earlier. The bands disperse on summer ranges and it is not possible to approach each band close enough for accurate classification on a single day. The return to winter ranges is a gradual process. By this time the yearlings have completed their second growing season and they do not differ much from adults when observed over a great distance. However, the following May when the nursery bands are again concentrated around lambing areas, it is possible to get accurate counts of yearling males, which have now reached their second birthday. Even though comparable to ewes in body size, they differ from them by the thickness of their horns. Adult ewes (2 years and older) have horns between 15.0 cm. and 31.2 cm. long, with 12.0 cm. to 13.0 cm. circumference at base (Table 41). The lengths of horns of two year old rams is on the average, 29.4 cm. (Table 40a) but the circumference at base is 17.7 cm. With a range from 14.0 cm. to 22.2 cm. (n = 12) there appears to be no overlap with ewe horns in this characteristic.

Mortality during the second year of life is difficult to determine. However, a fairly good estimate can be made if one assumes an equal sex ratio. Since sex ratios are about equal at birth as well as in the adult population, we have no reason to assume an unequal, sex - specific mortality rate in any one age class. For instance in May 1971, 59 lambs were born (30 ♂ 29 ♀ ?); in May 1972, 36 yearlings were alive (18 ♂ 18 ♀ ?); while in May 1973 there were still 17 two year old rams in the population. If the equal sex ratio holds true then only 1 ram died during his second year of

life. Similar computation for 1972 and 1971 indicate again mortality of one ram and none at all, respectively.

There is no doubt that mortality in this age class is low, it may perhaps be the lowest of any age class. It could only be accurately determined if all yearlings were marked. A small sample size would either overestimate mortality (if the one that dies happens to be a marked animal), or it would show no mortality at all (if the one that dies happens to be an unmarked yearling).

We have for the purpose of life table construction (Table 12) assumed that one ram out of this population dies during his second year of life, which works out to be 3% to 4%, depending on the total number of yearlings at the time.

No attempt was made to estimate the number of ewes that died during their second year of life. However, they suffered heavier losses through "man-inflicted" mortalities (Table 11). No life table was constructed for the female segment of this population since the data available were insufficient. A 10% mortality was assumed during the second year of life of ewes for the calculation of "ewes in reproductive age" (Table 8a). The error which may have been introduced here is of too small a magnitude to significantly change the lamb to ewe and yearling to ewe ratios. Taber and Dasmann (1957) calculated a 10% loss of yearlings for Dall sheep in McKinley Park, based on Murie's (1944) population data.

Because of the obvious dificulties in determining mortalities during the second year of life, very few investigators have attempted it. Luckhurst (1973) calculated a mortality of 14% by using yearling to ewe ratios for Stone sheep populations in northern British Columbia. This method of determining mortality rates can be criticized for the reasons given earlier.

Pitzman (1969) worked out population models for 1966 and 1967 of a Dall sheep population on the Kenai National Moose Range, Alaska. In 1966 this population included 39 yearlings. In 1967 there were 20 ewes of 2 years of age. If the sex ratio was equal in the 1966 yearlings, then there was no mortality during the second year of life for the females. Unfortunately he did not separate two year old males from older rams.

A few detailed studies have been done on Bighorn sheep and have been summarized by Geist (1971) as follows: "The survival of sheep through their second winter appears to be quite good. Wishart (1958) found that of 19 rams entering their second winter at least 17 survived, and of 26 ewes, 24 survived. However, these were offspring from a high-quality population and were probably large and well grown in turn. Woodgerd (1964) found that of 12 tagged yearling males, 11 survived to 2 years of age, and 4 of 5 tagged yearling ewes. Of 6 known Stone's yearling females and 4 yearling rams all survived the winter 1964/65. However, those observations come from sheep of high or good quality. Unfortunately the data for other populations are scant. However, since in the Banff bighorn populations, the ratio of $2\frac{1}{2}$ year old males per female is about the same as that for $1\frac{1}{2}$year old males per female, it appears that yearling males have a very good survival. For females there are no data."

This brief review of the literature indicates that most investigators observed a very low mortality rate during the second year of life.

4) Productivity of the Population

Productivity can be defined as the recruitment into the population of animals in breeding age.

As has been discussed in the previous section, mortality during

the second year of life is difficult to assess accurately, even though fair estimations are possible by considering equal sex ratios, and no sex - specific mortality during the second year of life. All evidence points to the fact that second year mortality is low and may well be the lowest of any age class. It is therefore reasonable to say, that the survival to yearling age, referred to by Cowan (1950) as "effective" reproduction is a very good indication of the productivity of the population.

Productivity can be referred to as good, if the recruitment into the adult population exceeds adult mortality, on the other hand, it can be referred to as poor, if it is smaller. Discussion of the life table of the population reveals, that an adult mortality of 26 to 27 animals can be expected in an "average" year. Inspection of Table 8a shows that during 1970 recruitment of 24 yearlings was "poor" productivity, during 1969 and 1971 (30 and 32 yearlings) it was sufficient to maintain a stable population, while in 1972 and 1973 (36 and 36 yearlings) it was good and should reflect itself in a build-up of adult numbers. However, this does not necessarily reflect itself in the total numbers of sheep present, because of the unknown factor of "emigration", which appears to be particularly important in these young animals.

COMPOSITION OF NURSERY BANDS

Our observations indicate that there is not only a segregation of (mature) ram bands from nursery bands during the summer months (May to late October) but also that within the nursery component of this population, ewes which have lambs tend to stay together while those which do not have lambs also form bands. This kind of segregation can lead to the introduction of great errors if, for instance, the reproductive performance of the population is determined from surveys of a few "sample" bands.

For instance, a count on the Mount Wallace summer range on July 10, 1972, revealed the following classification of a large nursery band: 6 rams (2.2 years of age), 57 ewes, 28 yearlings and 40 lambs. It is known that at the time there were at least 86 ewes, 36 yearlings and 40 lambs in the population, since these returned to winter range. Therefore, another band or more on summer range at the time consisted of 29 ewes and 8 yearlings plus perhaps a few young rams, but with no lambs whatsoever.

Great variation was also observed in the numbers or percentages of young males (2 to 3 years old) in nursery bands. The large nursery band referred to above, which had 6 young males out of a total of 91 "mature" sheep (or 7%), contained the largest percentage of young rams observed during this study. When these nursery sheep returned to winter range in September, only 1 young ram was with them (Table 8a), the others had joined ram bands during the latter part of the summer. Table 8a lists the numbers of young rams found in nursery bands, which came up in repeated classifications. The ram component in those nursery bands varied from 0% to 4%. While accompanying Dr. Geist into sheep ranges in the northern part of the Kluane Game Sanctuary (Lynx Creek area) in late July, 1971, we

classified several nursery bands whose composition totalled as follows: 3 rams (2.2 years old), 23 ewes, 14 yearlings and 17 lambs. In this case the proportion of young rams also amounted to 7%. While many authors refer to the presence of young rams in nursery bands, which introduces a bias into the lamb to "ewe" ratios, I am not aware of any published information as to what percentages of the nursery bands those young rams comprised. Comparisons to the Sheep Mountain population are therefore not possible.

STRUCTURE OF THE RAM SEGMENT OF THE POPULATION

The difficulty of getting reliable ram counts in this population has already been referred to. Only in May 1973, was it possible to classify the entire ram component of the population by a combination of ground and helicopter work.

The following table lists the largest numbers of rams classified during the past three springs.

TABLE: 9

CLASSIFICATION OF RAMS

| AGE GROUP | MAY 1973 | MAY 1972 | MAY 1971 |
|---|---|---|---|
| 2 years | 17 | 17 | 12 |
| 3 years | 15 | 7 | 9 |
| 4 and 5 years | 16 | 9 | 12 |
| 6 years and older | 26 | 15 | 30 |
| more than 360° curl* | 3 | 3 | 4 |
| | 77 | 51 | 67 |
| Total number in population | 77 | 82 | 85 |

* This group is not necessarily the oldest, but it has been segregated because of the ease with which these exceptional rams could be identified.

Unfortunately, the 1972 and 1971 counts cannot be considered as representative of the ram structure of a whole population because of the tendency of rams of similar age groups to form bands (Geist, 1971). The two year olds were all accounted for since they were still with nursery bands at the time, and I assume that most, if not all three year olds were also classified. Therefore the rams which were not classified because they were widely dispersed or mixed with members of other populations were rams of four years of age and older.

Even though the population has been stable over the five year observation period, the structure of the 1973 ram segment is that of an expanding population. This is explained by the exceptional lamb crop of 1971 which is reflected in 17 two year old rams, and also by the average lamb crop of 1970 which resulted in 15 three year olds in the 1973 ram structure. A complete classification of all rams in any other year would have indicated more "stable" conditions.

For comparative purposes, an attempt was also made in May 1973 to classify the ram segment of the population by using Geist's (1971) system. Since it was only possible to classify large numbers of rams in May, some modification of the system was necessary to accommodate fraction of years (2.5 years, 3.5 years in Geist, 1971). During May all rams have their birthdays and I therefore interpreted Geist's (1971) classification as follows: Class I — 2 year old rams; Class II — 3, 4 and 5 year old rams; Class III — 6, 7 and 8 year old rams; and Class IV — rams of 9 years of age and older.

In the fall of 1965, Geist also classified 72 rams of the Sheep Mountain population and his data are reproduced in the following table. For comparative purposes, our 1973 classification is given as well as

computed percentages from a life table (Table 12), based on 110 skulls of known age, which will be dealt with later.

TABLE: 10

COMPARISONS OF CLASSIFICATION OF RAMS

| I | II | III | IV | n | Year | Source |
|---|---|---|---|---|---|---|
| 19% | 47% | 18% | 15% | 72 | 1965 | Geist, 1971 |
| 22% | 40% | 26% | 12% | 77 | 1973 | Hoefs |
| 13% | 37% | 31% | 20% | 110 | Life table in 1968 - 1973 | present study |

Geist (1971) made reference to the low percentage of old rams (Classes III & IV = 33%) in this population compared to about 46% in the Stone Sheep population and 47% to 52% in the Bighorn sheep population he studied. He assumed that this low percentage may indicate poaching.

Even though poaching did occur in this population, I have my reservations as to its effectiveness in changing the age structure of the population. Our inquiries indicate that the numbers of sheep taken illegally did not exceed 4 to 6 per year. Some of this was "meat hunting" indiscriminate of sex or age, some was trophy hunting, selecting the biggest rams. Out of 75 to 85 mature rams in this population, about 13 will die from natural causes every year, the majority of these will be old rams. Therefore, the chances are fairly high that some of the big rams poached will have been old rams with a very low life expectancy left.

I think that the low percentage of old rams observed by Geist in 1965 can be explained by the following facts. Firstly, he classified 72 rams. His counts of rams and nursery bands on Sheep Mountain indicate that the population level has been similar to the present one. We can

therefore expect that another 10 rams or so were a portion of the population but were not classified, most likely because they were not on Sheep Mountain at the time. Because of the close association of younger rams to nursery bands — already mentioned — he probably did account for all the younger age classes but missed some old rams. This situation has been observed many times over the past 5 years. Secondly, his high percentage of 2 year old rams indicates an exceptional lamb crop in 1964, which is not the rule and, in a manner similar to our 1973 classification, introduces a bias toward young rams. Lastly, there is a significant age difference between Dall sheep and Bighorn sheep, and possibly also between Dall sheep and Stone sheep, at least as far as this population is concerned. We can therefore expect a higher percentage of old rams in these populations.

Perhaps the age structure calculated from the life table (Table 12) reflects "average" conditions much better than any single classification in time or location. This age structure has the advantage of being computed from a much larger sample size ($n = 110$); the skulls were collected over a much larger district, including areas known to be primarily ram ranges, and lastly the skull collection extended over a period of at least 6 years, thereby somewhat compensating for year to year fluctuations due to higher or lower birth and mortality rates.

Adult Mortalities; Mortality Factors:

During the 1970/71 and 1971/72 annual cycles most mortalities among adult sheep which occurred on winter ranges was accounted for and has been reproduced in Tables 11a and 11b.

These tables document losses of 23 and 25 adult sheep for the

TABLE: 11a

Mortalities in the Sheep Mountain population of Dall Sheep from May 1970 to late April 1971, on winter ranges.

a) "Man Inflicted Mortalities."

| Date | Sex | Age | File # | Cause of "Death" |
|---|---|---|---|---|
| May 1970 | ♀ | 6 years | D 6 | Trapped for Yukon Game Farm |
| May 1970 | ♂ | 1 year | - | Trapped for Yukon Game Farm |
| Winter 1970/71 | ♂ | mature | - | Died in snare during trapping operation |
| Winter 1970/71 | ♂ | mature | - | Died in net during trapping operation |
| Winter 1970/71 | ♂ | mature | - | Died in net during trapping operation |
| December 23/70 | ♀ | 5 years | D 7 | Poached |
| December 23/70 | ♀ | 9 years | D 8 | Poached |
| December 1970 | 2 ♂♂ | mature | - | Poached |
| March 12/71 | ♀ | mature | - | Poached |
| March 24/71 | ♀ | mature | - | Poached |
| | | | | Sum: 6 ♂♂ 5 ♀♀ |

b) Natural Mortalities

| | | | | |
|---|---|---|---|---|
| May 1970 | ♀ | 12 years | F 2 | Accident: fell into Williscroft Canyon |
| November 1970 | ♂ | 9.5 years | A 42 | Killed by wolves |
| January 2/71 | ♂ | 8.6 years | A 45 | Killed by wolves |
| February 1971 | ♂ | 2.8 years | A 47 | Apparently killed by coyote near trapping site |
| March 3/71 | ♀ | 13 years | D 9 | Driven onto ice of Kluane Lake by wolves and caught by writer. Died the following night most likely of pneumonia. |
| Winter 70/71 | ♀ | 13 years | D 21 | Cause of death not known |
| Winter 70/71 | ♂ | 11 years | A 64 | Cause of death not known |
| Winter 70/71 | ♀ | mature | - | Killed by coyotes |
| April 15/71 | ♂ | 1 year | - | Accident: broke back |
| April 1971 | ♂ | 8 years | A 56 | Killed by wolverine |
| April 17/71 | ♀ | 8 years | D 12 | Killed by coyotes |
| April 1971 | ♀ | mature | - | Cause of death not known |
| | | | | Sum: 6 ♂♂ 6 ♀♀ |

Total documented "mortality" of mature sheep: 12 ♂♂ 11 ♀♀

TABLE: 11b

Mortalities in the Sheep Mountain population of Dall Sheep from late May 1971 to late May 1972, on winter ranges.

a) "Man Inflicted" Mortalities.

| Date | Sex | Age | File # | Cause of "Death" |
|---|---|---|---|---|
| May 26/71 | ♀ | 1 week | - | Got tangled up in barbed wire of exclosure |
| May 27/71 | ♀ | 1 year | - | Collected by Yukon Game Farm |
| June 8/71 | ♀ | mature | D 13 | Got tangled up in netting surrounding corrals |
| September 27/71 | ♀ | mature | D 22 | Collected by Yukon Game Branch |
| September 27/71 | ♂ | mature | - | Collected by Yukon Game Branch |
| May 1972 | ♂ | 9 years | A 75 | Trapped for Yukon Game Farm, where it died in November. |
| May 1972 | 2 ♀♀ | mature | - | Trapped for Yukon Game Farm |
| May 1972 | ♂ | 2 years | - | Trapped for Yukon Game Farm |
| May 1972 | 3 ♀♀ | 1 year | - | Trapped for Yukon Game Farm |
| May 1972 | 1 ♂ | mature | - | Got tangled up in netting surrounding corrals. |
| | | | | Sum: 4 ♂♂ 9 ♀♀ |

b) Natural Mortality

| | | | | |
|---|---|---|---|---|
| November 1971 | ♂ | 9.5 years | C 46 | Cause of death not known |
| Winter 71/72 | ♂ | 12 years | A 83 | Cause of death not known |
| Winter 71/72 | 3 ♂♂ | mature | - | Cause of death not known |
| Winter 71/72 | 1 ♀ | mature | - | Killed by coyote |
| Winter 71/72 | 5 ♀♀ | mature | - | Cause of death not known |
| March 1972 | 1 ♂ | 3 years | - | Killed most likely by coyotes |
| | | | | Sum: 6 ♂♂ 6 ♀♀ |

Total documented "mortality" of mature sheep: 10 ♂♂ 15 ♀♀

1970/71 and 1971/72 periods respectively, which is almost the entire expected annual loss of about 26 sheep, calculated from Table 12. It is important that during both these years half the loss was "man-inflicted" mortality. Additional mortalities will have occurred on summer ranges, but these are assumed to be light compared to winter losses.

Table 13 in the appendix lists the ages at death of sheep that died during the study period. This table includes the natural mortalities of rams of Tables 11a and 11b. A total of 36 adult sheep are known to have died from natural causes on Sheep Mountain and surrounding areas during the study period. Of these 36 sheep, 34 (94%) died in the age classes of 8 to 9 years and older.

All potential mortality factors are discussed in detail below. Our investigations indicate that over the past five years this population remained fairly stable through losses balancing recruitment, in which perhaps "man-inflicted mortality" was the most important single cause of loss, followed by predation of coyotes, wolves, and eagles - to a lesser degree by lynx and wolverine, accidents, and dispersal. Other potential mortality factors appear to be of little or no importance at present.

1) Man-inflicted Mortalities:

Under this topic fall mortalities caused by trapping operations, removals of lambs and adult sheep for game farms and zoos, collections of sheep for museums and other purposes, poaching and traffic accidents.

In the past these mortality factors have been of great significance to this population. During the winters of 1970/71 and 1971/72 they have been the single most important mortality factor at least among adult sheep. Documented mortalities during these winters have been listed in Tables 11a and 11b. From 1968 to April of 1972, the following man-inflicted

mortalities are known to have occurred: 22 sheep (15 lambs, 4 ewes, 3 rams) removed for game farms and zoos; at least 6 mature sheep poached; at least 7 sheep died during trapping operations or got tangled up in the nets of corrals; four mature sheep were collected by the Yukon Game Branch for museums and other scientific purposes. A few sheep apparently were killed by trucks on the Alaska Highway (Mile 1060) near a salt lick, but the Yukon Game Branch has no official reports on this.

Before 1968, "man-inflicted" mortalities consisted entirely of poaching and appeared to have been of much less magnitudes than in subsequent years. Many interviews with informed local people led me to conclude that the numbers poached per winter from this population was never more than 4 to 6 animals subsequent to the establishment of the Game Sanctuary and was therefore of little consequence.

After a proposed "Kluane National Park" was officially announced in late winter 1971/72, Parks Branch staff was sent to the area. No further removal of sheep was permitted and poaching has practically ceased because of constant surveillance of the area by enforcement personnel.

2) Accidents:

Our observations indicate that accidents have been an important source of loss in this population.

In May 1970 a ewe, which must have fallen down some 200 feet, was found at the bottom of Williscroft Creek canyon. The carcass was in an advanced state of decomposition while the skin was completely intact. There was no sign of predation.

In April 1971 a yearling was caught which could hardly move. It was shipped to the Calgary Zoo where it died apparently from a broken back.

On May 26, 1971 a lamb was found dead, tangled up in the barbed wire of an enclosure. Two other lambs were found in spring 1972 at the bases of high cliffs with no signs of predation on them.

In May 1971 an ewe was observed with a broken front leg. Her subsequent fate could not be ascertained.

On January 2, 1971 a ram which had been handicapped greatly by a leg injury, presumably suffered in the rutting season, was killed by wolves.

A total of four sheep died while accidentally getting tangled up in the netting which surrounded corral traps. The writer observed on many occasions in spring during the melting period that rocks of all sizes became dislodged high in the cliffs above the large southeast facing slopes. While tumbling down they dislodged others and precipitated small "rock avalanches". Often sheep were grazing directly below and appeared to be completely unconcerned. There can be no doubt that occasionally sheep will fall victim to such events.

Accidents have been observed on several occasions with the captive Dall sheep herd held at the Yukon Game Farm at Whitehorse. In June 1973 a yearling ripped open his body cavity while jumping over a windfall and died soon afterward. In November 1973, a ewe lost one eye while fighting and a mature ram broke a front leg. These two sheep would have been relatively easy prey to wolves if these accidents had happened in the wild.

Accidents have also been reported from other areas. Kit Squirechuk, Warden with the Yukon Game Branch, found complete skeletons of six mature rams in a gully near Alligator Lake, south-central Yukon, presumably killed by either a rock slide or an avalanche. Falling rocks, slides and particularly avalanches are important mortality factors of European mountain ungulates

like chamois (Knaus, 1960) and ibex (Nievergelt, 1966). References to the significance of accidents in sheep populations are made by Berwick (1968), Wishart (1958), Smith (1954), and Murie (1944).

3) Predation:

The different potential predators are here discussed in an assumed order of priority.

a) coyote:

The coyote is the most common predator in the Sheep Mountain area. Interviews with "oldtimers" (J. Langevin, J. Haden) indicate that the region around the south end of Kluane Lake appeared to always have been a stronghold for coyotes. During the winter 1970/71, coyotes were seen almost daily and it was not uncommon to see as many as six together. Mr. E. Sais, who has lived in the area for the past two winters (1972/73 and 1973/74) assured me that coyotes are common and that they have been observed around his cabin and on the lake much more often than wolves.

Our observations indicate that coyotes take ewes and young sheep but apparently have difficulties in bringing down mature rams. I have on four occasions observed encounters of coyotes with old rams. Usually the rams do not even run away but simply stopped feeding and faced the coyote. On one occasion three coyotes approached a dispersed band of eight rams. Once they were noticed the rams dashed toward each other and formed a tight group. They then looked at the coyotes who sat down and in turn looked at the rams not more than 30 feet away. For about five minutes nothing happened after which the coyotes proceeded to trot uphill while the rams resumed feeding shortly after.

The behaviour of nursery bands toward coyotes is different. They always run when coyotes approach too closely. They would stop to feed and watch coyotes attentively over great distances until they have

moved out of sight.

During the winters of 1970/71 and 1971/72 at least five mature sheep are known to have been killed by coyotes. This is a higher rate than can safely be attributed to any other type of predator. Mr. Jim Cox of Whitehorse saw a coyote kill a young ram in late winter 1968/69 on the Alaska Highway near Mile 1061, and there are several unconfirmed reports by tourists of successful coyote predation along the Alaska Highway in winter.

Coyote predation on Bighorn sheep has been reported by Wishart (1958) and Spencer (1943). In most Dall sheep populations the coyote is not considered an important predator. However, Scott et al. (1950) state: "...On the Kenai and the Copper River, however, preliminary evidence in the form of eye witness accounts and examinations of coyote scats indicates that coyote predation on sheep does occur and may be a factor of considerable importance in these areas". Murie (1944) reports: "...In 1932, when many sheep were succumbing to the unusually severe winter conditions and others were weakened by them, it is reported that some sheep were killed by coyotes".

Our observations indicate that coyote predation on ewes and young sheep is an important mortality factor primarily in winter and spring (40% of total documented natural mortality). At other times of the year the sheep are usually found above timberline where coyotes have not been observed.

b) eagles:

Both bald and golden eagles have been observed in the area; however, only the latter species is abundant and will be discussed here.

The range of this population of Dall sheep has a very high number of golden eagles. The writer is aware of seven nests of which usually

five were occupied every season. Three are in the immediate vicinity of lambing areas.

Very few potential predators receive a more controversial treatment in the literature. Opinions of authors on the effects of eagle predation vary from one of considerable importance at the one extreme to one of negligibility at the other. While many investigators have observed eagles attacking or harassing sheep (Cummingham, 1970; Berwick, 1968; Jones, 1963; Banfield, 1953; Murie, 1944; Sheldon, 1930), the actual killing of a lamb has only been reported once (Kennedy, 1948). In Europe it is an established fact that eagles prey on chamois kids (Knaus, 1960; Fuschlberger and Nerl, 1969), and they are also considered potential predators of red deer fawns (Raesfeld, 1964), roe deer fawns and weakened adults (Raesfeld, 1965), and on ibex kids (Nievergelt, 1966).

Our observations on the relationship of eagle to sheep do not support conclusions reached by Dall sheep investigators in Alaska. Sheldon (1930) considers this relationship not as one of antagonism, but one of complete indifference. Palmer (1941) states: "The sheep appeared unconcerned about the eagles' presence". During our investigation we have witnessed many instances of eagles diving at sheep not only on the lambing grounds but also at other times of the year.

We can only agree with Jones (1963) statement: "Many times bands of ewes and lambs can be located by the presence of a circling eagle." While a kill was never observed, in two instances the attacked sheep were bleeding from their back and neck. Remains of lambs were found in or near three of the nests in May 1972 and 1973.

Previously, mention was made of an early lamb mortality of 15% and 25% for May 1971 and 1972 respectively during the first few weeks of

life. There is no doubt that a fairly high number of accidents will be involved here. However, if predation at this time is at all of importance, it can be only eagle predation. At this time the ewes with newly born lambs are in extremely difficult terrain into which none of the predators which become of importance later on in a sheep's life (wolves, coyotes, lynx) would venture.

I am therefore inclined to disagree with Murie (1944), Dixon (1938), and Sheldon (1930), who concluded that rarely do eagles take a lamb and would support Banfield (1953) who states: "...observations upon eagle-white sheep (Ovis dalli) relationships made during the investigation, led me to conclude that these raptors take a number of young lambs".

c) wolves:

The study area is within the range of a small wolf pack numbering at least 6 animals, plus a few other individuals. Sheep Mountain is not visited very often by these wolves. During the winter 1970/71 they came through at three or four week intervals. I have never seen more than three wolves on Sheep Mountain, but in late February 1973 I saw six at the mouth of Bullion Creek, some four miles west of the study area. Wolves were observed during the entire study period a total of eleven times, the great majority were sightings of single individuals.

Interviews with oldtimers and residents of the area (J. Langevin, J. Haden, F. Sais) indicate that on the Sheep Mountain area wolves were never too plentiful compared to other areas in the Kluane Game Sanctuary. We can at present only speculate on the possible reasons for this. Large packs of wolves are known to occur in the north as well as in the south of the Kluane Game Sanctuary (Hoefs, 1973). Packs of up to 20 wolves have been

observed. One reason may be a greater diversity of prey animals in those areas; Sheep Mountain is good only for sheep. The closeness of the Alaska Highway and extensive poisoning programmes carried out on Kluane Lake in the past may be additional factors.

We have direct evidence of only two rams being killed by wolves. In another instance a ewe was driven off the mountain onto the ice of Kluane Lake, but was not further pursued — probably because of traffic on the Alaska Highway.

There is no doubt that a number of sheep are killed by wolves every year, but for this population there is no evidence of the situation reported by Murie (1944) who concluded that the wolves are keeping the Mt. McKinley sheep population in check.

There is general agreement in the literature that the wolf is an important predator of sheep, wherever it has not been eliminated by predator control programmes (Luckhurst, 1973; Nichols and Erickson, 1972: Geist, 1971; Cherniavski, 1962; Murie, 1944; Palmer, 1941; Dixon, 1938). However, there is no general agreement as to whether or not predation by wolves regulates the sheep population.

Murie (1944) discusses wolf - sheep interrelations at length and appears to be convinced that the sheep populations are regulated by the wolves, as the following excerpts from his book reveal; Murie (1944:83) "...as will be discussed later in detail, it is the wolf, rather than the food supply, that appears to be the chief factor limiting the size of the sheep population".

Murie (1944:141) "...the fact that the sheep increased rapidly in the absence of wolves and have not increased during their presence indicates that the wolves have been the factor preventing the sheep from

increasing. I am fully aware how frequently 'obvious conclusions' are wrong, especially in prey - predator relationships. However, I found no other factor which seemed sufficiently operative to hold the sheep number in check. It seems, therefore, that the wolves are the controlling influence..."

Murie (1944:143) "...from the total observations made, the conclusion seemed evident that large losses among the yearlings are caused by wolf predation at times, and that these losses are probably most important in holding the sheep number in check". More recent studies by Haber of the same population do not support this earlier conclusion (Haber, personal communication).

The Sheep Mountain population of Dall sheep has been relatively stable over the past five years and our investigations indicate that it has been at about that level since the mid 1950's. During that time the wolves have been exposed to persecution by various methods (bounty systems, legal and illegal hunting, poisoning programmes). Their numbers have fluctuated accordingly. There is no doubt that intensive predator control programmes in the late 1940's and early 1950's have allowed the greatly depleted sheep population to build up faster — as will be discussed later -- than would have been the case in the presence of predators. But once the population reached a level, which appears to be the carrying capacity of their winter range, the effects of wolf predation appear to be negligible.

Our observations, therefore, tend to support those made by Nichols and Erickson (1969) who state: "...so far, our observations point to the wolf as being a relatively minor factor in sheep population fluctuations as a whole".

d) wolverine:

During the study period single wolverines have been seen on six occasions in alpine and sub-alpine altitudes. Predation of wolverine on sheep appears to be light; we have evidence of only one kill. An 8 year old ram was killed on April 20, 1971, at the base of a large scree slope. This area is covered by large and small boulders and travelling is extremely difficult. Snow had fallen the previous night covering up most holes between rocks. Besides the back injury inflicted by the wolverine, this ram had a broken front leg. It is possible that the ram broke his leg when trying to traverse this boulderfield and that he was caught subsequently by the wolverine. However, eye witness reports of another wolverine kill suggest that the wolverine may have caught the ram by the leg to start with.

In late winter (1950), Mr. D. Nowlan and J. Langevin, then stationed at Kluane Lake, found a freshly killed ram on the Alaska Highway (Mile 1062) and saw a wolverine run off. They inspected the carcass and found as the only external injury, a bitten-off leg. Only wolverine tracks were discovered in the snow surrounding the kill. Apparently the wolverine got hold of the ram's leg and did not let go until the ram succumbed.

Reference to the wolverine as predator on sheep is also found in Cherniavski (1962), Murie (1944), and Dixon (1938).

e) lynx:

While the lynx preys primarily on snowshoe hares it is known that it can successfully take big game animals (Bergerud, 1971; Raesfeld, 1964; Wishart, 1958). Lynx numbers fluctuate greatly and appear to undergo 10 year cycles as do the numbers of snowshoe hares.

On the study area the hares had reached their peak in 1970/71

and they were still fairly numerous in the 1971/72 winter. In the winter of 1972/73, very few were observed and hardly any in the winter of 1973/74. Judging from the return of reports from trappers to the Yukon Game Branch as well as from fur sales, the lynx numbers appeared to have reached their peak in the winter of 1972/73. In that winter, the hare number was already very low and it can be assumed that the lynx made considerable use of other prey species. This assumption is supported by evidence from the Yukon Game Farm at Whitehorse. In the summer of 1972 and during the following winter, a total of four Dall sheep and one deer were killed by lynx and a total of about 20 lynx were trapped on this 2 square mile property. The animal enclosures are large, and in no case did the fences help the lynx. The successful attacks were made by lynx lying in ambush behind rocks or windfalls along sheep trails. The Game Farm has been in operation for four years and in no other year did any losses occur due to lynx predation.

Lynx predation on wild Dall sheep has been reported by Sheldon (1930) and was assumed by Dixon (1938) and Murie (1944). Our observations support Murie's (1944) conclusion: "...When the hares disappear, leaving the lynx population stranded, no doubt the lynx in desperation hunted sheep."

There is no doubt in my mind that the above relationship also holds for Sheep Mountain, even though we have no direct evidence of lynx predation except for a trapped sheep that was killed by a lynx (J. Langevin, personal communication). An important factor in this connection is the absence of other suitable "buffer" animals as caribou, deer or goats in the study area.

f) cougar:

There are a number of undocumented sightings of cougars from the area reported by local people, the nearest one being from Mile 1070,

Alaska Highway, which is within the range of this sheep population. The writer has not observed cougars or their signs in the area during the five year study period.

The mountain lion can be a very effective predator on wild sheep, as has been reported by Green (1949), Couey (1950), Smith (1954), Wishart (1958), Moser (1962), and Hornocker (1967). It can therefore be anticipated that cougars — if they do occur in the area — will prey primarily on sheep for lack of other suitable game animals.

g) grizzly bear, black bear, fox, raven, and magpie:

These potential predators are of minor importance, but their effects under certain conditions should not be disregarded.

Grizzlies have been observed a total of twenty times during the study period and it is assumed that at least five are "residents" within the range of this sheep population. Grizzlies have been observed to feed on sheep in early spring on three occasions but a kill was never witnessed. Two residents (R. White of Mile 1070, Alaska Highway; and K. Squirechuk, Game Branch, Whitehorse), however, claim to have seen grizzlies kill mature rams. Auer (1917), sites two instances of grizzlies killing Dall sheep in the northern portion of the Kluane Game Sanctuary.

Black bears are rare in the area and appeared to be confined to the forested zone. On one occasion in May, 1972, I observed a black bear carrying portions of a sheep carcass. It is not known how the sheep died.

Foxes are not very common in the area; they have been observed only about a dozen times. Two dens were located in June, 1972, one of which had the remains of a ewe scattered around the various openings. This, however, is no evidence of predation since foxes are known to steal

from wolf kills and caches (Murie, 1944). Several ewes of the Sheep Mountain population prefer to give birth to their lambs in the "buckbrush" of sub-alpine altitudes instead of in the "conventional" cliffs. Foxes have been observed in such buckbrush communities several times hunting ptarmigan; therefore, possible encounters of foxes and newly-born lambs must not be ruled out. In Europe the fox is considered a potential predator of the young of the red deer (Raesfeld, 1964), roe deer (Raesfeld, 1965) and chamois (Fuschlberger and Nerl, 1969).

Ravens and magpies are common in the study area year-round. These birds by themselves are not capable of killing a sheep; however, their activities can sometimes greatly handicap an animal and predispose it to death from other reasons as the following two observations will indicate.

During the winter of 1970/71, two ewes were wounded and bleeding. One was shot by a poacher through one hind leg, the other had a shoulder injury most likely from a coyote attack. Both animals were capable of moving along fast whenever approached, but they lay down whenever left alone. The writer's attention was first drawn to these animals by the harassment of ravens and magpies. These birds were picking at the wound while the ewes — fully alive — tried to push the tormentors away with their horns and feet. Such activities certainly weaken a wounded animal even more and may delay or even prevent recovery.

The other observation comes from captive sheep at the Yukon Game Farm. Two mature rams were attacked by lynx in the winter of 1972/73. Only the skin was punctured around the neck region. Three other sheep had been wounded in a similar manner earlier and they had died from the infections a few days later. Once the mature rams were missing and lynx predation was assumed, a search started. One ram was found dead. The only

external injury were two picked-out eyes. The other ram was found and still alive. He was stretched out flat with some ravens trying to settle on his horns and get at his eyes. This ram recovered from the lynx infections, but would have died from the loss of his eyes had we not appeared in time.

In Europe, ravens are considered potential predators of roe deer fawns (Raesfeld, 1965) and chamois kids (Knaus, 1960; Fuschlberger and Nerl, 1969).

4) Dispersal:

Even though sheep are known to be very traditional in their utilization of home ranges, some immigration and emigration does take place (Geist, 1971).

Our observations support Geist's assertion even though it is felt that dispersal may at times be more important than is generally believed, and — as far as this population is concerned — it may be a corollary factor in keeping it stable. Dispersal is difficult to document, but the fact that a number of sheep were marked helped to prove it.

In late July, 1972, two young rams (marked) were seen in a large nursery band of the "Bullion Creek population". The Sheep Mountain nursery bands were known to be around Mt. Wallace at the time and most rams were at the head waters of Sheep Creek and Fisher Creek.

In early winter, 1972/73, Park wardens reported a tagged sheep at Congdon Creek. The head waters of this creek are used by some Sheep Mountain animals in summer, but they usually return to their traditional winter ranges, where they were also marked. This sheep had joined a small population wintering about 8 miles north of the Sheep Mountain winter ranges.

Another reliable report was of two sheep (apparently an ewe with yearling) that had successfully crossed Kluane Lake from Sheep Mountain to the Cultus Bay area in winter 1972/73.

As has already been mentioned, an ewe was driven onto the ice of Kluane Lake by wolves on March 3, 1971. The wolves did not pursue her and she continued to travel straight across the lake. Unfortunately, about half way across she encountered a large stretch of bare ice where she slipped and was unable to regain her footing. She was later caught by the writer but died the following night. It is reasonable to assume that she would have joined the sheep wintering in the Cultus Bay area on the east side of Kluane Lake, had she made it across. Such circumstances may on occasion lead to a forced dispersal.

In summer of 1973, tourists saw and photographed a "Fannin" colour morph sheep at the base of Sheep Mountain. It was a ram of four to five years of age, whose picture is in the writer's possession. Not once in five years of observations by the writer and associates, not once during an intensive survey of the Kluane Game Sanctuary in summer 1972 (Hoefs, 1973) have I encountered any coloured sheep, nor have any ever been reported from the area. The nearest records I have are from an area between the Donjek and White Rivers, where a coloured ram was shot by an outfitter. This location is 80 miles by air from Sheep Mountain. The nearest coloured population is found east of Lake Laberge, more than 100 miles east of Sheep Mountain. Wherever this ram had come from, it was a long way and involved crossings of major streams and possibly lakes.

Considering the low probability of actually witnessing dispersal, the few cases listed would indicate that it is a factor of some significance and that it should not be ruled out when considering the dynamics of a

population. Calculations from Table 12 reveal that on the average 13.2% or about 26 sheep die annually from the adult component of the population under study. Table 8a reveals that yearling recruitment has varied between 24 and 36 annually. Thus even in exceptional years, when 36 yearlings are recruited, only 10 sheep, which is less than 5% of the total population, would need to emigrate to maintain a stable situation, if mortality was "normal" in such a year. In an average year, with yearling recruitment of 32, only 6 sheep would have to disperse. It can be argued that such dispersal may be compensated for by an equal amount of immigration. We have so far no evidence of this. The "Fannin" sheep, for instance, did not stay with the Sheep Mountain population. Counts of young rams, in particular the ratios of marked to unmarked young rams, did not reveal any additions from other populations. Perhaps only "unsaturated" areas will keep immigrants.

5) Diseases, Parasites, Toothwear:

This study did not lend itself to a proper evaluation of such debilitating or "potential" mortality factors as diseases, parasites and dental anomalies, since it was carried out in a game sanctuary where few collections could be made.

Except for the disease "lumpy jaw", which will be discussed later, I did not find any obvious diseases or parasites in the few carcasses I was able to inspect. All the sheep that were caught for the Yukon Game Farm were healthy and had no external parasites, even though those caught in late winter had lost a lot of weight.

Death from pneumonia of captive sheep has been reported by Neiland (1972) and Murie (1944) and it is assumed to have been the cause of

death of an ewe caught on the ice of Kluane Lake in late winter 1970/71.

Lungworms were first reported by Gobel and Murie (1942) and it has recently been shown (Neiland, 1972) that 90% of sheep collected on Crescent Mountain, Kenai Peninsula, Alaska, showed lesions caused by the lungworm Protostrongylus stilesi Dikmans. Olson (personal communication) informed me that he did find evidence of lungworm infections on a few Sheep Mountain animals that he dissected. Large-scale periodic die-offs due to range deterioration and subsequent pneumonia - lungworm mortalities, as reported for bighorn sheep (Stelfox, 1971), have so far not been observed in Dall sheep populations.

Gibbs and Fuller (1959) reported a bile duct worm (Wyominia tetoni) in sheep collected from this population.

A number of internal parasites have recently been reported for Alaskan Dall sheep by Ericson and Neiland (1973) and Neiland (1972). The reader is referred to their reports for a detailed treatment of species involved and severity of infections.

Our observations indicate that "lumpy jaw" and associated dental problems (missing teeth, anomalies, uneven wear) as well as excessive wear of teeth appear to be common in this population.

Over 100 skulls were collected during this study, unfortunately very few were complete. Only twenty had lower jaws, of which 14 showed signs of "lumpy jaw". Very few of the skulls of old rams had a complete set of cheek teeth, uneven wear was fairly common, and tooth wear in general appeared to be excessive for the age of the animal. Olson (personal communication) who had the opportunity to inspect many lower jaws of live-trapped animals, confirmed my observations on the high incidence of "lumpy jaw", he also informed me that many of the mature animals had badly

worn or missing incisor teeth.

Whether or not these phenomena are more severe in this population than in others remains to be studied since they appear to be widespread and have been reported by Murie (1944), Neiland (1972), and Ericson and Neiland (1973) for Alaskan Dall sheep populations, by N. Simmons (personal communication) for Dall sheep from the MacKenzie Mountains, Northwest Territories, by Sheldon (1932) for Stone sheep in northern British Columbia, by Couey (1950) and Green (1949) for Rocky Mountain bighorn sheep from Montana and Alberta, respectively, and by Allred and Bradley (1966), Bradley and Allred (1966) and Allred and Bardley (1965) for Desert bighorn sheep in the southwestern United States.

Murie's (1944) assumption that actinomycosis was the causative agent of "lumpy jaw" in Dall sheep has recently been questioned by Neiland (1972). He isolated both Corynebacterium pyogenes and Fusobacterium necrophorum from a severe case of "lumpy jaw" but found no evidence of Actinomyces. Neiland (1972) concluded: "...in any event, the evidence at hand suggests that there is as yet no factual basis for classifying "lumpy jaw" of Dall sheep as actinomycosis."

To what extent this disease would effect a population is not known. Murie (1944) assumes that "...the annual loss due to this disease is not extensive", but he does indicate that it predisposes affected sheep to predation when he states: "...disease is an important factor in the predation among sheep in the 2 to 8 year old age groups and not so important in the old age group."

Allred and Bradley (1965) conclude: "...Necrosis and other dental problems must be considered as an important limiting factor affecting the ecological life expectancy of this population."

Neiland (1972) states: "It seems to me that there are two principal ways in which this chronic disease condition can significantly diminish the welfare of severely affected individuals or populations. If extensive malocclusions and/or loss of molars significantly impair mastication of forage, the victims will not be able to efficiently utilize what they eat and will lose condition disproportionately to the prevailing seasonal nutritional potential of the range they inhabit. The animal probably will be at a greater disadvantage on winter range where the forage is relatively coarser, less succulent and of poorer quality..."

"Another way in which chronic lumpy jaw may seriously influence the victim's welfare is that such abscesses may serve as reservoirs of infection from which other organs may be infected. In considering actinomycotic lump jaw, Jubb and Kennedy (1963) claim that "metastatic spread via the blood stream gives rise to secondary lesions particularly in such organs as lungs, liver, bone and brain." This, of course, can also occur with other bacterial agents, eg. Corynebacterium, Brucella, etc.

There appears to be general agreement that there is a high correlation between tooth wear and life expectancy. Cherniavski (1962) states: "On the basis of a study of the dentition of Snow sheep it can be assumed that the age of 14 - 15 years under natural conditions is the limit; for at this time the teeth are completely worn down." Murie (1944) reports: "...tooth wear indicates that an 11 or 12 year old ram has about completed his life span, and animals a year or two younger are probably beginning to fail." In his taxonomic treatment of North American sheep Cowan (1940) remarks: "...the ultimate maximum age in sheep is limited largely by the life span of the teeth."

Evidence has been presented earlier that the maximum span of life in the study population is lower than that of other populations investigated. Perhaps the observed degree of tooth wear and related anomalies explain the lower maximum life span. This is difficult to document. Firstly, our sample size is too small to be conclusive; secondly, I am not aware of any published information on Dall sheep which expresses tooth wear quantitively so that comparisons could be made.

The fact, however, remains that Sheep Mountain sheep do not live as long as their relatives in other areas. The large amount of silt ingested by these animals will definitely accelerate tooth wear, and may be the reason. As has been discussed in detail in the section on vegetation, loess is being deposited on the winter range vegetation whenever a strong wind blows down the Slims River valley. Grasses and sedges do not lend themselves to depositions of loess because of their narrow and upright stems and leaves. On the other hand, plants which have finely dissected, pubescent, horizontally oriented, sometimes sticky leaves, catch silt. In this latter group fall species like Artemisia frigida, Artemisia rupestris, and Eurotia lanata. These species are important elements of the flora of winter ranges studied by me, and all retain their leaves throughout the winter when the sheep are feeding on them. Artemisia rupestris is particularly important in this connection. It is a prostrate, viscid plant which catches large amounts of silt. During range productivity studies it was found that the oven-dry weight of this plant consisted at times of as much as 50% mineral matter.

Some supporting evidence for this observation comes from Egorov (1967). When discussing variation in longevity of Siberian sheep he states: "...The main difference is that central Asian bighorn sheep

eat a great quantity of mineral particles carried by wind together with plants. The quantity of such particles may be so large that simply touching grasses and shrubs, when passing, raises clouds of dust. This dust is particularly heavy in the eastern Pamir. There is no dust on the vegetation of the Yakutian habitats of Bighorn sheep. The rate of wear of the teeth has a direct relationship to the contamination of the food with mineral particles. This is demonstrated to its greatest extent in the Pamir Argali (longevity 8 to 10 years) and least in the Bighorns of Yakutia (longevity 18 to 20 years)".

6) Weather:

It is known that severe winters with deep and crusted snow as well as rain followed by cold wind can cause significant mortalities in ungulate populations. This subject has been dealt with in detail by Stelfox (1971) for Rocky Mountain bighorn sheep and by Edwards (1956) for ungulates in general. It has also been reported from Europe for the ibex (Nievergelt, 1966). I will therefore restrict my comments to comparisons with other dall sheep populations.

During the five year study period we have not observed any mortalities due to severe winters. Many people have been interviewed to ascertain whether severe winter losses have occurred in the past. There is no evidence for this; neither on Sheep Mountain nor in other areas of the Yukon.

Alaskan investigators appear to agree that severe winters can be an important mortality factor of sheep populations as the following excerpts from the literature reveal.

Nichols and Smith (1971) report: "One herd on Surprise Mountain

(Kenai Peninsula, Alaska) is known to have declined by about 20% because of a harsh winter 1969/70".

Leopold and Darling (1953) concluded: "Basically, then, weather appears to be the main factor governing year-by-year numbers of sheep, with predation a secondary or corollary influence".

Scott et al. (1950) comment on weather as follows: "This factor may occasionally be of equal or greater importance than predation in limiting or decimating sheep populations everywhere".

Palmer (1941) states: "...a chief factor effecting abundance of mountain sheep, as with deer and moose, is that of cyclic occurrence of severe winters of deep snow and crusting".

Murie (1944) deals with the subject in detail: "...The snow conditions in the winter of 1928/29, according to reports, caused quite a large loss among the sheep...The month of April proved to be the hardest one of the year for sheep...it is believed that many sheep starved to death...For the part of the range he (a ranger) had investigated near headquarters he estimated that a third of the sheep population had died... In February 1932 it was reported that all records for snowfall had been broken, that 72 inches had fallen in six days...(from 1932 report): We have suffered a severe loss of Mountain Sheep during the winter as a result of heavy snows; also the predatory animals have taken their toll. Ranger Rumohr counted 15 dead sheep while on his way from Toklat. He examined many of the carcasses for evidence of wolf kills, but in most cases it appeared that the deaths were the result of starvation".

In another context Murie (1944) refers to weather as a density-dependent mortality factor: "...The deep snows have played an important role in the control of the sheep population. Probably the larger the

population the more drastically are the sheep effected. A large population quickly devours the food available on ridge tops and they must all go down to the deeper snow in search of food. A smaller number might find sufficient food on the ridge tops to pull them through a severe winter. This is an example of one of the regulatory devices of nature".

A comparison of average annual snowfall data between three Alaskan stations and Whitehorse in the Yukon Territory may be revealing in this connection. These data are, for Fairbanks 60.4 inches, Anchorage 59.7 inches, and Mt. McKinley 75.4 inches compared to Whitehorse 60.4 inches (courtesy of H. Vahl, Chief, Whitehorse weather office). Annual snowfall in the Kluane area is even less than that of Whitehorse (see section A of this thesis). The Alaskan stations get more snow, in particular the Mt. McKinley area gets 60% more snow than Whitehorse and probably twice as much as Sheep Mountain.

There is no doubt that this decrepancy will in part explain the differences observed in severity of winters and related sheep mortalities, even though the effects of wind, steepness of terrain, as well as thawing regimes (e.g. chinooks) will have their modifying influence.

The responses of sheep to several weather elements (snow, wind, temperature) will be discussed in detail later.

7) Competition:

The only possible competitor appears to be the Arctic Ground Squirrel (Spermophilus undulatus), which is very common throughout the range of this sheep population particularly on wintering areas. Limited observations suggest that a number of plant species are utilized by both sheep and ground squirrels (Lincoln, 1972). A number of other herbivorous mammals are found in the area but are at present of no importance as

competitors (moose, goat, pika, marmot, porcupine, red squirrel, chipmunk, as well as a number of "small" mammals).

On the other hand the introduction of horses into the area must not be disregarded as insignificant. During the winter 1970/71 six horses continuously utilized the grassy slopes at the base of Sheep Mountain's east slope for seven months (November to May).

In view of the apparent capacity population of Dall sheep on the mountain the introduction of competition by horses may well lead to a reduction of the sheep population.

LIFE TABLE:

"A life table is a concise summary of certain vital statistics of a population. Beginning with a cohort, real or imaginary, whose members start life together, the life table states for every interval of age the number of deaths, the survivors remaining, the rate of mortality, and the expectation of further life. These columns are symbolized by dx, lx, qx, and ex, respectively, whose x stands for age " (Deevey, 1947). Life tables can also be used to determine such ecological parameters as age composition of a population, mean mortality rate, rate of replacement and practical questions like the percentage of rams becoming "legal" in a given year. Based on skull collections by Murie (1944) in Alaska, life tables have been constructed for Dall sheep by Deevey (1947), Kurten (1953), Taber and Dasmann (1957), Buechner (1960), Caughley (1966) and Bradley and Baker (1967). Particularly Deevey's (1947) tables have become classics and have been widely reproduced. They have been justly criticized, most recently by Bradley and Baker (1967), for the following reasons: The sexes were combined, although Murie (1944) had pointed out that rams lived longer than ewes; a number of skulls (23%) without horns were judged by other criteria to be nine years of age or older and were placed in the old age classes; lastly and most important, his table is based on skulls only, greatly underestimating mortality in the young age classes whose skulls are more difficult to find, are often eaten by predators and disintegrate and decay more quickly.

Taber and Dasmann (1957) recognized this underestimation of juvenile mortality and made adjustments based on the following assumptions: 1) ewes breed first at 2.5 years, 2) average production per adult ewe is 1.0 lamb, 3) sex ratio at birth is equal, 4) mortality of yearlings

during the second year of life is not more than 10%. These assumptions apply to the Sheep Mountain population, even though a productivity of one lamb per adult ewe must be considered the maximum, since twins have never been observed.

The most realistic modification of the life table was made by Bradley and Baker (1967) who combined data obtained from skull collections with data on mortalities in the juvenile age classes obtained from surveys of sheep in the field. They had at their disposal 513 skulls of known age of Desert bighorns and observations on mortalities of juveniles (based on lamb:ewe and yearling:ewe ratios) over a 17 year period. Bradley and Baker (1967) also reworked Murie's (1944) data. Based on a sample size of 464 Dall sheep skulls of known age (Murie's collection prior to 1937) and direct observations by Murie on juvenile mortality over a three year period, they produced modified life tables for Dall sheep which are the most realistic reflections of the population dynamics of a Dall sheep herd so far published.

To come up with these life tables, it was necessary to combine two methods of life table construction, the Kdx series and the Klx series. Deevey (1947) refers to these two types as vertical and horizontal life tables respectively. The Kdx series is obtained from a knowledge of age at death of a random or representative sample of a population, while the Klx series requires a knowledge of the population structure of a living population or the observation of a single cohort throughout its life. If these two methods are combined, it is important that the population is stable.

Bradley and Baker's (1967) modified tables can only be criticized on a few minor points. First, our observations (Tables 7a; 7b) show that mortality during the lambing period may be as high as 20%. Therefore

lamb:ewe ratios established after the lambing season when nursery bands are again joined and when routine surveys are made, do not reflect the true natality rate of a population. They already show a reduced ratio. Second, lamb:ewe and yearling:ewe ratios do not accurately reflect mortalities during the first year of life, since mature ewes also die during this period. Third, the successful combination of these two methods (Kdx and Klx) of life table construction necessitates a stable population. As the authors themselves pointed out, the Desert bighorn population declined from around 3000 in the 1950's to about 1500 by around 1960.

It is appropriate to use Bradley and Baker's (1967) method of life table construction for the Sheep Mountain population since evidence has been presented (Table 3) that this population has been stable during the 5 years of observation, and, as will be discussed later, there are good indications that the population has been at the present level since about 1955.

For the construction of Table 12 the ages of 110 rams were determined by counts of horn rings. This sample was obtained from field collections and from privately-owned skulls. About 55 skulls came from the range of the Sheep Mountain population (Figure 1), the others came from surrounding areas in the Kluane Game Sanctuary. For the construction of the life table, these two sets have been lumped, since we have so far no evidence that the surrounding populations of Dall sheep are different from the one under study. They have been protected for the same length of time and censuses (Hoefs, 1973) indicate that their population density is just as high. Table 13 in the appendix lists for each set of horns used in the life table the location of kill as well as the present owner, should later studies indicate that a separation of skulls is justified.

The life table is restricted to ram skulls since only 7 ewe skulls

TABLE: 12

LIFE TABLE FOR RAMS OF SHEEP MOUNTAIN POPULATION

| X | F | dx | 1x | 1000qx | ex |
|---|---|---|---|---|---|
| 0 - 1 | 60* | 340 | 1000 | 340 | 5.48** |
| 1 - 2 | 7* | 26 | 660 | 40 | 7.03 |
| 2 - 3 | 4 | 25 | 634 | 40 | 6.30 |
| 3 - 4 | 4 | 24 | 609 | 40 | 5.55 |
| 4 - 5 | 6 | 35 | 585 | 60 | 4.76 |
| 5 - 6 | 5 | 27 | 550 | 50 | 4.07 |
| 6 - 7 | 10 | 58 | 523 | 110 | 3.22 |
| 7 - 8 | 11 | 65 | 465 | 140 | 2.57 |
| 8 - 9 | 17 | 96 | 400 | 240 | 1.91 |
| 9 - 10 | 21 | 118 | 304 | 390 | 1.35 |
| 10 - 11 | 18 | 104 | 186 | 560 | 1.01 |
| 11 - 12 | 12 | 71 | 82 | 860 | 0.65 |
| 12 - 13 | 2 | 11 | 11 | 1000 | 0.55 |

| | |
|---|---|
| X | Age in years. |
| F | Frequency in sample. |
| dx | Numbers dying in age interval out of 1000 born. |
| 1x | Numbers surviving at beginning of age interval out of 1000 born. |
| 1000qx | Mortality rate per 1000 alive at beginning of age interval. |
| ex | Expectation of life, or mean lifetime remaining to those attaining age interval. |
| * | Computed (based on direct observations during study). |
| ** | Mean length of life is 5.48 years for rams. |

(Table 13) became available during the study period. Murie (1944) was very fortunate in locating so many skulls of ewes (212 ♂♂ and 131 ♀♀ skulls of known age in the collection prior to 1937).

The 110 ram skulls of known age made up the Kdx component of Table 12. It is interesting that the 0 - 1 and 1 - 2 age groups are absent from the skull data. Skulls of both sexes in these age classes and those of ewes of all ages are easily destroyed by scavengers and are of lower visibility than ram skulls.

Evidence has been presented earlier for an average mortality of 34% and 4% during the first and second years of life respectively. These data are the Klx component of the life table. They have been converted into Kdx data and inserted into the table by computing frequency figures from mortality percentages; [110 skulls represent 62% (100% - 34% - 4%) of the total sample size, 60 represents 34% and 7 represents 4%].

The life table is another documentation of the typical mortality pattern observed in sheep and other ungulates. There is a high juvenile mortality, followed by a low mortality from one to six years of age, followed by progressively higher mortality rates in the older age classes. For reasons mentioned earlier, this life table cannot be compared to those by Deevey (1947), Buechner (1960), and Woodgerd (1964) who used only skull data. A comparison with Bradley and Baker's (1967) modified life table for Dall sheep, based on Murie's (1944) data, is justified.

The most obvious difference is the mean length of life, being 4.76 years for rams in Mt. McKinley Park and 5.48 years for rams on Sheep Mountain. This difference of .72 years is entirely due to a much higher mortality rate of Mt. McKinley sheep in their first year of life. Bradley and Baker (1967) used 66% for the first year of life, based on Murie's

(1944) estimates. I consider this estimate extremely high; considering many subsequent surveys of sheep in various areas of Alaska, I think that 40% or 50% would have been a more realistic figure. Some reference in Murie's (1944) work was along these lines "...If the lamb crop in 1938 was about the same as in 1939, then one half of the lambs had succumbed during the first year".

Since the lamb class is the largest age group in the life table such a difference in mortality rate changes the mean life expectancy of the entire population significantly.

Mortality trends in the other age classes are remarkably similar. There is some evidence, however, that the maximum life expectancy is one year longer in McKinley Park than in the Kluane area. Murie (1944) found 3 skulls of 13 - 14 years old, so far the 12 to 13 years age class has been the oldest observed in the Kluane area.

Not enough data became available to construct a life table for the female component of the population. Bradley and Baker (1967) made up such a table for Mt. McKinley ewes, based on Murie's (1944) skull collection and direct observations on juvenile mortality. The average life expectancy for ewes was 2.85 years, a considerable reduction from the 4.26 years for rams. This difference resulted primarily from a much higher mortality rate during the first year of life (72% for ♀♀ vs. 60% for ♂♂), which remains to be documented and is therefore open to criticism. To a lesser degree the lower mean length of life for ewes resulted from higher annual mortality rates in the older age classes, and a maximum life expectancy of only 11 - 12 years vs. 13 - 14 years for rams.

Such a difference in mean length of life should reflect itself in an unbalanced sex ratio in favour of males, unless this is compensated

by a greatly unbalanced sex ratio at birth in favour of females. There is no evidence to substantiate either of these claims. Murie (1944) stated that the sex ratio of sheep is about 50:50; later censuses by Nichols and Erickson (1969) put the sex ratio in Mt. McKinley Park at 98 rams to 100 ewes. Murie did not determine the sex of lambs at birth, but Table 6 in this paper presents evidence that the sex ratio at birth is around equality.

Whatever evidence is available on the female component of the Sheep Mountain populations with respect to population structure, mortality pattern and therefore mean length of life suggests that there cannot be a great difference to that of the male component of the population. Sex ratios are equal at birth and slightly in favour of ewes among adult sheep. The maximum life expectancy of ewes is at least as long as that for males.

If there is a significant difference in the mean length of life between ewes and rams, and if this difference does not reflect itself in an unbalanced sex ratio among adult sheep, then some compensatory mechanism must be active to maintain such balance. This could be in the form of a steady "drain" of rams out of the area. It is known that emigration of both rams and ewes out of the area takes place, and this may at times be an important factor to keep the population stable. However, to compensate for the discrepancy in mean length of life between ewes and rams of a magnitude (2.85 years vs. 4.26 years) suggested by Bradley and Baker (1967) would necessitate mass emigrations of up to 50% of the rams out of the area which would upset the sex ratios in neighbouring populations. During the study period many excursions were made into the ranges in neighbouring sheep populations and during 1972 the writer did helicopter and ground

surveys of the proposed Kluane Park on contract to the Canadian Wildlife Service. We have no evidence, whatsoever, of an upset sex balance in favour of males in surrounding populations. It is therefore concluded that a shorter life expectancy of ewes, if it at all exists, is of too small a magnitude to be of any consequence to the dynamics of this population.

Historical review of the population trend in this herd.

The earliest historical data stem from the turn of the century when the area attracted the interest of placer miners, many of whom passed through on their way to the Chisana River area in Alaska (Muller, 1967). Interviews with old-timers, familiar with the history of the Yukon, also indicate that some of the miners coming to the Yukon during the gold rush days (1897 - 1900) travelled via the Chilkat pass and Shakwak valley to Kluane Lake, and hence down the Kluane, Donjek, White and Yukon Rivers to Dawson.

Silver City at the south end of Kluane Lake, formerly known as "Kluane", was established in 1903 as the regional mining recorder's office, and in 1904 an R.C.M.P. detachment as well as a post office were set up in this village. At the time up to 200 people lived in the area, mining gold primarily in Bullion Creek and to a lesser degree in Sheep Creek (courtesy of R.C.M.P. historical section, and Yukon Archives). A wagon road connected Whitehorse with Kluane, and further travel was by boat on Kluane Lake. There was also a horse trail along the west side of the lake, more or less following the route, now occupied by the Alaska Highway (Young, 1947).

After an initial boom during the first decade of this century mining activity in the area declined, the centre of placer mining being moved to the Burwash Creek area at the north end of Kluane Lake. The R.C.M.P. detachment at Silver City was withdrawn in 1907, the post office closed in 1910 but was re-opened from 1913 to 1921 (Yukon Archives). During these years the number of miners working in Bullion and Sheep Creeks varied greatly (100 men in 1907 and 1908, 17 men in 1909 - 10, 2 men in 1911 - 12, and 28 men in 1915 - 16 (Courtesy of Yukon Archives).

After the closing of the post office (1921) Silver City lost its

official status but remained to be occupied till 1937 by people (usually of native extraction) engaged with fox farming (Young, 1947, John Haden, personal communication). Inspection of the Mining Recorder's documents reveal that one or two placer claims were mined in Sheep Creek more or less continuously till 1969, and up to 3 placer claims were worked in Bullion Creek till 1973.

While we have no data on the number of sheep on Sheep Mountain before the time when the first miners came into the area, it is reasonable to assume that the mountain was probably occupied at carrying capacity level at 150 to 200 adult sheep. This is based on observation made by early outfitting parties in other areas of the Kluane Game Sanctuary which have similar sheep densities (Martindale, 1913 and Auer, 1917); it is also based on vegetation studies made by the writer, which indicate that the distribution of grasslands and forests on the mountain is essentially stable, with no succession taking place under the prevailing environmental conditions. Therefore the amount of winter range and winter forage available must have been very similar at the turn of the century to what it is now.

The reduction of the herd of sheep on Sheep Mountain began with the intrusion into the area by white men. The area was not hunted by Indians at the time. The nearest Indian band at Burwash used to live on the east side of Kluane Lake and it had its traditional hunting grounds north of Kluane Lake in the drainage of the Kluane, Donjek and White Rivers and around Teepee Lake. Burwash Landing was established in 1903 by two Alsatians, Eugene and Louis Jacquot, and named after Major Lockwood Burwash, a mining recorder at the time (Muller, 1967). The establishment of this trading post and base camp for outfitting parties attracted the Indians and they settled here. However, they continued to hunt in their traditional areas to the

north (J. Sais, Father Huijbers, personal communications).

There is general agreement that the miners hunted the sheep very heavily, since game was their only source of fresh meat, and since up to 200 of them worked essentially around Sheep Mountain in the early 1900's. To hunt game for sale was legal at the time and hunting parties from as far away as Dawson were observed in the Kluane area (McGuire, 1921). Reference to the severe depletion of game by miners at the time is also made by Sheldon (1904), who visited the Watson River area along the Chilkoot Trail: "...mining prospects are being worked, and the sheep are practically exterminated. A sight of big game is only to be obtained twenty or thirty miles farther to the west".

No data are available to assess the degree to which the sheep population had become depleted at the time, but indirect evidence points to the fact that the area had become useless to trophy hunters. Several books have been published about big game hunting in the Kluane area early in this century (Martindale, 1913; McGuire, 1921; Auer, 1917; and Young, 1947).

While all these hunting parties spent some time at the south end of Kluane Lake, either because the outfitters' base camp was located at Silver City or because they rode up the Slims River to the Kaskawulsh Glacier for the purpose of hunting mountain goats, none of these parties considered it worthwhile to hunt sheep in the Slims Valley. To do this they rode 60 to 100 miles to the northwest and hunted the Donjek and White River drainage and the mountain ranges around Teepee Lake and St. Clair Creek. Interviews with some of the descendants of the outfitters of such days (Dixons, Jacquots) support our assumptions that there were no sheep left in the Slims Valley to hunt. At present the sheep populations in the Slims River valley are just as dense as those of the Donjek valley (Hoefs, 1973).

The Sheep Mountain population probably began to recover during the 1930's when mining activity in the area reached a low point and when only one family was left at Silver City. John Haden (now at Whitehorse) lived at Silver City from 1930 to 1937 with his parents where they farmed foxes. Interviews with him revealed that some sheep were taken on Sheep Mountain by him at the time, but the principal source of meat for man as well as foxes were moose and fish. Gus Lolan, a prospector now living at Whitehorse, worked a placer claim at Sheep Creek in 1937, and had worked in Bullion Creek in previous years. Discussions with him revealed that the sheep population of Sheep Mountain had recovered in the late 1930's and that he had counted between 150 and 200 sheep on the mountain in spring and fall. He claims that the area was at that time already known to Yukoners as the best sheep country. According to him the annual take by miners at that time was not more than 4 to 6 sheep, and he was not aware of any Indian hunting in that area.

The population received its second severe blow as a consequence of the construction of the Alaska Highway (1942-43). As had been the case during the gold rush days early in this century, Sheep Mountain was again in a very vulnerable location along the route of the proposed Highway. At no other place over its entire length does the Alaska Highway come into so close a contact with an important sheep range.

While nothing official has been published on this issue, interviews with many old-timers reveal that army personnel responsible for the building as well as maintenance of this highway engaged in massive slaughters. Game was used not only as food, but also for target practice. Reference to the depletion of game along the road is found in a report by Clark (1945), who was commissioned to do the first biological reconnaissance of the area after

it had been declared a "park reserve". Excerpts from two letters also support this assumption. A. Retallack (Historical researcher for White Pass and Yukon Route) writes at the author's request: "I talked with two men who had been with construction crews. The Canadian was quite vehement about the destruction of game, particularly for sport on the north end of the highway. The second, an American, who was around Muncho Lake, said game was their only dependable source of fresh meat and great discrimination was exercised in obtaining it".

In a letter of May 28, 1946 by G.T. Duncan, Inspector of B.C. Police, to L.H. Finney, Act. Commissioner, Defence Project in Northwestern Canada, the following reference is found: "Partly owing to the amount of hunting done by United States' soldiers and civilian workers, during construction of the Highway, game animals and birds are not plentiful near the road".

Indication of the severity of depletion of sheep in the Kluane area can be obtained from a report by Cameron (1952) who collected mammals in the area in 1949 for the National Museum of Canada. Under "Dall sheep" the following notes are found: "This species was observed on several occasions on the slopes of the Kluane Mountains, west of Kluane Lake. On June 25 seven were seen in a draw above the Shakwak Valley...Tracks and scats were noted in an alpine meadow on Kluane Mountains (most likely Sheep Mountain) on July 1 and in a river flat of the Slims River on July 2nd. All those observed were pure white". An investigator making a reconnaissance of the same area at this time, would count several hundred sheep.

Even though a National Park Reserve for the area was officially declared on December 8, 1942 (Hoefs, 1971), supposedly providing full protection for the wildlife in Kluane, enforcement did not start until 1950 when Joe Langevin was stationed in the area as forest ranger and game warden.

Banfield (1960) visited the area in 1951 and made the following comment: "Accompanied by Warden Langevin I examined, on foot, the Sheep Mountain winter range in detail on June 21st. There was abundant sign of winter sheep occupancy, but nowhere did the vegetation show signs of excessive utilization. Langevin reported counting 43 sheep on the range during the winter months. I found that the sheep were extremely wary, although they nominally had eight years of sanctuary".

Banfield (1960) visited the area again five years later and reports: "On May 29, 1955, 95 sheep were counted from the highway on Sheep Mountain. Warden Langevin reported that the sheep population, then totalling 200, had shown a steady increase since 1951".

Personal communication with J. Langevin, who now lives in Dawson, reveal that he was stationed in the Kluane area from 1950 to 1961. When he arrived at the area the winter sheep population was between 45 and 50, and apparently had been at that level for some years previously. They built up very quickly and by 1955 (after lambing in late May) had reached close to 200. The maximum numbers had then remained fairly stable between 150 and 200 until 1961 when J. Langevin left the area.

This rather quick build-up can not be explained by natural increase alone, and would suggest that immigration was an important factor. According to J. Langevin, the philosophy at the time was that predators kept the sheep from increasing. He was therefore engaged in extensive predator control programs. While no statistics were kept on the numbers of predators taken, Langevin remembered that he took 6 wolves, 6 wolverines and many coyotes from Sheep Mountain during one winter.

No detailed counts were made in the area from 1961 to 1965, when V. Geist spent a fall with the population to study social behaviour. Geist

(1971) writes: "I stayed there from September 14th to November 24th, 1965. The largest single gathering or band of sheep I counted was 106 animals, almost entirely females and juveniles. The largest ram band I observed numbered 51 animals".

These counts, made during fall, correspond very closely to those made by the writer during 1969 to 1973 and indicate that the total population was maintained at about 200 adult sheep (see Table 1 in appendix).

The writer appeared in the area in 1969 and kept surveillance over this population to this date. During these years the population has maintained itself at a remarkable stable level of about 200 adult sheep ± 15%, fluctuating slightly up and down with the good and bad lamb crops.

Even though this population has not been kept under close scrutiny, the accessibility of its range from the Alaska Highway has allowed for periodic checks by the Yukon Game Branch since 1950 as well as very frequent observations by many highway travellers. From these observations we know that no major die-off, as reported for Rocky Mountain Bighorn sheep by Stelfox (1974), has occurred in this population. Nor are we aware of any die-off in any other Yukon sheep population.

Evidence has been presented of this population increasing to an optimum level of about 200 sheep (at dates as far apart as 1937 to 1939, 1955 to 1961, 1965, 1969 to 1974) and maintaining itself at that level, which appears to be the carrying capacity of its winter range.

These observations are in direct opposition to claims made by Stelfox (1974) that sheep can not "regulate" their numbers and build up to levels that exceed the carrying capacity of their range, and are therefore subject to periodic die-offs of perhaps 25 to 30 year intervals.

Plant Phenology:

During this investigation three plant phenological phenomena were looked into:

a) The dates at which certain plant species came into bloom.

b) The rate of growth and drying-up of important winter range forage plants.

c) The altitudinal plant phenological advance during spring, using Carex filifolia as an indicator species.

All three of these phenological characteristics in some way affect the grazing behaviour, food selection, range use pattern and vertical migrations of sheep and they will be referred to when these topics are discussed. At this point the description will therefore be restricted to botanical aspects.

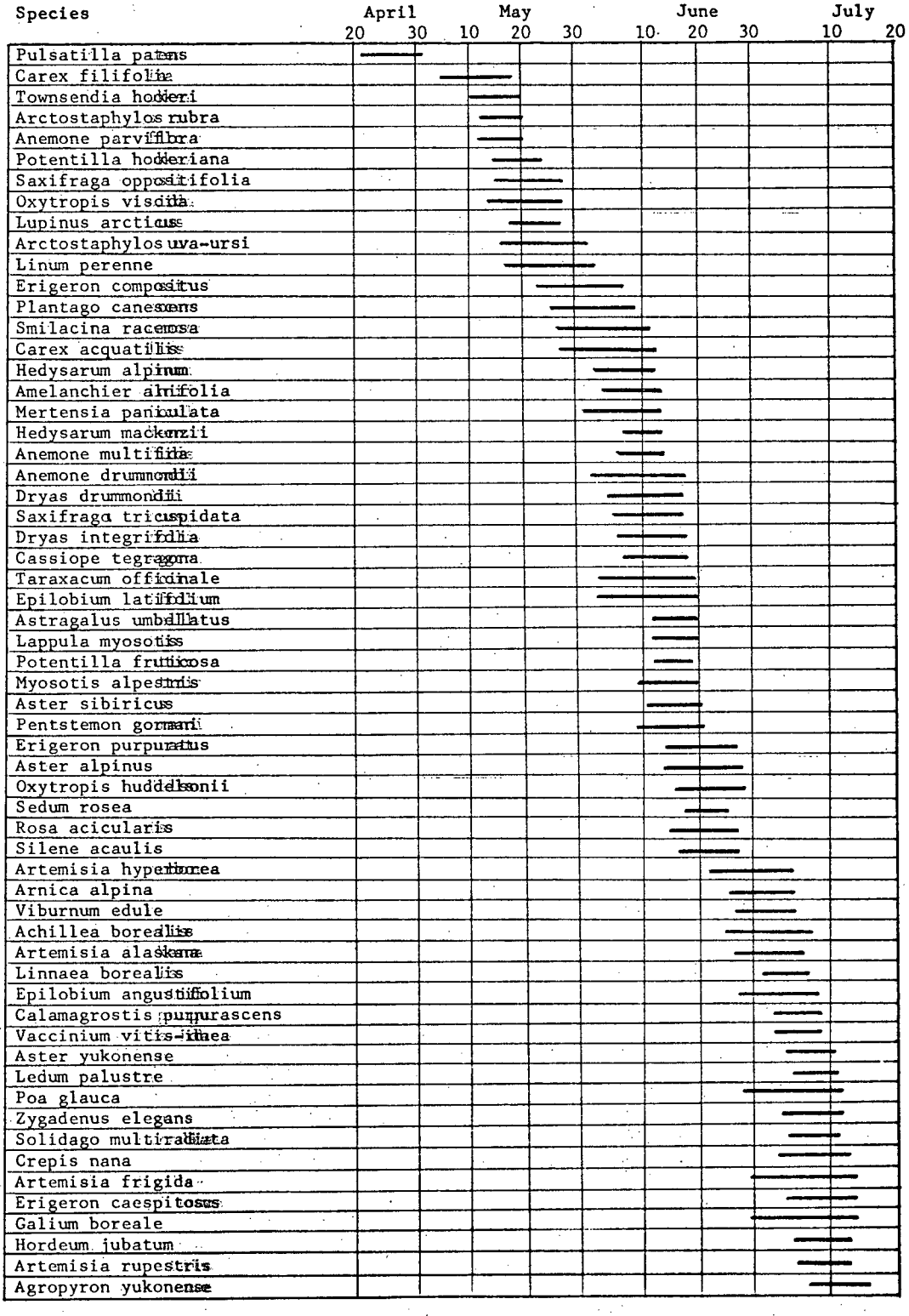
Dates of first flowering:

Table 13 lists 60 flowering plants that grow on the range of the sheep population under study and gives their first flowering dates arranged approximately in phenological sequence. Since observations were done over 3 seasons, with considerable differences in weather patterns, the first flowering dates are ranges of 10 days to 2 weeks and not individual days. Great variations were observed particularly between the spring of 1971 compared to 1970. Some flowers came into bloom as much as 10 days earlier in 1971. The data presented here, particularly for June when many plants came into bloom, must be considered conservative, since it was not physically possible because of other duties to check every marked species every day. However, it is unlikely that any of the dates are out by more than 4 days.

Table 13 includes a number of plants which grow in various altitudes and in various plant associations at the same altitude. However, only plants

**TABLE: 13**

Dates of first flowering of Sheep Mountain plants



growing on the most "advanced" sites, in a phenological sense, are considered here. An example may demonstrate this point. Pulsatilla patens is the first plant - with the exception of willows - to have open flowers. On sunny south-facing, protected slopes with grassland vegetation in the boreal zone these pasque flowers may in favourable springs be seen as early as April 22nd. However, the same species can occasionally also be found at alpine elevations of 5500' where it does not come into bloom until late May or early June.

Table I3 reveals that Pulsatilla patens is the only plant that may come into bloom in April, about 26 species begin to bloom during May in an average year, 19 species in June and 15 species in July. With the exception of Carex filifolia and Oxytropis viscida which come into bloom in May, all other important dall sheep winter range forage plants (Artemisia frigida, Agropyron yukonense, Calamagrostis purpurascens, Poa glauca, Artemisia hyperborea) are late bloomers, most of them not starting before July. While there are many exceptions to this rule it is in general true that members of the families Ranunculaceae and Leguminosae are among the first to come into bloom while members of the Compositae and Gramineae families are among the last.

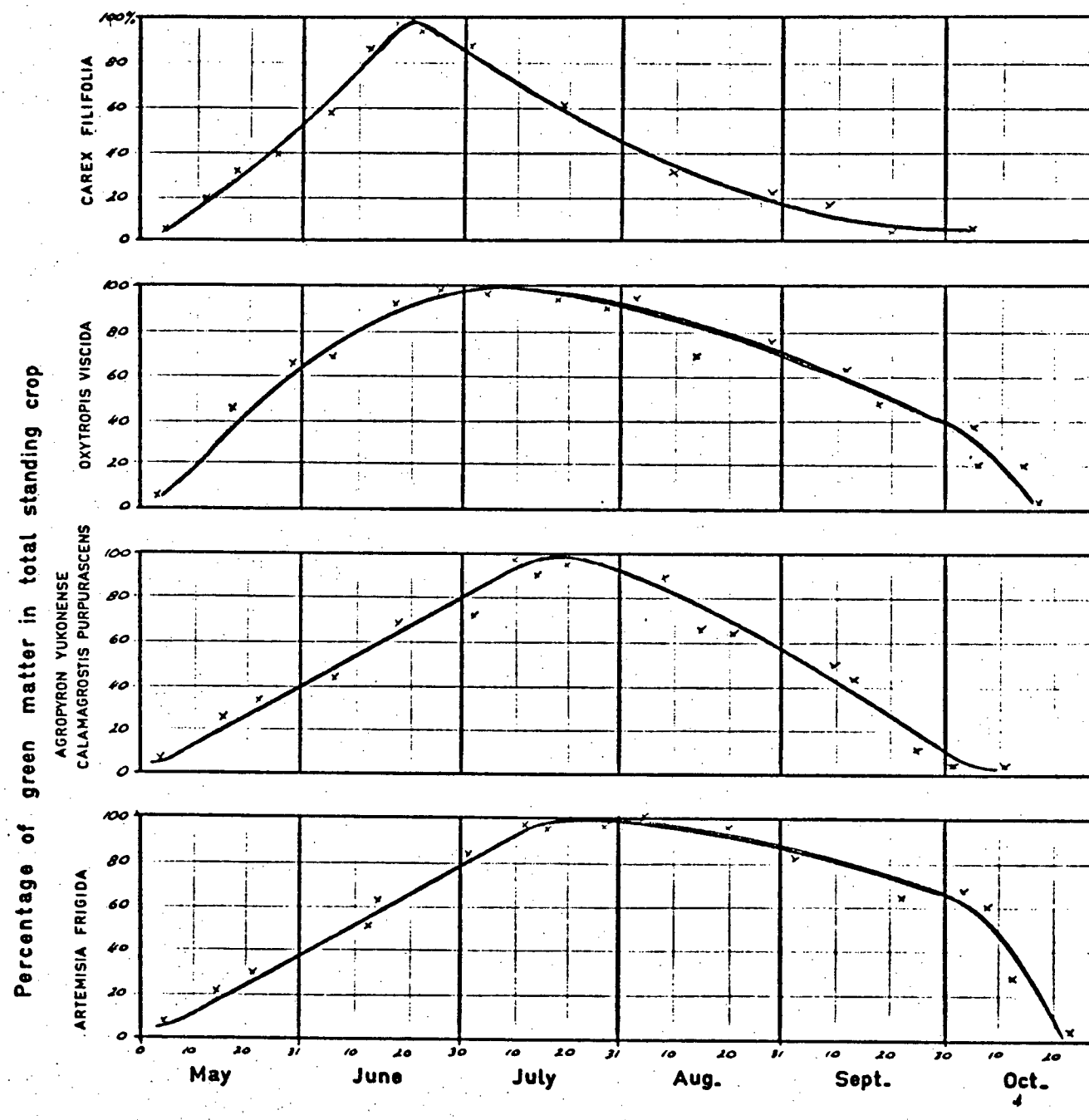
Rates of growth and drying-up of important winter range forage plants:

Figure 2 gives a graphical demonstration of the seasonal sequence of growth and drying-up of five important forage species. Each point on these curves represent the average value of 10 measurements on different plants.

All samples were drawn from altitudes of about 3000'. Some growth had taken place on all these species by May 5, 1971, but the subsequent growth rates until the annual maximum was achieved differed greatly among them. Carex filifolia, and Oxytropis viscida grew fastest, while Artemisia frigida had the slowest growth rate. The grasses Agropyron yukonense and

FIGURE: 2

PHENOLOGICAL SEQUENCE OF GROWTH AND DRYING-UP OF IMPORTANT WINTER RANGE FORAGE PLANTS



Calamagrostis purpurascens had intermediate rates. No noticeable difference was observed between these two species, therefore the respective growth curve represents both these species. Even though the actual growth curves have been drawn by hand, it is reasonable to say through interpolation that by May 31st Oxytropis viscida had achieved about 65% of the annual maximum, Carex filifolia about 55%, Agropyron yukonense and Calamagrostis purpurascens about 40% and Artemisia frigida only about 35%. The maximum of annual growth was reached by Carex filifolia by June 20, by Oxytropis viscida by July 5, for the grasses by July 18 and for Artemisia frigida by July 20.

Even greater differences were observed in the rates at which these species dried up. In Carex filifolia this process began immediately after maximum growth was reached and seeds had developed. By July 31 less than 50% of the standing crop consisted of green matter and by the end of August less than 10% green matter, consisting of the basal portions of the leaves, was left. The fact that the temperatures throughout July and August did not drop to the freezing point at this altitude may indicate that the length of the growing season in this rather short-rooted plant is determined by moisture deficiency and its heridity and not by unfavourable temperatures.

Similar trends, even though of a much more delayed scale, were found in the two grass species Agropyron yukonense and Calamagrostis purpurascens. Drying up commenced after seeds had developed but by the end of August about 60% of the total standing crop still consisted of green matter, and it only dropped to less than 10% during the last week in September. Both Oxytropis viscida and Artemisia frigida behaved very differently in that these species dried up very slowly and retained a very high percentage of green matter until late fall. The ultimate death of green vegetation being determined by heavy frost in early October. In contrast to the grasses and Carex filifolia,

the green matter in the standing crop of Oxytropis viscida still consisted of 40% and that of Artemisia frigida of 65% by September 30, when Carex filifolia and the grasses were already dried up completely.

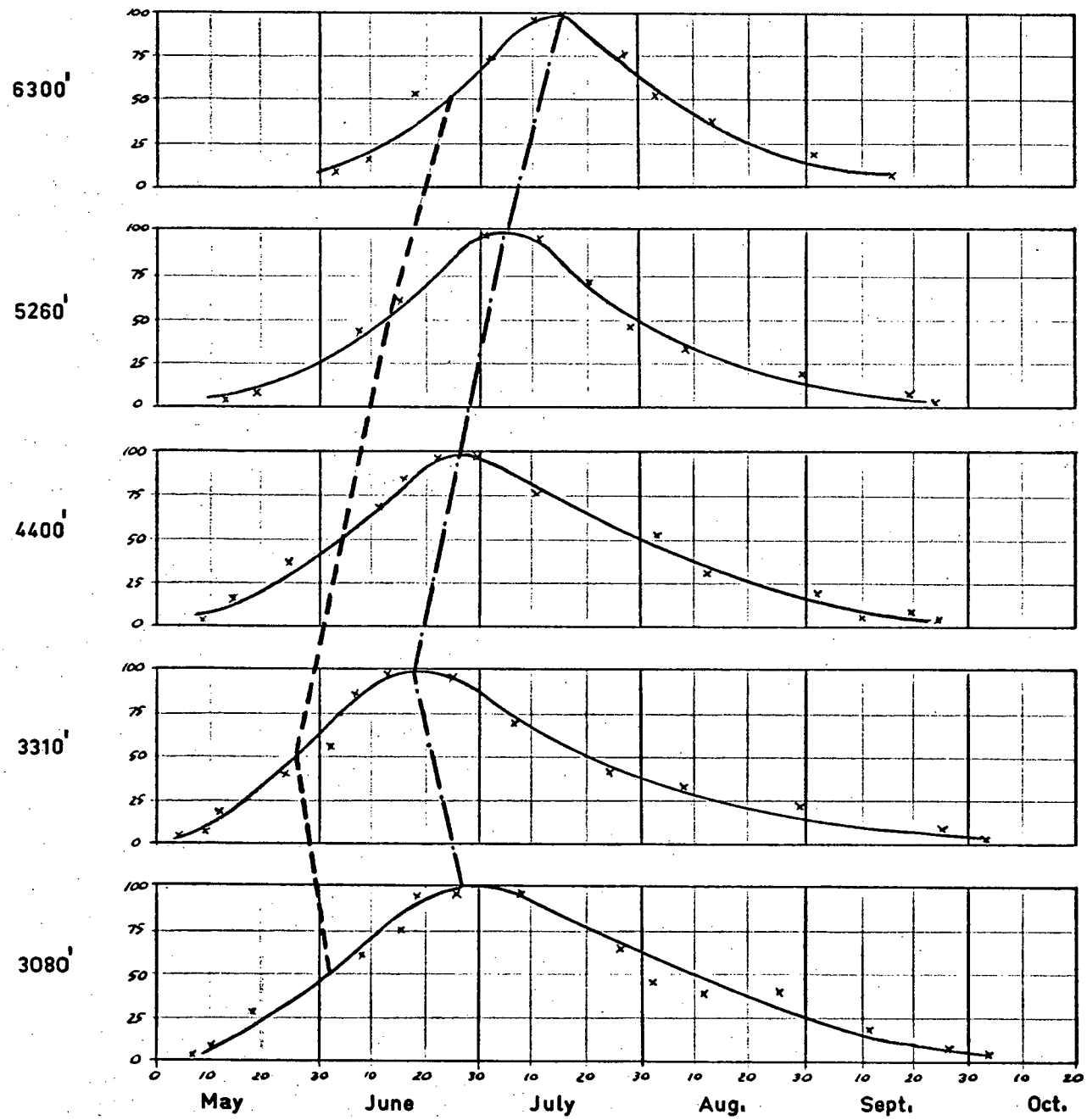
The altitudinal advance of plant development:

Figure 3 shows the growth curves of Carex filifolia at five sites with increasing altitudes. Lines connecting the points at which 50% and 100% of the annual growth was achieved give an indication of the vertical phenological march. For reasons, as yet unexplained, the plants at an elevation of 3310' were phenologically more advanced than those at an altitude of 3080'. One reason may have been that the plants at the lower altitudes were during the course of a day more often subject to shade cast by surrounding trees. Since the lines connecting 50% and 100% growth points are parallel it will suffice to discuss one of them. At an altitude of 3310' Carex filifolia reached maximum annual growth around June 18, at 4400' around June 26, at 5260' around July 5, and near the peak of Sheep Mountain, at 6300', it took till July 15, 1971.

The speed of vertical advance of plant development was therefore 3000' per month or about 1000' per 10 days. It is not possible to quantify within similar terms the sequence of dry-up, since this is influenced not only by temperature or altitude but also by moisture deficiency. This speed of vertical advance agrees with Hopkins' (1920) bioclimatic law, which states that there is a delay in vegetation development of about 3 to 4 days for each 100 to 130 meters increase in altitude as well as with Stoddart and Smith's (1955) remark that: "Most observers agree that the (altitudinal) difference approaches one day for each 100 feet of altitude".

FIGURE = 3

GROWTH OF CAREX FILIFOLIA AT VARIOUS ALTITUDES DEMONSTRATING VERTICAL PHENOLOGICAL ADVANCE




— — — 50 % of annual growth completed

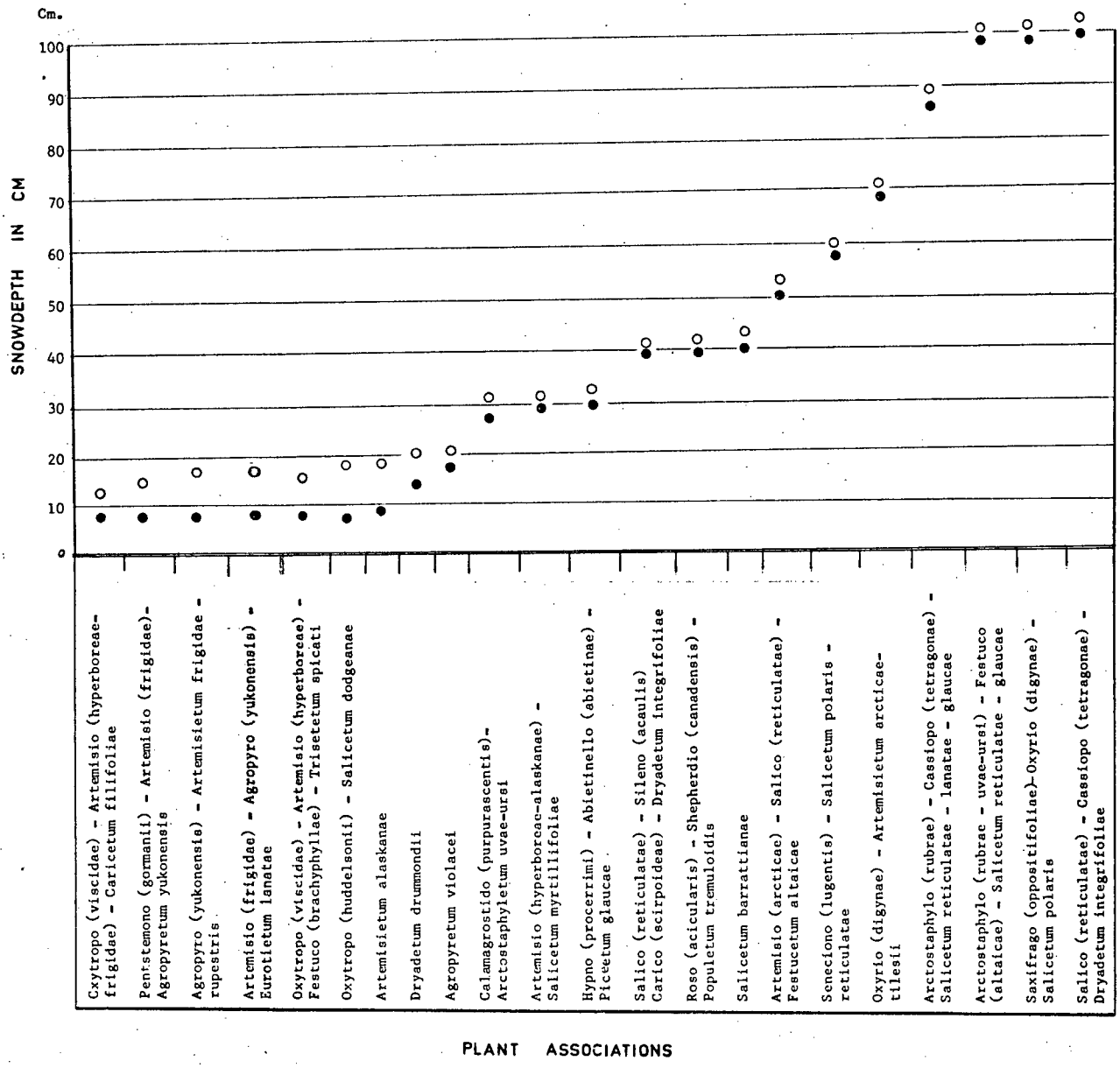
— . — . Maximum of annual growth completed

Response to snow conditions:

As has been described in the first part of the thesis, dealing with vegetation, the study area is characterized by a dry, continental climate, which has been classified as semi-arid. The annual precipitation is less than 10 inches, and during the year of intensive study (1970/71) it was 8.2 inches in the boreal zone at 2800 feet elevation, and 9.6 inches in the alpine zone at 5380 feet elevation. Approximately 46 inches of snow fell in the alpine zone during that winter and about 35 inches in the forested zones. Considerable re-distribution of snow took place through wind action, primarily blowing from the south-west down the Slims River valley. This wind removed the snow cover from exposed south and west-facing slopes and left it in the depressions or on north and east-facing slopes which were on the lee sides of the prevailing winds.

Figure 3 in the first part of this thesis describes in detail the duration of snow cover, and the average and maximum snow depths recorded at monthly intervals for the 32 plant associations of the study area. Our discussion here will therefore be limited to the month of March when snow depths are the deepest for the year, but which has representative conditions as far as the relationship between plant associations is concerned. Figure 4 gives the average and maximum snow depths for the 22 plant associations utilized by sheep over the annual cycle. Dry grassland associations, at the one extreme, had average snow depths of 8 to 10 cm. with maximum not exceeding 18 to 20 cm. immediately after new snow. The month of March as well as January and February had its Chinooks (Foehns), characteristic for this area, during which snow was removed from exposed areas and deposited in depressions. There was, therefore, a considerable acreage of bare areas during this month, even though the average snow depths were 8 to 10 cm.

**Figure: 4** Average and maximum snowdepths during March



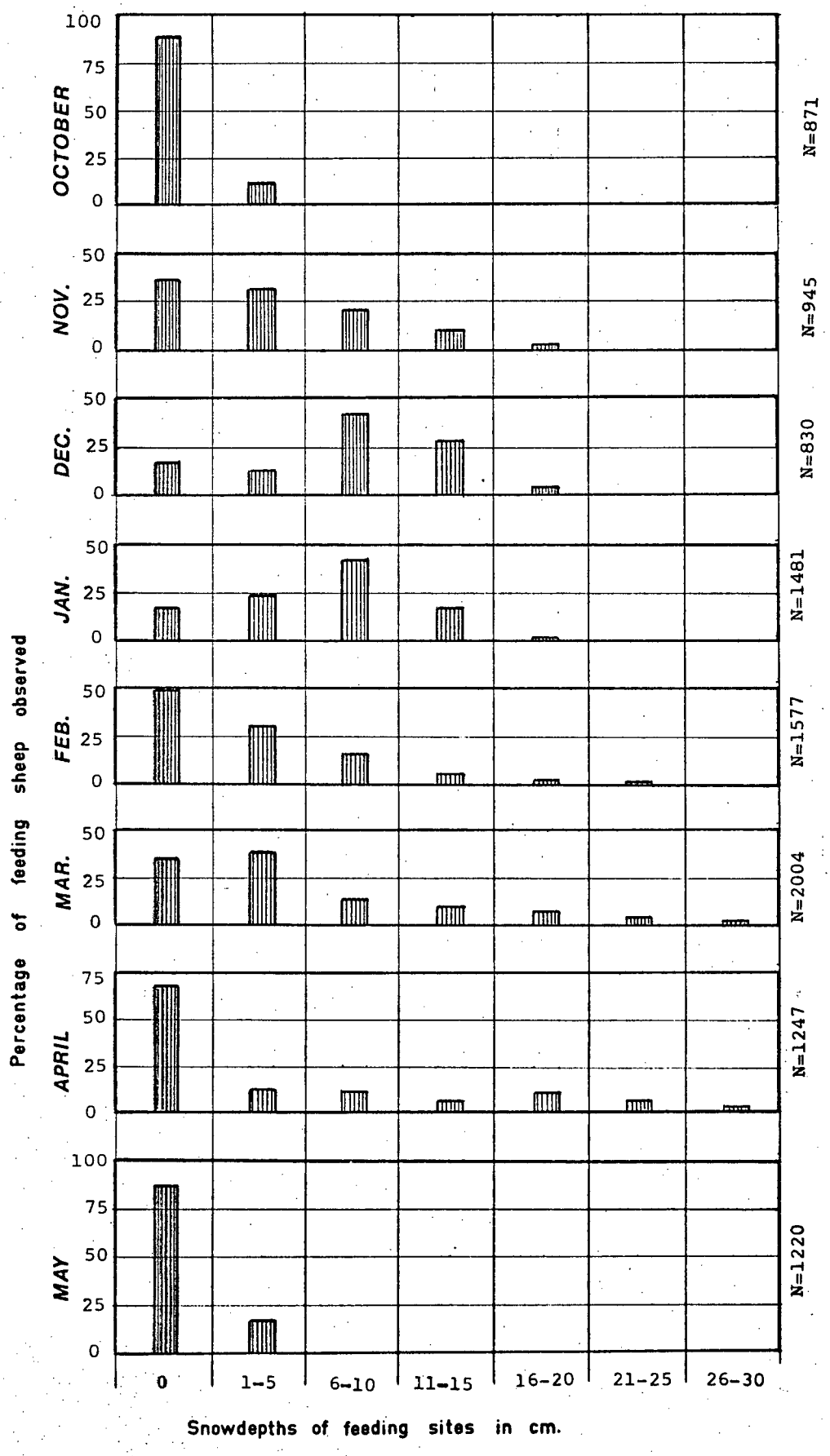
At the other extreme are associations in alpine depressions, or on north-facing slopes or willow communities in the boreal or sub-alpine zones, into which snow was re-distributed, after being swept from exposed grassland associations nearby. The maximum snow depths recorded on such sites was about 100 to 110 cm.

Figure 5 gives the snow depths of feeding areas on a monthly basis over the winter. Most feeding took place on bare, wind-swept areas, and no feeding was observed in snow depths exceeding 30 cm.

During May and October feeding in snow was only observed on the day or two immediately following a fresh snow fall. During these months the temperatures rose on many days high enough to melt the snow on the south-facing slopes with open grassland vegetation. During November the average snow depths of alpine elevations was 20 to 25 cm., but in the boreal and sub-alpine zones, where most sheep were found, the average snow depths of all plant associations was only 10 to 15 cm., with many exposed ridges free of snow. However, during this month, the distribution of sheep is very much affected by the rutting season. Rams feed very little and spend most of their time chasing ewes. Such ewes may subsequently feed in sites with snow conditions not normally preferred at this time of the year. This may explain the distribution of Figure 5 for November, when considerable feeding did take place in snow-covered areas even though wind-swept sites were available.

During the 1970/71 winter there was no pronounced chinook during the month of December and snow began to accumulate. The average snow depths of all plant associations utilized by sheep was 30 to 35 cm. at alpine elevations and 15 to 20 cm. in the boreal zone. The acreage of bare areas was smallest for the entire winter. This is reflected in the distribution of feeding sites in Figure 5. Most feeding took place in 6 to 10, and 11 to

**FIGURE: 5** Snowdepths in feeding areas



15 cm. of snow, 42.5% and 26.7% respectively. Only 15.1% of the total feeding observed was done on bare, wind-swept areas.

The month of January had a very strong chinook which blew for 2 days removing the snow from many exposed areas. This resulted in a shift of feeding sites to areas with less snow depths than in December. Neither in January nor in November and December was any feeding observed in snow deeper than 20 cm.

Late winter and spring (February, March, April, May) was characterized by frequent strong winds from the southwest which removed the scanty snow cover from many exposed areas. Figure 6 is a photograph of Sheep Mountain taken in late February, which shows the extent of bare areas. During February, March and April about 50% of all feeding took place on bare areas, and another 25% in snow depths of less than 5 cm. However, as late winter approached, two opposing trends in sheep feeding behaviour with respect to snow depths are obvious from Figure 5. While most sheep feed in areas with little or no snow cover, the forage on such areas is being removed and particularly preferred food plants are becoming scarce. This fact results in a certain percentage of sheep digging through a considerable depth of snow in order to get at preferred forages. This trend is obvious from Figure 5. As the winter advances some feeding takes place at progressively deeper snow, even though many bare areas are available. During March and April some feeding was observed in snow as deep as 30 cm.

During May the snow has melted from winter ranges and feeding in snow took place only after a snow fall.

Considering the winter as a whole, the following summary can be made: 49.2% of all feeding was possible on areas with no snow (Figure 7), 21.4% took place in snow shallower than 5 cm., and 17.4% in up to 10 cm. of

Figure 6: Sheep Mountain in late February, showing extent of bare, wind-swept areas.

Figure 7: Typical winter scene, sheep using bare, wind-swept areas for grazing.

snow. Up to this depth no pawing is necessary and sheep expose the forage by pushing the snow aside with their muzzles. About 8.7% of the feeding took place in snow depths of 11 to 15 cm., 2.4% in 16 to 20 cm., and 0.8% and 0.1% respectively required craters to be pawed into 25 and 30 cm. of snow.

If these statistics are compared to those of Figure 4, it becomes obvious that most feeding did take place in dry, exposed grassland associations; the only exception was some feeding in the willow community, Arctostaphylo (rubrae-uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae-glaucae, even though it is covered by very deep snow. These willow stands occupy depressions between exposed ridges with grassland vegetation and the snow removed by winds from the latter is deposited here. Trails are maintained through these willow stands which lead from one ridge to the next. Feeding on willow takes place along such trails and along the edges of such stands, and all feeding is on leaves remaining on the branches and occasionally on the tips of twigs and therefore exclusively above the snow, and therefore not relevant in this context.

Our observations that sheep prefer to feed on bare, wind-swept areas whenever a choice is possible, supports findings by other northern sheep investigators.

Murie (1944) writes: "As a rule there is relatively little snow on the winter range, even on the flats, although deep snows do occur occasionally. Prevailing south winds, which often become strong, blow many of the ridges and slopes free of snow."

Geist (1971) observed, "If they (the sheep) have a choice they appear to prefer feeding on windswept ridges and on slopes cleared of snow by snowslides and avalances, rather than pawing away snow".

Nichols (1971) remarks: "Sheep usually winter in alpine zones although in some local areas they may descend into the brush zone or even into timbered areas. In general, these animals are dependent upon and become restricted to the high, wind-blown ridges where vegetation is available".

This general observation of sheep behaviour seems to also apply to asiatic snow sheep. Nasimovich (undated) states: "In winter they (the sheep) prefer to feed in localities where there are wind-swept areas or where the depth of snow does not exceed 3 to 4 cm.".

Response to Temperature:

The average monthly temperature for the four altitudinal levels are given in Table 14. A further breakdown into portions of months was done for those times (May, June, October), when great variations in altitudinal distribution of sheep were observed within a month. Table 14 also shows the average temperatures at the average elevations during the various months or portions of months. Vertical annual migrations will be dealt with in detail in a separate section, and only a few comments will be made here.

The temperature trend revealed in Table 14 is characteristic for a continental station. January being the coldest month with an average temperature of - 17.9 F., average temperatures below the freezing level (+32 F.) were recorded for all months starting October 15 to April 30. Only June, July and August have average temperatures of around 50 F. or slightly more. The average annual temperature range being 75 F. December and January have temperature inversions during very cold, calm weather, which resulted in higher average temperatures for alpine elevation compared to those of the valley floor. November and February were "transitional months", in that strong winds, reducing any altitudinal temperature difference, alternated with days during which the normal lapse rate prevailed as well as with a few short term inversions. The combined effects of these three variants resulted in small altitudinal differences of average temperatures during these months. During the remainder of the year, from March to October, the normal lapse rate was in effect resulting in the peak station (+ 6380') temperatures being between 10 and 15 F. colder than the average temperatures at the valley floor (+2800 feet). The only departure observed was that the station at 3610 feet had occasionally a slightly higher

TABLE: 14 Average Temperatures at Sheep Mountain during 1970/71.

| Elevation | Year | Jan. | Feb. | March | Apr. | May 1/2 | May 1/2 | June 1/3 | June 2/3 | June 3/3 | July | August | Sept. | Oct. 1/2 | Oct. 2/2 | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1970 | | | | | | | 46.4 | 49.5 | 48.9 | 50.7 | 49.9 | 39.8 | 31.2 | 17.8 | 16.5 | -2.4 |
| 2800' | 1971 | -17.9 | 15.2 | 10.4 | 26.9 | 38.8 | 42.4 | 54.6 | 54.0 | 52.9 | 57.1 | 53.8 | | | | | |
| | 1970 | | | | | | | 46.0 | 51.2 | 54.2 | 55.3 | 52.9 | 39.0 | 34.0 | 24.8 | 14.4 | 0.7 |
| 3610' | 1971 | -15.2 | 15.8 | 9.2 | 29.0 | 38.1 | 39.8 | 53.2 | 56.2 | 53.2 | 56.5 | 53.8 | | | | | |
| | 1970 | | | | | | | 34.5 | 36.1 | 35.7 | 43.5 | 43.7 | 31.1 | 27.2 | 12.0 | 11.9 | 3.5 |
| 5380' | 1971 | - 8.8 | 11.2 | 4.5 | 19.6 | 26.2 | 32.4 | 43.4 | 42.7 | 44.6 | 48.4 | 45.7 | | | | | |
| | 1970 | | | | | | | | | 34.5 | 39.5 | 38.7 | 29.9 | 20.5 | 10.4 | 10.4 | |
| 6380' | 1971 | | | 1.2 | 14.4 | 19.2 | 23.4 | 36.3 | 37.8 | 38.6 | 45.2 | 40.9 | | | | | |
| Ram Bands- elevation | | 3232 | 3417 | 3351 | 3675 | 4016 | 4431 | 3900 | 4328 | 4760 | 6336 | 6503 | 5867 | 5626 | 4199 | 4199 | 3532 |
| - av. temp. | | -15.9 | 15.6 | 9.7 | 28.6 | 35.4 | 36.4 | 51.6 | 53.0 | 40.1 | 45.3 | 40.3 | 30.5 | 25.6 | 20.5 | 13.6 | 0.4 |
| Nursery Bands- elevation | | 3597 | 3999 | 3668 | 3886 | 3973 | 3976 | 4194 | 4860 | 5849 | 6012 | 5924 | 4411 | 4058 | | 4199 | 3876 |
| - av. temp. | | -15.1 | 14.8 | 9.1 | 27.5 | 35.7 | 38.3 | 50.6 | 46.7 | 41.3 | 46.4 | 43.1 | 35.4 | 25.9 | | 13.6 | 1.1 |

Average temperature in °F

Elevations in feet above sea level

temperature than that of the valley floor. This difference can perhaps be explained by the fact that the valley station was located in an opening in the forest and received less sunshine than the station at 3610 feet, which was located on a large open grassland. Because of inversions in winter and cooler temperatures in summer the annual average temperature range at the alpine station at 5380 feet was 57.2 F., which was 17.8 F. less than that of the valley station (+ 2800').

Table 14 also reveals that considerable differences may exist between years since the average temperatures for June, July and August are given for 1970 and 1971.

An inspection of the monthly average altitude of the sheep and the correlated temperatures (Table 15), reveals that these animals are exposed to a reduced annual temperature range, compared to that observed at the valley floor. By being in slightly warmer temperatures during December and January because of inversions, and by moving into cooler alpine elevations during summer, rams experience an annual average temperature range of 68.9 F. and nursery bands one of 65.7 F. compared to 75.0 F. measured at the valley floor (+ 2800').

The fact that ewes and lambs are at slightly higher elevations in January and December and thereby are exposed to slightly less severe temperatures may support the speculation that they depend much more on favourable winter temperatures than rams do because of their less favourable surface area to mass ratio, which results in relatively more heat loss.

Geist (undated), in a theoretical treatment on the significance of thermoclines to the biology of wintering mountain sheep, elaborates on the advantages incurred by sheep through moving into warmer temperatures at higher altitudes. By doing so, sheep would draw less rapidly on their fat

TABLE: 15 ALTITUDINAL MOVEMENT OF SHEEP IN RESPONSE TO TEMPERATURE

| Date | Jan. 16 | Jan. 25 | Jan. 20 | Jan. 27 | Jan. 21 | Jan. 23 | Jan. 10 | Dec. 31 | Jan. 9 | Jan. 1 | Dec. 10 | Jan. 13 | Jan. 8 | Feb. 4 | Dec. 18 | Feb. 15 | Dec. 11 | Dec. 22 | Dec. 13 | Jan. 6 | Feb. 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp. (base) | -38° | -36° | -35° | -34° | -33° | -26° | -23° | -22° | -20° | -15° | -12° | - 7° | - 3° | - 2° | + 8° | +10° | +12° | +13° | +24° | +27° | +35° |
| Temp. (+5400') | -20° | -21° | -20° | -21° | -18° | -17° | - 1° | - 9° | -14° | +10° | +12° | -10° | - 8° | + 5° | +11° | +19° | +13° | +11° | +16° | +19° | +23° |
| Elevations (♂) | 3187 | 3153 | 3170 | 3303 | 3210 | 3162 | 3230 | 3442 | 3282 | 3346 | 3912 | 3214 | 3337 | 3323 | 3792 | 3500 | 3938 | 3690 | 4081 | 3556 | 3530 |
| N (♂) | 30 | 43 | 34 | 26 | 31 | 37 | 39 | 26 | 46 | 35 | 25 | 41 | 43 | 39 | 38 | 57 | 24 | 41 | 26 | 41 | 36 |
| Elevation (♀) | 3406 | 3021 | 3208 | 3317 | 3376 | 3331 | 3779 | 3597 | 3790 | 3612 | 4083 | 3628 | 3904 | 4052 | 4096 | 3850 | 4108 | 3877 | 4266 | 4362 | 4650 |
| N (♀) | 68 | 76 | 62 | 103 | 70 | 74 | 58 | 75 | 49 | 75 | 72 | 58 | 52 | 58 | 54 | 77 | 48 | 52 | 76 | 43 | 60 |

Temperatures in °F

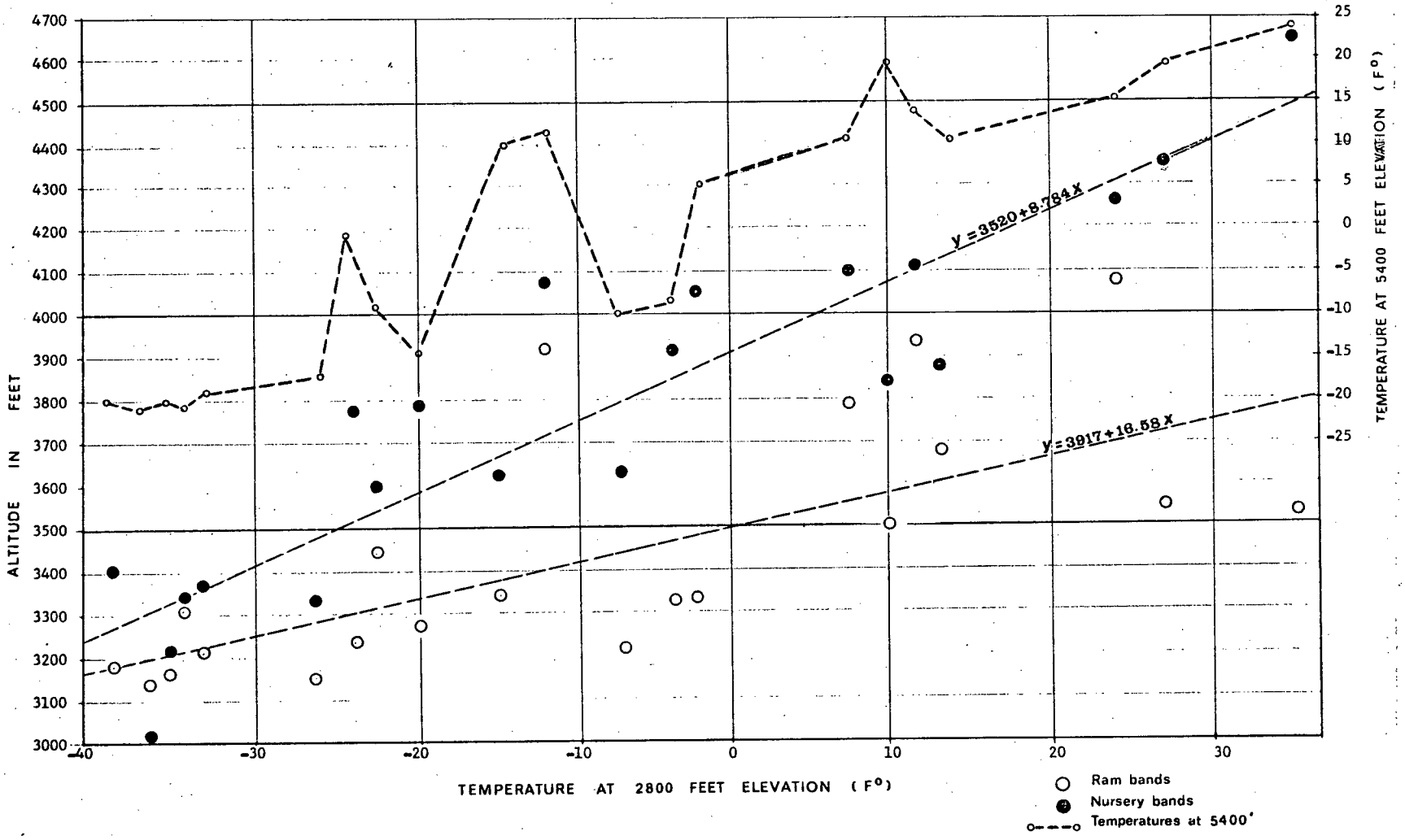
Elevations in feet above sea level

reserves, which may become a critical factor near the end of a winter. Geist (undated) further stresses that the advantages of moving into more favourable side of the thermocline are more important to ewes and lambs than to rams for reasons stated above.

To test whether the observations made by Geist (undated) on Bighorn sheep with respect to utilization of winter ranges within the thermocline would also apply to the Dall sheep population under study, the data for all the days of December, January and early February for which detailed classifications into ram and nursery bands had been made were analysed with respect to ambient temperatures and altitudinal movements. Our analyses in Table 15 and Figure 8 reveals a very different trend for this sheep population. The coldest days are spent at lowest altitudes and sheep moved up into higher elevations as the temperatures rose. This correlation (Figure 8) is very striking for nursery bands ($r = 0.91$; $p<.001$), but is also evident for ram bands, even though less pronounced ($r = 0.70$; $p<.001$).

Figure 8 also shows the temperature at 5400' elevation during the observation days of Table 15. There is no attempt by these sheep to take advantage of the higher temperatures in the thermocline during cold winter days. At temperatures of -35 F in the valleys, sheep were concentrated at elevations of 3000 to 3400 feet, where the advantage of temperature increases were about 2 to 3 F., while at the same time they could have gained as much as 12 to 18 F. by moving up to the 5000 to 6000 foot level. On the other hand, on warm days, with temperatures in the valley of 25 F. to 35 F., sheep could have stayed at low elevations and taken advantage of such warm spells, but the ewes moved up to 4300 to 4700 foot levels, where temperatures were on the average 15 F. <u>colder</u> than at low elevations.

## FIGURE: 8 Response of sheep to winter temperatures



This trend of moving into higher elevations as the temperatures in the valley increased will in part explain the great variation in altitudinal distribution of sheep within a given month, and also differences between months during winter. As will be discussed in the section on vertical migration, there is a very good correlation between mean monthly temperatures at the valley floor and mean monthly altitude of sheep distribution.

Response to Wind:

The study area is characterized by frequent and strong winds which are important to the re-distribution of snow during the winter months and which add to the dryness during the growing season by increasing the evapo-transpiration rates. Table 16 gives the average monthly wind speeds during 1970/71 for the 3600' station at Sheep Mountain as well as the 2600' station of the Arctic Institute at Kluane Lake. The totallizing anemometers do not record wind direction, but measurements with a hand anemometer and compass indicated that the prevailing winds at Sheep Mountain were from the southwest and from the north, with only a few instances of rather low-velocity winds blowing from the southeast.

There are some obvious differences between the two stations in Table 16. In contrast to the Sheep Mountain area the Kluane Lake station, which is set up on level ground according to Department of Transport standards, measures the full force of winds blowing from the east. These east winds lose their velocity after fanning out over Kluane Lake and have lost much of their impact on reaching Sheep Mountain. On the other hand, the strong southwest winds so important on Sheep Mountain, appear to lose their velocity after passing the Slims River delta and reaching the wide valley of Kluane Lake. Measurements of such winds at the Arctic Institute Station, located some 3 miles east of Sheep Mountain on the east side of Kluane Lake, have been substantially lower than those recorded at Sheep Mountain. These differences are reflected in Table 16. Higher average velocities are recorded for Sheep Mountain for months with frequent strong west winds (February, April, May), while higher average velocities are recorded at the Kluane Lake station for months with strong north or east winds (January, November). Slight differences in velocities between these

TABLE 16: Average Monthly Wind Speeds During 1970/71

| | Sheep Mountain +3600' | | Kluane Lake* +2600' | |
|---|---|---|---|---|
| | 1970 | 1971 | 1970 | 1971 |
| January | | 4.7** | | 7.4 |
| February | | 10.3 | | 5.8 |
| March | | 6.0 | | 7.8 |
| April | | 10.6 | | 7.5 |
| May | 9.3 | 13.3 | | 7.8 |
| June | 9.9 | 9.0 | | 5.5 |
| July | 9.3 | 9.9 | | 5.4 |
| August | 10.8 | 7.6 | | |
| September | 6.6 | | | |
| October | 4.7 | | | |
| November | 5.4 | | 9.6 | |
| December | 6.4 | | 4.9 | |

* Arctic Institute weather station at Mile 1054 Alaska Highway (courtesy of Benjey (1974)).

** Wind speeds expressed in miles/hour.

two stations are also due to the 1000' difference in altitude. Below timber line (within the boreal vegetation zone) only a slight increase in wind velocity with altitude was noticed. The average annual wind velocity was 6.6 miles/hour at 2600' elevation and 8.1 miles/hour at 3600' elevation. However, the velocity increases significantly when ascending above the forested zone and the sub-alpine shrub zone. At the 5400' station the annual average wind velocity was 15.8 miles/hour. During February 1971 when frequent strong winds blew down the Slims River valley, the alpine station recorded average weekly velocities of 44.7 and 50.5 miles/hour for the first two weeks of the month, and hand anemometer measurements indicated gusts of up to 100 miles/hour during that time. During such conditions it is not possible to walk upright, and the station had to be serviced by crawling to it.

It proved to be extremely difficult to accurately determine the wind speed in mountainous terrain at the level of two to three feet above the ground, - the level at which sheep operate. Slight differences in terrain (aspect, nearness to cliffs), proximities to trees, shrubs, boulders, windfalls, as well as the distribution of sheep in relation to one another are all influencing factors. Such determinations can only be successfully carried out by equipping the sheep themselves with instrumentation and recording exposure to wind through telemetry. Our approach, therefore, had to be considerably simplified. For the most part velocities were broken down into broad categories of 5 miles/hours (10, 15, 20 miles/hours, etc.), and the location of sheep during windy weather was broken down into three groups: a) definitely exposed to wind, b) definitely in a protected, sheltered location, and c) in a "neutral" position, if neither 'a' or 'b' could be accurately determined.

Table 17 lists the windy days during December, 1970, January and February 1971, for which these kinds of analyses was possible. November was not considered, since the distribution of sheep during that month is primarily influenced by the rutting season, and March was not considered since it was a fairly calm month with no cold winds from the north.

The wind velocities, directions, the average altitude at which the sheep were found and the temperature at that altitude were recorded during the time of observations, which was usually between 11:00 a.m. and 2:00 p.m., - the warmest time of the day. Much more severe conditions can be expected for the night, but at that time the sheep are resting in close proximity to one another, often in sheltered, protected locations, thereby reducing radiative and convective heat loss.

It is obvious from an analysis of Table 17 that there is no apparent response of sheep to wind velocities as such, through a change in altitude or by seeking protected locations. For instance, on February 7/71, as well as on January 23/71, sheep were exposed to winds of approximately 25 miles/hour. On February 7/71, 72% of the sheep observed (n = 120) were feeding in exposed locations, while on January 23/71, only 9% (n = 111) were feeding on exposed ridges, while 76% had sought sheltered areas.

However, a clear relationship becomes obvious if the exposure to wind velocities is combined with that of ambient temperatures.

This combined effect has been referred to as wind chill, and considerable work has been done on the subject in relation to human physiology. From wind chill charts (Folk, 1966) the different local (actual) temperatures can be converted to equivalent temperatures due to the effects of various wind velocities. For example, if the local temperature is 23 F. and the wind speed is 25 miles/hour, a person loses heat as if the dry bulb

TABLE: 17 RESPONSE OF DALL SHEEP TO WIND CHILL

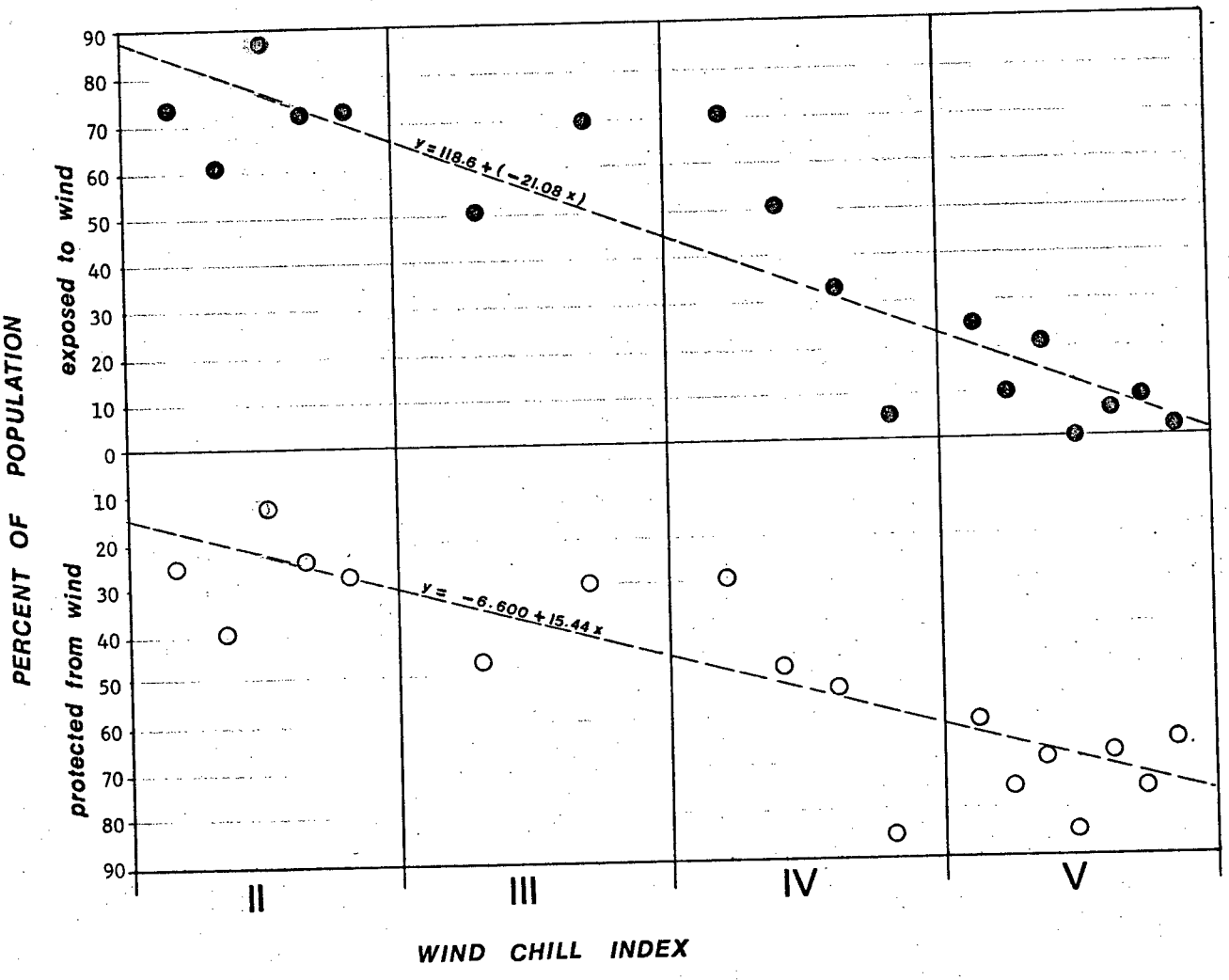
| Date | Wind Speed | Wind Direction | Average Altitude of sheep | Ambient Temp. at altitude | Percent of Sheep exposed to wind | protected from wind | in neutral locations | Wind chill index |
|---|---|---|---|---|---|---|---|---|
| Dec.22/70 | 2 m/h | south | 3900' | 0°F | 74% | 24% | 2% | II |
| Dec.13/70 | 5 m/h | south | 4240' | +12°F | 61% | 39% | 0% | II |
| Feb.11/71 | 20 m/h | west | 3820' | +25°F | 88% | 12% | 0% | II |
| Feb. 7/71 | 25 m/h | west | 4120' | +40°F | 72% | 23% | 5% | II |
| Feb.21/71 | 35 m/h | west | 3840' | +30°F | 73% | 27% | 0% | II |
| Jan.20/71 | 3 m/h | east | 3180' | -30°F | 51% | 47% | 2% | III |
| Feb.17/71 | 35 m/h | west | 3730' | +20°F | 70% | 30% | 0% | III |
| Feb. 5/71 | 25 m/h | west | 3650' | +10°F | 71% | 29% | 0% | IV |
| Dec.11/70 | 20 m/h | west | 4120' | 0°F | 51% | 49% | 0% | IV |
| Feb. 1/71 | 30 m/h | west | 3360' | + 5°F | 33% | 53% | 14% | IV |
| Jan.10/71 | 10 m/h | north | 3580' | - 7°F | 5% | 84% | 11% | IV |
| Jan.21/71 | 10 m/h | east | 3320' | -33°F | 25% | 61% | 14% | V |
| Jan.13/71 | 20 m/h | north | 3460' | - 8°F | 10% | 76% | 14% | V |
| Dec.30/70 | 20 m/h | north | 3490' | -20°F | 21% | 69% | 10% | V |
| Jan. 9/71 | 15 m/h | north | 3500' | -20°F | 0% | 84% | 16% | V |
| Dec. 1/70 | 25 m/h | north | 3700' | - 5°F | 7% | 68% | 25% | V |
| Jan.23/71 | 25 m/h | north | 3270' | -20°F | 9% | 76% | 15% | V |
| Jan. 8/71 | 25 m/h | north | 3680' | - 8°F | 2% | 65% | 23% | V |

were -10 F. Wind chill charts consist of several hyperbolic curves, because the higher wind velocities are more effective than the lower ones, and divide the environmental conditions into 5 wind chill indices, with increasingly severe consequences in case of exposure. For instance, Index I describes comfortable conditions under normal precautions, while Index V gives conditions under which exposed flesh will freeze in less than one minute.

Even though Dall sheep, together with arctic foxes, are the best insulated northern mammals (Scholander et al., 1950), our observations show a very strong positive correlation between increasingly severe exposures, expressed as wind chill index, and the sheep's response in seeking sheltered locations ($r = 0.88$; $p<.001$). Figure 9 shows this relationship. The wind chill Index I is irrelevant in this context, since it deals with either calm conditions during winter or windy conditions during summer. Under conditions of wind chill Index II on the average 74% of the sheep were feeding on exposed sites, while 25% were feeding in protected locations. At the other extreme, under conditions of wind chill Index V, 71% of the sheep were feeding in protected areas and only 11% were exposed. The positive response appears to take place under conditions of wind chill Index IV, when most rams are still feeding in exposed areas while ewes and lambs are in protected locations. This can possibly be explained by the less favourable surface area to mass ratios of the latter types of sheep, and the related consequence of proportionally greater heat loss.

A positive response was also found between wind chill indexes and the average altitude of the sheep ($r = 0.62$; $p<.005$). Analysis of Table 17 will reveal that the average elevation of sheep under wind chill Index II conditions is 3984' (above timber line), while that under wind chill Index V conditions is 3489'. The exception to this linear trend is the

**Figure: 9** **Response of Dall sheep to wind chill**



elevation under wind chill Index III conditions (3455'). However, since it is based on a sample size of only two days (n = 2), it is inconclusive. Sheep appear to move down to areas which provide protection through trees and shrubs, if the conditions at higher altitude approach those of wind chill Indexes IV and V.

Table 17 reveals that conditions of wind chill Index V are usually associated with winds from the north, while those of wind chill Index II are usually associated with winds from the southwest. To further test for the avoidance by sheep of cold north winds, the distribution of sheep on the winter range was analysed. During the winter of 1970/71 only the months of December and January had strong winds from the north, and therefore only these two months were looked into.

The northeast side of Sheep Mountain, which is exposed to the full force of winds from the north, has a limited amount of winter range of about 50 acres with vegetation cover of the orders ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS and CALAMAGROSTIDO (PURPURASCENTIS) - ARCTOSTAPHYLETALIA UVAE-URSI (Map section A-7, B-7, C-7, and portions of D-7). Approximately 8 to 10% of the winter grazing takes place on these sites. During December 1970 the grazing distribution was mapped on 16 days. During 6 days the wind blew from the north, and during these days only 2.0% of the population (n = 96) utilized these exposed areas, while on the remaining 10 days, when conditions were calm or when the wind was from directions other than north, an average of 16.3% of the population used these sites. This difference is statistically significant (p=0.009).

This response was similar during January, even though not quite as distinct. On days with north winds (n = 7) an average of 1.6% of the sheep population utilized the winter range on the northeast slope, while

during 10 days with no north wind, an average of 7.0% used these sites ($p=0.079$).

No comparisons to other Dall sheep populations are possible since these factors have not been looked into in other areas. Detailed work, however, has been carried out on the European Ibex by Nievergelt (1966). Unfortunately Nievergelt did not use wind chill indices, only wind speeds and directions. However, some similarities in response to wind between the ibex and the Dall sheep populations are apparent. During winter (November to April) the ibex sought protected locations during winds from the north. During summer they behaved indifferently with respect to wind directions.

During winter an increasing percentage of the ibex population were found in protected locations as the wind speed increased. On the other hand, during summer the ibex seemed to enjoy exposed locations.

Vertical Migration:

The sheep population under study undertakes a seasonal or annual re-migration, as defined by Blood (1963) since they return to the same winter range each year. This seasonal re-migration has an altitudinal basis.

A number of factors have been considered as the causative agents of vertical migrations in ungulates, these include nutritional advantages by following the newly emerging vegetation (Nievergelt, 1966; Blood, 1963; Dixon, 1938), weather factors, most importantly snow (Nichols and Heimer, 1972; Edwards and Ritcey, 1956; Edwards, 1956; and Nasimovich, undated), but also temperature (Schroder, 1971; and Christie, 1967) and humidity (McCullough, 1964), as well as combinations of forage and weather factors (Hebert, 1972; Blood, 1963; Nievergelt, 1966). Blood sucking insects can also be responsible for vertical migrations of sheep (Egorov, 1967).

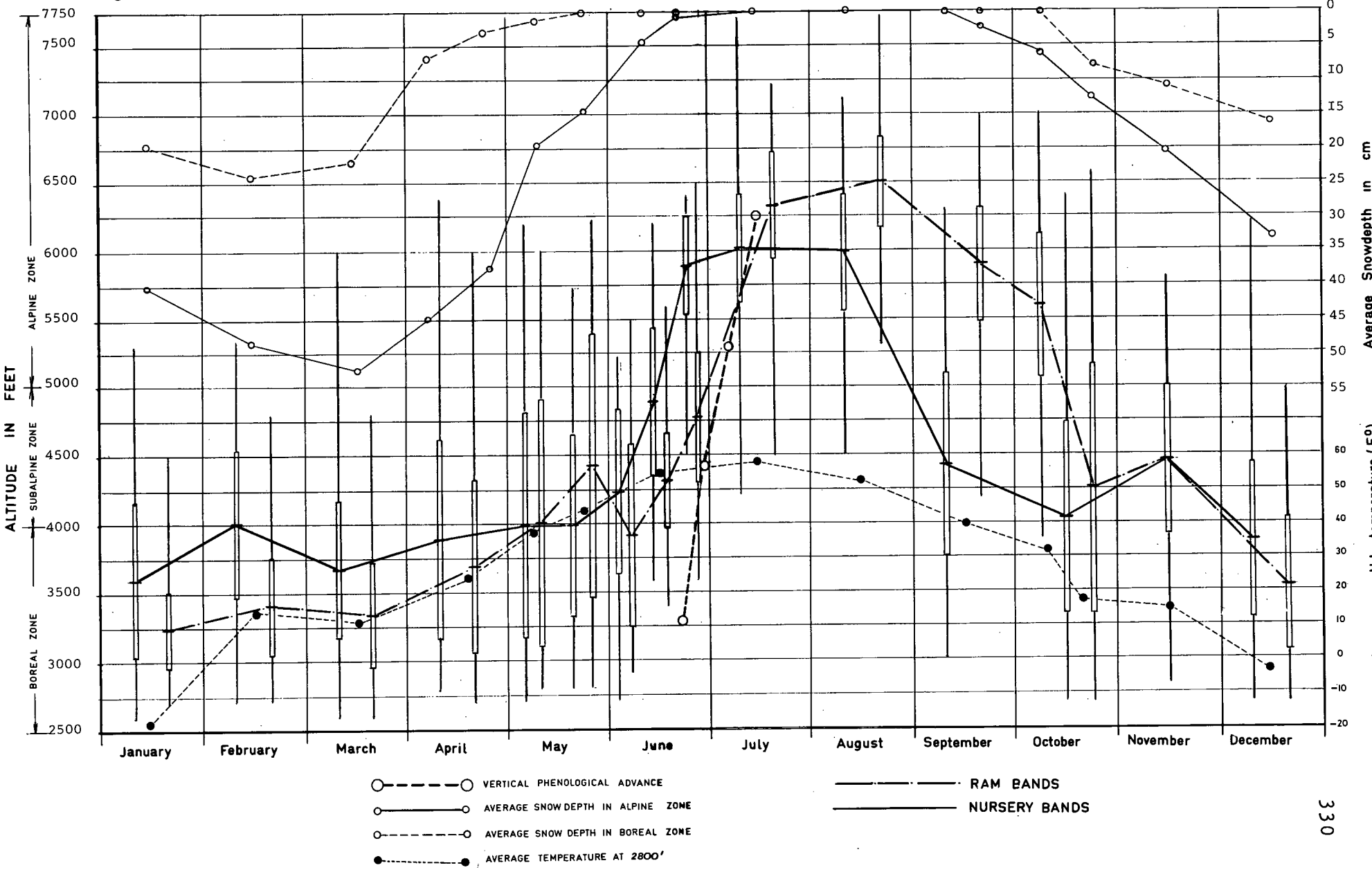
Figure 10 and Table 18 show the annual trend of vertical migration of the Sheep Mountain population. Rams and nursery bands are treated separately and the data for each month reveal the mean, two standard deviations and the ranges observed. Data have further been broken down for those months during which a pronounced vertical migration was observed. Figure 10 also reveals the annual fluctuations in snow depths for the boreal and the alpine biogeoclimatic zones as well as the average monthly temperatures. To reveal the relationship of the annual sheep migration to the vertical plant phenological advance, the line connecting the completion of 100% of annual growth of Carex filifolia at various altitudes has been transferred from Figure 3 to Figure 10.

In contrast to some of the investigators cited above, our observations do not support the claim that one single environmental variable is the stimulant for vertical migration. As an inspection of Figure 10 will

TABLE: 18

| TIME PERIOD | | SEX | NO. OF SHEEP OBSERVED | MEAN ALTITUDE (FEET) | STANDARD DEVIATION (FEET) | RANGE (FEET) |
|---|---|---|---|---|---|---|
| JANUARY | | FEMALE | 928 | 3597 | 584 | 2600 - 5300 |
| JANUARY | | MALE | 650 | 3232 | 278 | 2700 - 4500 |
| FEBRUARY | | FEMALE | 843 | 3999 | 540 | 2700 - 5300 |
| FEBRUARY | | MALE | 594 | 3417 | 365 | 2700 - 4800 |
| MARCH | | FEMALE | 1450 | 3668 | 499 | 2600 - 6000 |
| MARCH | | MALE | 891 | 3351 | 386 | 2600 - 4800 |
| APRIL | | FEMALE | 1004 | 3886 | 725 | 2800 - 6400 |
| APRIL | | MALE | 556 | 3675 | 642 | 2700 - 6000 |
| MAY | 1/2 | FEMALE | 371 | 3973 | 812 | 2700 - 6200 |
| MAY | 1/2 | MALE | 331 | 4016 | 909 | 2800 - 6000 |
| MAY | 2/2 | FEMALE | 932 | 3976 | 676 | 2800 - 5700 |
| MAY | 2/2 | MALE | 331 | 4431 | 970 | 2800 - 6200 |
| JUNE | 1/3 | FEMALE | 407 | 4194 | 604 | 2700 - 5200 |
| JUNE | 1/3 | MALE | 341 | 3900 | 671 | 2900 - 5500 |
| JUNE | 2/3 | FEMALE | 422 | 4860 | 544 | 3600 - 6200 |
| JUNE | 2/3 | MALE | 264 | 4328 | 330 | 3400 - 5600 |
| JUNE | 3/3 | FEMALE | 397 | 5849 | 348 | 4500 - 6400 |
| JUNE | 3/3 | MALE | 447 | 4760 | 477 | 3600 - 6500 |
| JULY | | FEMALE | 1112 | 6012 | 384 | 4200 - 7300 |
| JULY | | MALE | 1088 | 6336 | 381 | 5400 - 7700 |
| AUGUST | | FEMALE | 744 | 5924 | 418 | 4500 - 7100 |
| AUGUST | | MALE | 889 | 6503 | 339 | 5300 - 7700 |
| SEPTEMBER | | FEMALE | 1922 | 4411 | 684 | 3000 - 6300 |
| SEPTEMBER | | MALE | 777 | 5867 | 419 | 4200 - 6900 |
| OCTOBER | | FEMALE | 1266 | 4058 | 705 | 2700 - 6400 |
| OCTOBER | 1/2 | MALE | 365 | 5626 | 520 | 3900 - 7000 |
| OCTOBER | 2/2 | MALE | 358 | 4253 | 898 | 2700 - 6600 |
| NOVEMBER | | COMBINED | 1131 | 4199 | 546 | 2800 - 5800 |
| DECEMBER | | FEMALE | 718 | 3876 | 573 | 2700 - 6200 |
| DECEMBER | | MALE | 221 | 3532 | 489 | 2700 - 5000 |

**Figure: 10** *VERTICAL MIGRATION OF SHEEP POPULATION*



reveal good correlations are found between the altitude of sheep and snow depth, temperature and vertical advance of plant development during early summer. This is to be expected since all these factors are interrelated. The snow line can not retreat unless the temperature rises, and new plant growth can not begin until the snow has retreated and the temperature has melted the frost in the soil.

Since some pronounced differences exist between ram bands and nursery bands with respect to vertical movements, these two groups of sheep will be discussed separately. The range of altitudinal movement of this population is restricted by the valley floor at about 2560' and the peak of Mt. Wallace at about 7750'. Continuous vascular vegetation begins to fade out at an altitude of 6800', but isolated plants of Saxifraga oppositifolia and several lichens are found on the peak of Mt. Wallace. As is apparent from Figure 13, treeline is found at about 4000' and the altitudinal limit of tall shrubs is found near 5000' elevation.

Rams are largely confined to elevations of the boreal zone (2500 to 4000 feet) throughout the winter (December to April). During these months their vertical distribution is much more restricted than that of the nursery bands, and they are found at considerably lower elevations than nursery bands. During these months vertical movements have been known to be influenced by temperature and wind chill. As has been pointed out the response to sheep to these environmental factors is more obvious in nursery sheep, which resulted in greater variations in the vertical distributions compared to rams (Figure 10).

Pronounced rises in temperatures during late April and throughout May resulted in a considerable retreat of snow. As a consequence vegetation formerly covered by snow became available. A significant portion of the ram

segment of the population followed the retreating snow line to alpine elevations, which resulted in the small peak in the curve of Figure 10 for rams in late May. The vertical distribution of ewes at this month is greatly influenced by the lambing period. Ewes retreat to cliffs at alpine elevations to give birth; this has nothing to do with the retreating snow line. During late May all rams are found again at low elevations to utilize the newly emerging vegetation. Both rams and nursery bands follow the vertical advance of plant phenology (Figure 10), but ewes are ahead of rams, following exposed ridges with advanced vegetation and reach their summer range by the end of the month. Rams take more time during the vertical ascent, and make extensive use of the sub-alpine shrub zone. They do not reach their altitudinal goal until July. During July the nursery bands are found at higher altitudes (6012') than at any other month. They are now on the average 2415 feet higher than during January, when they are found at lowest elevations. Rams reach their highest mean elevation during August (6503'), during the latter part of which some nursery bands already begin their descent. The average altitudinal range over the year for rams was 3271 feet, more than 800 feet greater than for female bands. While on alpine summer range (July and August) the monthly vertical range is smaller than at any other month. As will be discussed in the section on range use, movements at this time are with respect to aspect and slope, seeking out vegetation in the youngest phenological state. The vertical descent in nursery bands takes place in late August and during the first half of September. This is a very gradual process and during it the nursery sheep make extensive use of the willows in the sub-alpine shrub zone as well as of herbaceous vegetation which is still "green" at lower elevations. Rams remain at alpine elevations throughout September in spite of the fact that

practically all vegetation has dried up at that altitude. Rams descend during the second half of October. At this time there are no nutritional advantages to be gained by moving to lower elevations. Since the snow depths at alpine elevations are also no hindrance yet, it is assumed that the vertical descent of rams is largely caused by the reproductive urge. The vertical distribution during November is largely influenced by the rutting behaviour. Responses found during other winter months with respect to snow, wind, and temperature were largely non-existing now, with the reproductive urge being the overriding factor. During December, sheep descended further and established the trend observed throughout the winter, with rams being found at lower elevations than nursery sheep and responding less readily to environmental changes.

Our observations therefore lead us to assume that nutritional, climatological as well as behavioral parameters are involved in explaining the annual vertical migration of this population.

Perhaps a most important factor, very often not even considered, is the necessity of sheep to migrate for the simple reason of protecting their winter range. Observations by the writer (Hoefs, 1974) indicate that the sheep can do very well by remaining at the valley floor elevations all year, and that there are a few small wild populations in the Yukon which occupy cliffs along rivers and which do not migrate to alpine elevations during summer. The lack of "thermische Behaglichkeit" [a phrase used by European investigators (Nievergelt, 1966; Schroder, 1971 a, b; Hofman and Nievergelt, 1972) to indicate sensitive temperature or cooling effect] does not seem to adversely effect the sheep, except that they have been observed to drink more often; and as far as nutrition was concerned, — if weight gains are a good indicator — there were no disadvantages (Hoefs, 1974).

The Sheep Mountain winter ranges appeared to be occupied at carrying capacity level, and therefore any diversions of feeding to other areas, or any postponement of the utilization of their winter range will be an advantage. Perhaps, this is the reason why the rams stay at alpine elevations to late October and do not make use of more nutritional vegetation at lower elevations as the ewes do.

Diurnal feeding rhythm:

Our observations indicate that the daily activity rhythm is proportional to the length of the photoperiod. On clear days sheep begin to feed around dawn and at night they continue to feed one to two hours beyond the time of sunset.

Figure 11 shows this relationship for three dates: May 20, April 11 and December 21, with different photoperiods. The data are based on observations taken approximately at hourly intervals, and the sample size was about 100 sheep for December and 150 sheep for April and May.

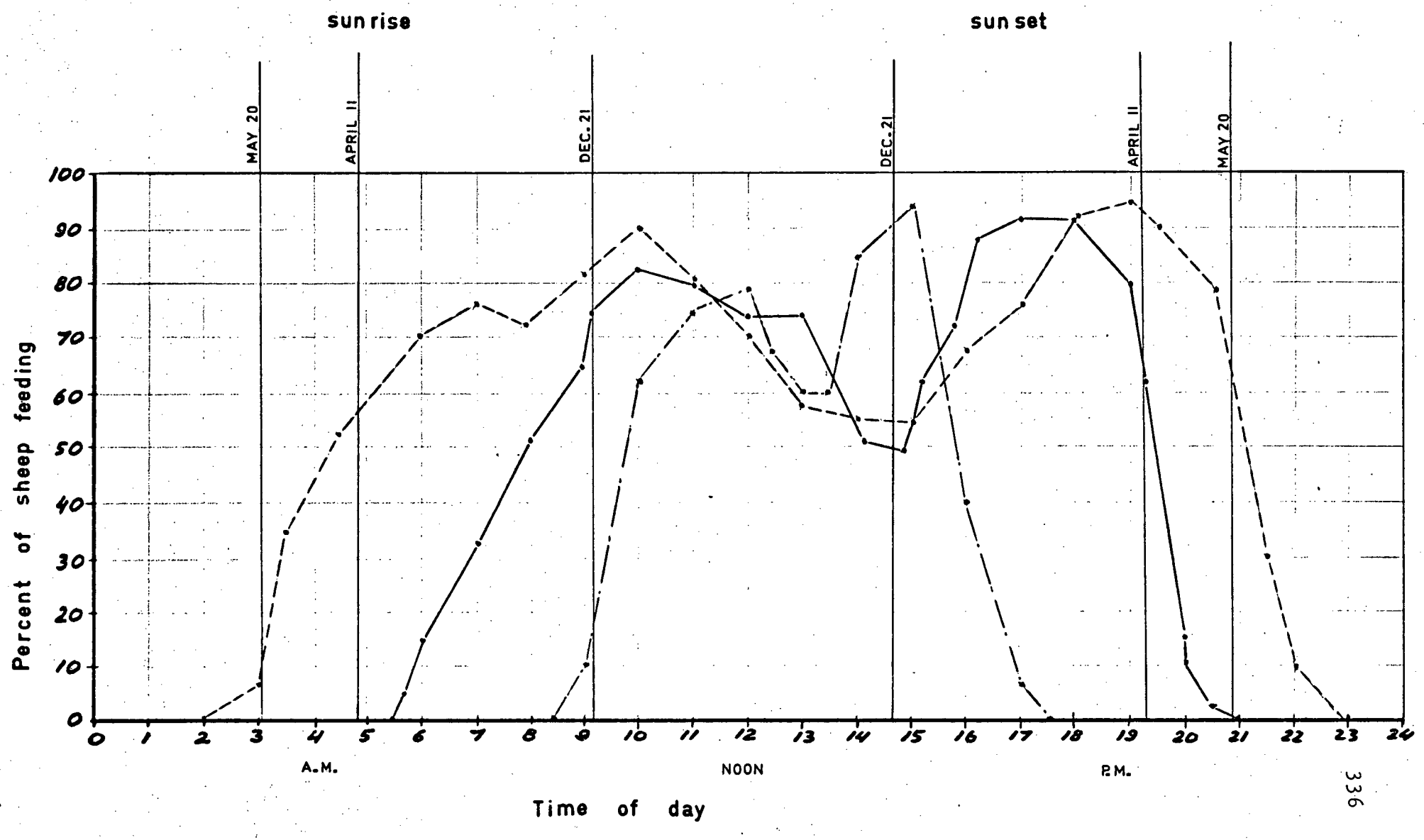
Sheep begin to feed very actively after rising in the morning. Most sheep take part in this feeding period which continues to about 1000 to 1100 hours; after this the activity declines and in the early afternoon, between 1200 and 1400 hours many sheep are resting and ruminating. Feeding activity increases again in the late afternoon and reaches the peak of the day about one hour before sunset, when over 90% of the sheep in the population are actively engaged in feeding. After sunset the feeding activity declines sharply, but some sheep have been observed to feed up to two hours after sunset, when it was already very dark.

On a population basis there are therefore two distinct peaks in feeding periods, one in the morning and one in the later afternoon, when 80% to 90% of the animals are active, and one very distinct resting period or "siesta" around mid day.

For an individual animal the feeding and resting periods alternate throughout the day. However, the noon hour resting period is the longest and coincides with that of many other sheep in the population. At this time sheep not only ruminate but actually sleep. All other resting periods appear to be rather short interruptions of feeding, perhaps with the purpose to

**FIGURE: 11**

# Diurnal Feeding Rhythm



ruminate in order to make room for more food. Each individual feeding period consists of two phases. The first and longest portion is taken up by very active feeding on abundant, "stable" forage plants. Under ideal conditions, for instance when new grass shoots first appear in spring (Agropyron yukonense, Calamagrostis purpurascens, Carex filifolia), a mature ram may feed at a rate of 1200 to 1500 interactions (bites) per hour. At the end of such active feeding period, which may last one to two hours there comes a very short phase of highly selective feeding. During this phase, which may last 10 to 15 minutes, considerable walking is done in search for preferred forages. During late May and early June such selected food items include the flowers of Pulsatilla patens and Oxytropis viscida. For short rest periods sheep may bed down anywhere, often in the midst of actively feeding sheep. It is only for the night and occasionally for the long mid day rest that preferred bedding sites near escape terrain are sought.

My observation that there are two peaks in the daily feeding period of Dall sheep separated by a mid day resting period, supports observations made for other Dall sheep populations.

Dixon (1938) did observations in Mt. McKinley National Park and writes: "The mountain sheep's daily program during the summer was as follows: Through the early morning hours, from 3 o'clock until 8 o'clock they foraged about actively, often descending nearly to timber line. By 10 o'clock they returned to the higher cliffs and during the heat of the day were found bedded down at the foot of perpendicular cliffs or escarpments which protected them from the unexpected approach of any enemy from above. They directed their watch downward and were able to detect readily the approach of any enemy from below. Six o'clock in the evening usually marked the time of the second grazing period in the day".

While Dixon's (1938) observations were restricted to the summer months, another Alaska investigator (Nichols, 1972) reported a similar activity rhythm for the winter period: "Our observations during November and December showed peak feeding activity of Dall sheep to be at or just after dawn and again in the afternoon just before and after sunset. During the middle of the day, most sheep were seen to be resting, though some were up at all times. The general pattern of movement each day of reasonable good weather was to feed and move upward in the morning, then back down into the cliffs and gulches in the evening. On days of strong winds and blowing snow, the sheep remained low on the slopes and in the gulches, sometimes moving into the alder zone to feed".

In contrast to these findings several investigators working with bighorn sheep (Blood, 1963; Smith, 1954; Mills, 1937) reported three peaks in the daily activity rhythm, one of them around noon, coinciding with the major resting period of Dall sheep.

No feeding was observed at night during our investigation with sheep on native range, nor was it observed by the writer (Hoefs, 1974) while watching a band of semi-captive Dall sheep for a one year period. There is no agreement in the literature as to whether night-time feeding does occur or not. Croften (1949), as cited by Hunter (1954), remarks that hill sheep graze and move very little during the hours of darkness. Wallace (1884) found that hill sheep do not eat during the short summer nights, but do it in the long winter nights between the hours of 11 p.m. and 2 a.m. Tribe (1950) reviewed this subject and concluded that moving about as well as feeding does occur.

It is likely that no generalization is possible on this point. An important factor will be the differing day lengths to which a given population

is exposed. The northern most sheep population in the Yukon is found in the British Mountains at a latitude of 69° 30'. At this latitude the sun does not rise above the horizon from early December to mid January. During this six week period the sheep have no choice but to feed in the dark.

Range Use and Forage Selection:

To appreciate this section it is essential that the reader be familiar with Part 1 of this thesis, which describes in detail the various plant associations found on Sheep Mountain, familiar with the species found in each of these associations, and the vegetation map on which the distribution over the mountain of the various plant associations is shown.

The range use and forage selection is discussed on a monthly basis. Tables for each month reveal forage utilization through direct observations as well as rumen analyses, and a map shows the distribution of grazing during that time.

Variations have been found between forage utilization as revealed by direct observations compared to rumen sample analyses. But this variation can be expected. Direct observations were meant to represent the forage utilization of the entire population over a month. Great care was taken to distribute the observation time proportional to the sexes and to the various plant associations utilized. On the other hand, it is unrealistic to assume that a rumen sample represents the composition of the forage of the population. It only reveals the diet of one animal for one particular day. Therefore, if rumen samples are meant to be representative, a fairly large number of them will have to be collected, and such collections would have to be spread over the entire month and over the various habitats utilized by sheep at any one time. This conclusion is also drawn by Hansen (Nichols & Heimer, 1972).

That this assumption is realistic is borne out by the observation that greatest differences in forage composition between rumen samples and direct observation were found for those months when only one or two rumen samples were available, while a good correlation was found for those months

when a fairly large number of samples were available. Table 19 gives a summary of the origins of the rumen samples. Individual analyses are given in the respective months.

The data used in the monthly descriptions are weighted means of the various forage species. These were calculated by using the number of observation days per month and combining them with the number of rumen samples available for that month, evaluating each rumen sample as representative for the forage composition of one day. The utilization of various plant associations per month is revealed in Table 20. These data have been compiled by superimposing the monthly distribution maps on the vegetation map in Part 1 of this thesis.

Each monthly discussion has a brief introduction about factors which have been shown to influence the distribution of sheep over the mountain and the forage utilization. These factors include some weather data (snow, wind, temperatures), phenological events and certain behavioural phenomena as band size and percentage of mixed bands at that time.

Definitions of such terms as "selection" or "preference" have been adopted from Hoefs (1974) and are dealt with in the section on "general discussion of annual trend in range use and forage selection". The use of the term "significant" in the monthly discussions has no statistical connotation.

A general discussion at the end about trends observed over the annual cycle concludes this section on range use and forage selection.

Table: 19

History of Rumen Samples

| Rumen Sample Number | Time of Death | Sex | Location of Kill | Cause of Death natural + unnatural ++ |
|---|---|---|---|---|
| 1 | Jan. 1971 | ? | Sheep Mountain | + |
| 2 | Jan. 2/1971 | M | Sheep Mountain | ++ |
| 3 | Jan. 1971 | F | Sheep Mountain | + |
| 4 | Feb. 3/1971 | M | Kaskawulsh Glacier | ++ |
| 5 | Feb. 13/1971 | F | Sheep Mountain | + |
| 6 | Feb. 23/1970 | F | Sheep Mountain | + |
| 7 | Feb. 24/1970 | F | Sheep Mountain | + |
| 8 | February 1972 | F | Sheep Mountain | + |
| 9 | March 3/1971 | F | Kluane Lake | + |
| 10 | March 3/1971 | F | Sheep Mountain | + |
| 11 | March 12/1971 | F | Williscroft Creek | ++ |
| 12 | March 24/1971 | F | Sheep Mountain | + |
| 13 | March 1973 | M | Sheep Mountain | + |
| 14 | April 15/1971 | F | Sheep Mountain | + |
| 15 | April 23/1971 | M | Christmas Creek | ++ |
| 16 | April 27/1971 | M | Sheep Mountain | + |
| 17 | April 29/1970 | F | Sheep Mountain | ++ |
| 18 | April 1971 | ? | Sheep Mountain | + |
| 19 | April 1972 | ? | Bullion Creek | + |
| 20 | May 14/1974 | M | Sheep Mountain | + |
| 21 | May 23/1971 | M | Vulcan Creek | ++ |
| 22 | May 25/1971 | F | Sheep Mountain | ++ |
| 23 | May 26/1971 | Lamb F | Sheep Mountain | + |
| 24 | May 1970 | ? | Canada Creek | + |
| 25 | June 7/1971 | F | Sheep Mountain | ++ |
| 26 | June 17/1971 | M | Vulcan Creek | ++ |
| 27 | June 18/1971 | M | Vulcan Creek | ++ |
| 28 | July 19/1969 | F | Auriol Range | ++ |
| 29 | July 19/1969 | F | Auriol Range | ++ |
| 30 | July 19/1969 | F | Auriol Range | ++ |
| 31 | July 19/1969 | F | Auriol Range | ++ |
| 32 | Aug. 3/1973 | M | Kusawa Lake | ++ |
| 33 | Aug. 3/1973 | M | Kusawa Lake | ++ |
| 34 | Sept.10/1970 | M | Christmas Creek | ++ |
| 35 | Sept.12/1970 | M | Vulcan Creek | ++ |
| 36 | Sept.13/1970 | M | Vulcan Creek | ++ |
| 37 | Sept.27/1971 | F | Williscroft Creek | ++ |
| 38 | Sept.27/1971 | M | Williscroft Creek | ++ |
| 39 | Oct.21/1969 | M | Sheep Mountain | ++ |
| 40 | Nov.17/1970 | M | Sheep Mountain | + |
| 41 | Dec. 1971 | F | Sheep Mountain | + |
| 42 | Dec.22/1970 | F | Christmas Creek | ++ |
| 43 | Dec.22/1970 | F | Christmas Creek | ++ |

++ unnatural mortality includes collections and accidents in trapping and transplanting operations.

Table: 20

Utilization of different habitat types (plant associations) over the annual cycle by Dall Sheep.

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pentstemono (gormanii) - Artemisia (frigidae) - Agropyretum yukonensis | 61.3 | 60.7 | 56.7 | 45.5 | 34.5 | 168 | 0.6 | | 21.2 | 45.1 | 41.0 | 49.9 | 36.1 |
| Agropyro (yukonensis) - Artemisietum frigidae - rupestris | 14.9 | 17.2 | 24.6 | 18.5 | 8.9 | 5.4 | | | 14.8 | 18.2 | 22.3 | 16.7 | 13.5 |
| Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae | 1.3 | 0.2 | | 2.0 | 1.7 | 10.1 | 44.1 | 52.3 | 5.9 | 6.3 | 4.1 | 3.7 | 11.0 |
| Arctostaphylo (rubrae-uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae | 2.5 | 3.9 | 2.7 | 6.9 | 13.4 | 37.0 | | | 31.1 | 8.8 | 7.1 | 8.8 | 10.2 |
| Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi | 13.0 | 7.3 | 10.5 | 10.0 | 13.4 | 7.7 | | | 2.3 | 7.1 | 5.2 | 11.8 | 7.4 |
| Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati | 0.4 | | <0.1 | 4.7 | 5.1 | 2.2 | 20.3 | 13.7 | 2.9 | 0.7 | 0.3 | 0.2 | 4.2 |
| Agropyretum violacei (scree slopes) | 1.5 | 2.8 | 1.1 | 3.8 | 6.3 | 2.3 | 7.9 | 4.7 | 6.0 | 6.1 | 4.4 | 1.4 | 4.0 |
| Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum filifoliae | 2.9 | 4.6 | 1.3 | 3.6 | 3.5 | 4.6 | 1.7 | 3.8 | 8.2 | 3.0 | 8.2 | 2.2 | 4.0 |
| Oxytropo (huddelsonii) - Salicetum dodgeanae | | | | | 0.1 | | 10.3 | 6.2 | 0.2 | 0.2 | | | 1.8 |
| Cliff habitats | 0.8 | 0.8 | 0.1 | 2.2 | 6.5 | 2.1 | 1.9 | 0.1 | 0.4 | 1.5 | 2.0 | 1.0 | 1.6 |
| Arctostaphylo (rubrae) - Cassiopo (tetragonae) - Salicetum reticulatae - lanatae - glaucae | 0.4 | 0.5 | 0.2 | 1.1 | 1.1 | 6.1 | | 1.1 | 0.7 | 0.3 | 0.5 | 1.8 | 1.2 |
| Roso (acicularis) - Shepherdio (canadensis) - Populetum tremuloidis | 0.5 | 0.4 | 1.1 | 0.7 | 3.1 | 2.2 | | | 1.7 | 1.0 | 1.6 | 1.4 | 1.1 |
| Salicetum barrattianae | | | | | | | 6.9 | 5.5 | <0.1 | 0.2 | | | 1.1 |
| Artemisio (frigidae) - Agropyro (yukonensis) - Eurotietum lanatae | | 1.3 | 1.4 | 0.4 | 1.6 | 0.3 | | | 1.4 | 0.6 | 3.2 | 0.6 | 0.9 |
| Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae | | | | | | | 2.3 | 4.4 | | | | | 0.6 |
| Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae | 0.5 | 0.3 | 0.3 | 0.6 | 0.2 | 2.3 | | | 0.7 | 0.4 | | 0.5 | 0.5 |
| Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris | | | | | | | 2.1 | 4.4 | <0.1 | <0.1 | | | 0.5 |
| Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae | | | | | 0.1 | 0.7 | | 1.0 | 1.7 | | | | 0.3 |
| Seneciono (lugentis) - Salicetum polaris - reticulatae | | | | | | <0.1 | 1.5 | 1.8 | | | | | 0.3 |
| Dryadetum drummondii | | | | | 0.2 | 0.1 | | | | 0.4 | | | 0.1 |
| Artemisietum alaskanae | | | | | 0.3 | <0.1 | <0.1 | 0.7 | 0.8 | <0.1 | | | 0.1 |
| Oxyrio (digynae) - Artemisietum arcticae - tilesii | | | | | | | <0.1 | 0.3 | | | | | <0.1 |
| Salico (reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae | | | | | | | 0.4 | | | | | | <0.1 |

SUM OF ALL = 100%

TABLE: 21 Statistics on Range Utilization

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average number of sheep on Sheep Mountain | 99.0 | 109.5 | 131.5 | 126.5 | 117.9 | 71.6 | 24.7 | 35.4 | 111.5 | 115.5 | 80.9 | 94.6 | $\bar{x}$ = 93.2 |
| Maximum number | 120 | 155 | 153 | 164 | 146 | 124 | 75 | 80 | 142 | 150 | 131 | 114 | 164 |
| Minimum number | 84 | 75 | 107 | 67 | 63 | 0 | 0 | 0 | 21 | 55 | 17 | 72 | 0 |
| Observation days per month | 21 | 21 | 21 | 18 | 19 | 20 | 21 | 20 | 19 | 22 | 18 | 22 | $\bar{x}$ = 20.2<br>sum = 242 |
| Sheep days per month mapped | 2067 | 2300 | 2761 | 2276 | 2243 | 1432 | 515 | 709 | 2119 | 2546 | 1460 | 2081 | sum= 22520 |
| Number of map sections used | 20 | 19 | 16 | 24 | 26 | 25 | 10 | 12 | 16 | 22 | 18 | 19 | 33 |
| Number of map quadrats used | 292 | 342 | 344 | 417 | 517 | 346 | 118 | 153 | 326 | 318 | 215 | 263 | 3651 |
| Number of section providing 90% of range use | 11 | 9 | 9 | 14 | 16 | 20 | 5 | 6 | 9 | 6 | 9 | 13 | 16 |
| Average intensity of range use (sheep days per acre per mos.) | 5.5 | 4.2 | 6.3 | 4.7 | 3.3 | 3.1 | 3.1 | 3.4 | 5.0 | 5.3 | 5.3 | 5.2 | 54.4 sheep days per acre per year |
| Maximum intensity of range use per quadrat(sheep days per acre) | 31.6 | 25.6 | 27.9 | 23.3 | 22.9 | 11.2 | 11.3 | 11.6 | 22.2 | 21.8 | 25.1 | 38.2 | 94.0 sheep days per acre per year |
| Number of plant associations utilized | 12 | 12 | 12 | 13 | 17 | 17 | 14 | 14 | 18 | 18 | 12 | 13 | 23 |
| Number of plant associations providing 90% of feeding sites | 4 | 4 | 3 | 6 | 8 | 8 | 6 | 7 | 7 | 6 | 7 | 5 | 5 |

TABLE: 22

Statistics on forage utilization

| Month | Number of Observation Days | Number of Feeding Interactions Recorded | Total Number of Species Utilized | Number of Species Contributing 75% of Forage | Number of Species Utilized t only 0.1% Less |
|---|---|---|---|---|---|
| January | 9 | 16425 | 40 | 6 | 11 |
| February | 8 | 13440 | 36 | 5 | 12 |
| March | 8 | 44515 | 35 | 6 | 9 |
| April | 12 | 34390 | 33 | 6 | 13 |
| May | 10 | 34255 | 57 | 7 | 18 |
| June | 10 | 30890 | 50 | 10 | 20 |
| July | 8 | 7540 | 53 | 10 | 19 |
| August | 8 | 8650 | 63 | 13 | 22 |
| September | 10 | 9100 | 54 | 11 | 21 |
| October | 10 | 9214 | 44 | 6 | 16 |
| November | 9 | 6295 | 34 | 6 | 8 |
| December | 7 | 12695 | 40 | 5 | 15 |
| Year | 109 | 227409 | 110 | 13 | 71 |

Range Use During January:

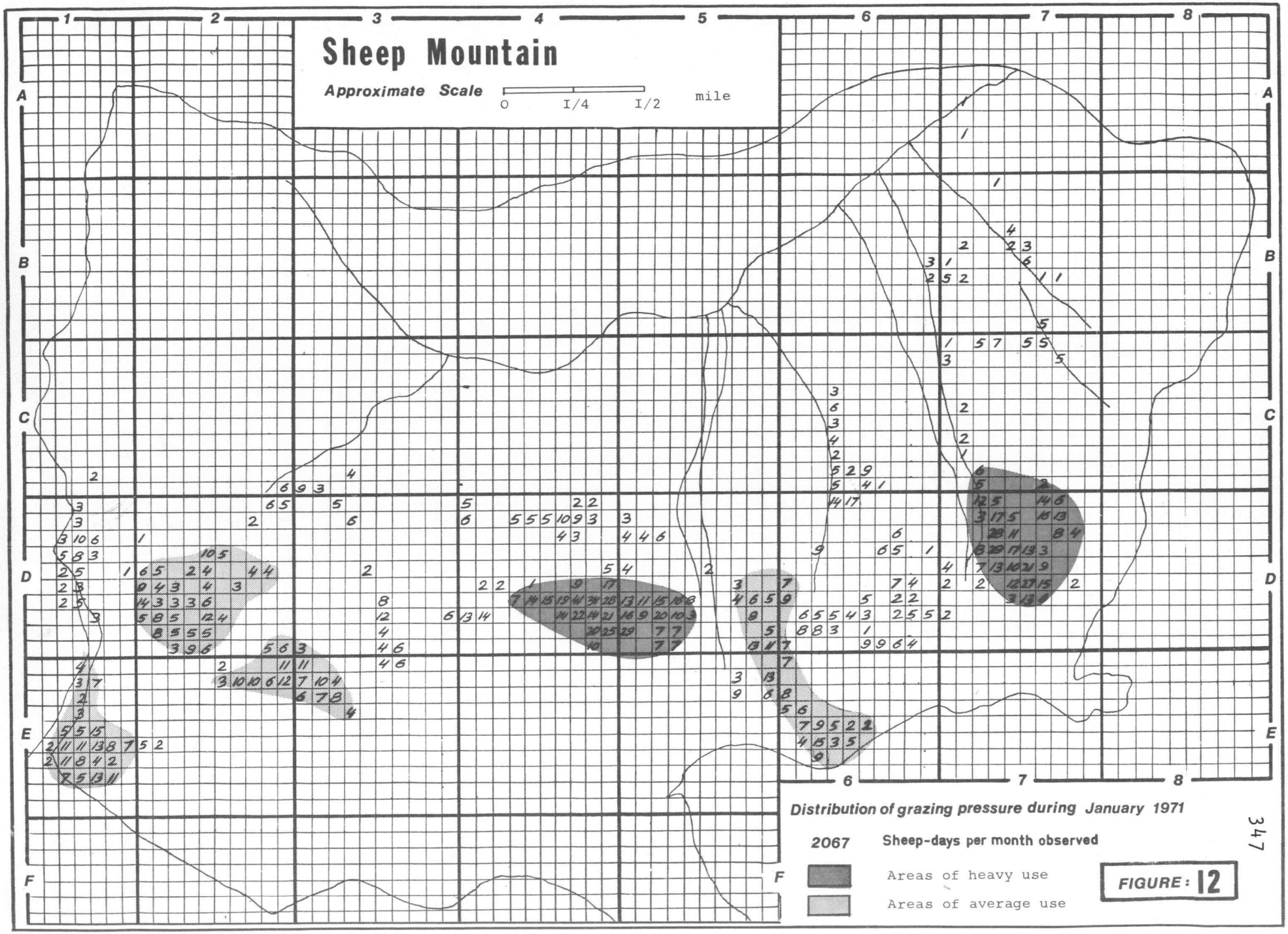
This month had the coldest average temperature for the year (-17.9 F) as well as the greatest range between maximum and minimum temperatures (+41 - 56 = 97 F). There were frequent strong winds from the north (on 8 days), and temperature inversions during cold calm weather. A chinook early in the month (2nd to 5th) resulted in snow removal from exposed areas, but subsequently a total of 5 cm. (2 inches) snow fell on 3 days. The average snow depths of all plant associations in the boreal zone was 19 cm. (7.6 inches).

All plants are dormant at this time, with "green" vegetation restricted to the following species: all coniferous plants, Equisetum variegatum, Equisetum scirpoides, Linnaea borealis, Arctostaphylos uva-ursi and Vaccinium vitis-idaea.

The average band size for the month was 7.1 sheep (range 6.0 to 9.1), but there was still considerable mixing of sexes, with 36.6% (range 9% to 58%) of all bands observed containing nursery sheep as well as rams.

The distribution of sheep was mapped on 21 days; with a mean number of 99.0 sheep on the mountain per day (range 84 to 120), resulting in 2067 sheep days. Figure 12 shows the distribution pattern. A total of 20 sections were utilized, but as few as 11 supplying 90% of the forage (Table 21). The average grazing intensity for those quadrats that were utilized was 5.5 sheep days per acre, with the maximum being 31.6 sheep days per acre in quadrat 4D.68 (Table 21).

Sheep were concentrated at lower elevations than at any other time of the year because of the cold temperatures, and very little use was made of the east slope because of strong north winds, which further added to the concentration of grazing on south and west sides. Almost 83% of




Distribution of grazing pressure during January 1971

2067 Sheep-days per month observed

Areas of heavy use

Areas of average use

FIGURE: 12

347

all grazing took place in the boreal biogeoclimatic zone, and only 13% and 4.0% respectively in the sub-alpine and alpine zones.

A total of 12 plant associations were utilized (Table 20), but as few as four of them provided 90% of the forage; all of them being grassland associations (Table 20), with 61.3% of all grazing taking place on sites occupied by the association Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis. This is the highest utilization rate documented for any plant association at any time of the year. While snow conditions in this association were comparable to other grasslands (Figure 33, Part 1 of thesis), the intensive use can be explained by the fact that this association is more widely distributed at low elevations than most of the other grasslands (Vegetation map, Part 1 of thesis).

Figure 12 shows the concentration areas of grazing pressure during the month. Heavily used areas are shaded darker than those with average use. The exact rates for the six areas are as follows, starting from the left: #1 (1E) 4.4 sheep days per acre per month, #2 (2D) 2.8, #3 (2 - 3E) 4.1, #4 (4 - 5D) 7.9, #5 (6E) 4.1, and #6 (7D) 5.3 sheep days per acre per month respectively.

Area #1 was exclusively used by rams, in #6 and in #2 80% and 60% respectively of the grazing was by rams. On the other hand, 90% of the grazing in #4 and 80% of the grazing in #3 and #5 was by nursery bands. Rams descended to lowest elevations in area #1 and #6, while nursery sheep did so in area #5. The fact that sheep used the lowest elevations in these particular sites can be explained by the closeness of these areas to escape terrain. Similar areas with equal or better forage in low elevations of map sections 3E, 4E, 5E, are largely avoided since they have no escape terrain.

Forage Use During January:

During this month feeding sheep were observed on 9 days, and a total of 16,425 interactions were recorded and are expressed as percentages in Table 23. Three rumen samples became available for analyses (Table 24).

Sheep are known to have utilized at least 40 different species during January, 15 of which provided 90% of the forage, and 11 of which were only utilized to a degree of 0.1% or less. Only 5 species provided 71.4% of all the forage taken (Carex filifolia: 21.6%; Calamagrostis purpurascens: 19.6%; Artemisia frigida: 15.7%; Agropyron yukonense: 9.5% and Salix glauca: 5.0% (Tables 29, 30).

This early in the winter sheep were able to choose preferred forages, since very little grazing had taken place, particularly at low elevations, and heavy utilization was also possible along the forest edge [Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi sites with 13.0%, Table 26], since snow conditions were no hindrance yet. This ability to select is reflected in the relatively high percentage of preferred forages in the diet as well as in the low percentage of unpalatable species. It is also reflected in the "quality" of forage taken from the same species (leaves vs. stems, for instance). Such preferred forage plants include the following: Agropyron yukonense: 9.5%, Oxytropis viscida: 1.8%, Eurotia lanata: 4.1%, Astragalus williamssii: 1.5%, Achillea lanulosa: 1.0%, Artemisia dracunculus: 0.8% and Hedysarum mackenzii: 0.1%, while unpalatable species - which receive increasingly greater utilization as winter progresses - contributed the following percentages: Artemisia rupestris: 2.4%, Arctostaphylos uva-ursi: 1.7%, Juniperus horizontalis: 0.8% and Juniperus communis: 0.1%. Rumen analyses proved that almost 80% of the Calamagrostis

TABLE: 23

Feeding Observations during late winter and spring.

| SPECIES: | Jan. | Feb. | March | April | May |
|---|---|---|---|---|---|
| Calamagrostis purpurascens | 20.1 | 23.7 | 26.3 | 21.7 | 15.7 |
| Carex filifolia | 19.8 | 27.7 | 11.8 | 10.2 | 25.2 |
| Artemisia frigida | 15.8 | 19.4 | 23.9 | 22.2 | 10.4 |
| Agropyron yukonense | 11.0 | 10.5 | 5.3 | 2.4 | 14.5 |
| Eurotia lanata | 5.4 | 1.6 | 1.9 | 1.3 | <0.1 |
| Salix glauca | 4.9 | 1.0 | <0.1 | <0.1 | 1.5 * |
| Carex scirpoidea | 3.1 | 0.1 | 1.1 | 1.9 | 0.9 |
| Artemisia rupestris | 3.1 | 1.7 | 5.1 | 5.5 | 0.2 |
| Rosa acicularis | 2.0 | 2.2 | <0.1 | | |
| Astragalus mackenzii | 2.0 | 0.1 | 0.1 | | |
| Arctostaphylos uva-ursi | 1.9 | 1.8 | 7.1 | 8.8 | 5.5 |
| Artemisia hyperborea | 1.8 | 0.7 | 1.1 | 4.4 | 1.7 |
| Oxytropis viscida | 1.8 | 0.6 | 0.4 | 2.5 | 2.9 * |
| Achillea lanulosa | 1.2 | <0.1 | <0.1 | | |
| Artemisia dracunculus | 0.9 | 0.6 | 0.5 | | |
| Juniperus horizontalis | 0.7 | 3.4 | 10.4 | 8.1 | 2.3 |
| Potentilla hookeriana | 0.6 | 0.4 | 0.4 | | 0.1 |
| Oxytropis huddelsonii | 0.6 | <0.1 | | | |
| Salix arctica | 0.6 | | | | 0.9 |
| Epilobium angustifolium | 0.6 | | 0.3 | | |
| Linnaea borealis | 0.4 | | | | |
| Bromus pumpellianus | 0.3 | 0.7 | 0.6 | | <0.1 |
| Dryas integrifolia | 0.3 | <0.1 | 0.4 | 5.0 | 1.9 |
| Poa glauca | 0.3 | 1.5 | 0.5 | 3.0 | 1.5 |
| Erigeron caespitosus | 0.1 | 0.2 | 1.1 | | <0.1 |
| Juniperus communis | 0.1 | 0.3 | 1.1 | 1.2 | <0.1 |
| Salix lanata | 0.2 | 0.1 | | | 0.3 |
| Populus tremuloides | 0.2 | 1.6 | <0.1 | | 0.9 * |
| Arctostaphylos rubra | 0.1 | | | <0.1 | 0.2 * |
| Festuca altaica | 0.2 | <0.1 | | 0.6 | 5.8 |
| Solidago multiradiata | <0.1 | 0.1 | 0.1 | | |
| Hedysarum mackenzii | <0.1 | | | | |
| Trisetum spicatum | <0.1 | | | 0.9 | 1.5 |
| Ledum palustre | <0.1 | | | 0.1 | |
| Plantago canescens | <0.1 | 0.1 | 0.4 | | 0.1 |
| Artemisia alaskana | | 0.2 | | | <0.1 |
| Astragalus nutzotinensis | | <0.1 | | | |
| Epilobium latifolium | | <0.1 | 0.1 | | |
| Picea glauca | | | <0.1 | <0.1 | |
| Aster alpinus | | | <0.1 | | |
| Anemone multifida | | | <0.1 | | <0.1 |
| Salix reticulata | | | | <0.1 | 0.9 |
| Cassiope tetragona | | | | 0.1 | |
| Vaccinium uliginosum | | | | 0.1 | |
| Chamaerhodos erecta | | | | | 0.7 * |
| Carex concinna | | | | | 0.2 * |
| Festuca brachyphylla | | | | | 0.9 |
| Cetraria islandica | | | | | 1.5 |
| Pulsatilla patens | | | | | 0.6 * |
| Populus balsamifera | | | | | 1.1 * |
| Dryas drummondii | | | | | <0.1 * |
| Lupinus arcticus | | | | | <0.1 * |
| Anemone parviflora | | | | | 0.1 * |
| Pentstemon gormani | | | | | <0.1 * |
| | 100% | 100% | 100% | 100% | 100% |
| Grasses (total) | 54.8 | 64.2 | 45.6 | 40.7 | 66.2 |
| Forbs (total) | 35.2 | 25.6 | 35.8 | 41.1 | 20.7 |
| Browse (total) | 10.0 | 10.2 | 18.6 | 18.2 | 11.6 |
| Mosses & Lichens (total) | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 |
| | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

* New spring growth

TABLE: 24

Rumen sample analysis for January

| SPECIES | Samples #1 | 2 | 3 | Mean |
|---|---|---|---|---|
| Carex filifolia | 32* | 17 | 31 | 26.7 |
| Artemisia frigida | 17 | 12 | 17 | 15.3 |
| Calamagrostis purpurascens | 16 | 22 | 17 | 18.3 |
| Agropyron yukonense | 8 | 3 | 4 | 5.0 |
| Salix glauca | 4 | 6 | 6 | 5.3 |
| Artemisia hyperborea | 3 | | | 1.0 |
| Poa glauca | 1 | | 1 | 0.7 |
| Oxytropis viscida | 1 | 1 | 3 | 1.7 |
| Artemisia rupestris | 1 | | | 0.3 |
| Arctostaphylos uva-ursi | 1 | 2 | 1 | 1.3 |
| Artemisia dracunculus | 1 | | 1 | 0.7 |
| Rosa acicularis | 1 | 3 | 1 | 1.7 |
| Pentstemon gormani | 1 | 1 | | 0.7 |
| Erigeron caespitosus | | 2 | 1 | 1.0 |
| Aster alpinus | | 2 | | 0.7 |
| Eurotia lanata | | 1 | | 0.3 |
| Dryas integrifolia | | 1 | | 0.3 |
| Bromus pumpellianus | | 1 | | 0.3 |
| Juniperus horizontalis | | 1 | | 0.3 |
| Plantago canescens | | 1 | 2 | 1.0 |
| Tortula ruralis | | 1 | | 0.3 |
| Shepherdia canadensis | | | 1 | 0.3 |
| Linum perenne | | | 1 | 0.3 |
| Achillea borealis | | | 1 | 0.3 |
| Juniperus communis | | | 1 | 0.3 |
| | | | | 84.1 |
| Unidentified grasses | 10 | 17 | 11 | |
| Unidentified forbs | 3 | 2 | | |
| Unidentified browse | | 4 | | |
| | 100% | 100% | 100% | |
| Total grasses | 67 | 60 | 64 | 63.7 |
| Total forbs | 27 | 23 | 26 | 25.3 |
| Total browse | 6 | 16 | 10 | 10.7 |
| Total mosses & lichens | 0 | 1 | 0 | 0.3 |
| | 100% | 100% | 100% | 100% |

*Values expressed as percent frequency of occurrence in sample.

purpurascens parts in the rumen consisted of leaves and only 20% of the coarse stems of this bunch grass.

Alpine and sub-alpine elements in the diet include Artemisia hyperborea with 1.6%, Oxytropis huddelsonni with 0.5% and Carex scirpoidea with 2.3%. The utilization of browse in the boreal and sub-alpine zones consisted of feeding above the snow by taking the leaves which had remained on the branches (Salix glauca: 5.0%, Salix lanata: 0.2%, Populus tremuloides: 0.2%).

The forage taken during January can be broken down into the following broad classes: Grasses and grasslike vegetation: 57.0%, Forbs: 32.7%, browse: 10.2% and lichens and mosses: 0.1%. The feeding on the latter group was most likely accidental; it consisted of some fragments of Tortula ruralis in a rumen sample. This moss grows in close association with bunches of Carex filifolia or clumps of Artemisia frigida, and it will be very difficult to feed on these major forage items without also taking some of the moss.

Range Use During February:

This month was exceptionally mild, the average temperature being 15.2 F and the range 80 (Maximum + 46 , minimum -34 F). It was characterized by frequent strong west winds (10 days), but with no wind from the north. While the average snow depth in the boreal zone for all plant associations increased over January through 4 cm of fresh snow to 24 cm total, the

frequent west winds removed the snow from many exposed areas and feeding conditions for sheep were better than during the previous three months.

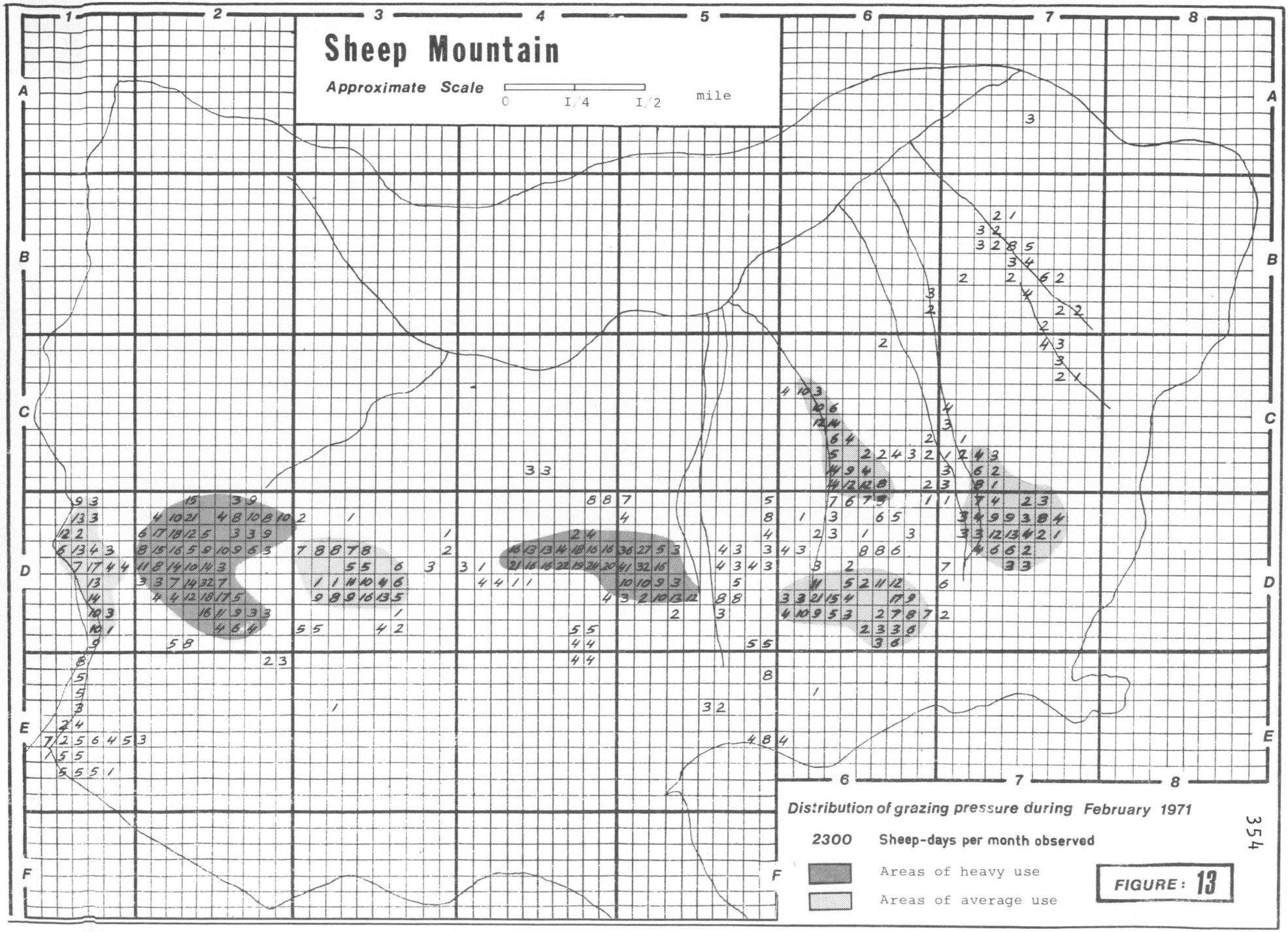
The plant phenological characteristics were the same as in January.

The average band size was with 6.6 sheep per band similar to that in January (7.1), but there was a further segregation of sexes. Only 23.1% (r = 10% to 41%) of the bands observed were mixed, compared to 36.6% for January.

The distribution of sheep was mapped for 21 days. The average number of sheep on the mountain being 109.5 (r = 75 to 155), the number of sheep days per month observed was 2300. Figure 13 shows the distribution of grazing sites. A total of 19 sections were utilized, but as few as 9 provided 90% of the forage (Table 21). The average grazing intensity of the area used was 4.2 sheep days per acre per month, the maximum being 25.6 sheep days per acre per month in quadrat 5D.41 (Table 21).

Sheep were not quite as concentrated as during January. The mild temperatures resulted in a general upward movement of nursery bands (400') and of rams (200') compared to the previous month. The lack of cold winds from the north resulted in a heavier utilization of the east slope (Sections 7A, 7B, and 7C). These two facts are obvious from a comparison of Figures 12 and 13. Because of the general upward movement there was a slight reduction of utilization of winter range of the boreal zone (78.6%) compared to January (83.0%), and a corresponding increase in the use of sub-alpine communities (17.6% in February compared to 13.0% in January). As in January there was very little use of the alpine zone (3.8%).

A total of 12 plant associations were utilized, but as few as 4 of them provided 90% of the forage (Table 20). As expected there was a


Sheep Mountain
Approximate Scale
0 1/4 1/2 mile
1 2 3 4 5 6 7 8
A B C D E F
Distribution of grazing pressure during February 1971
2300 Sheep-days per month observed
Areas of heavy use
Areas of average use
FIGURE: 13

reduction of grazing in low level associations [Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi (7.3% vs. 13.0%) and Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis (60.7% vs. 61.3%)] compared to January and a corresponding increase of utilization of grassland communities of higher altitudes [Agropyro (yukonensis) - Artemisietum frigidae - rupestris (17.2% vs. 14.9%) and Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum filifoliae (4.6% vs. 2.9%)]. The utilization of scree slope associations increased from 1.5% to 2.8% (Table 20).

Figure 13 shows the concentration areas of grazing through shading. The rates for the 7 sites are, from left to right: #1 (1D) 4.2 sheep days per acre per month, #2 (2D) 4.8; #3 (3D) 3.8; #4 (4-5D) 8.1; #5 (6D) 3.5; #6 (6C) 4.6; and #7 (7D) 2.6 sheep days per acre respectively. A close comparison of these sites to those of Figure 12 for January will reveal that there was a general upward trend of grazing, in particular of those very low elevation sites of January, which received little grazing pressure during February.

Forage Use During February:

During this month the feeding of sheep was observed on 8 days and 13,440 interactions were recorded (Table 22). Five rumen samples were available, and because of this high number there was a good agreement of forage use assessment as evaluated through direct observation vs. rumen sample analyses (Tables 23 and 25).

Sheep utilized at least 36 species during February, only 5 of which made up three-quarters of the forage (Carex filifolia: 25.5%, Calamagrostis purpurascens: 20.0%, Artemisia frigida: 19.1%, Agropyron yukonense: 7.7% and Salix glauca: 3.1% and 12 of them provided only 0.1%

TABLE: 25

Rumen sample analysis for February

| SPECIES | Samples # 4 | 5 | 6 | 7 | 8 | Mean |
|---|---|---|---|---|---|---|
| Carex filifolia | 28* | 26 | 31 | 18 | 9 | 22.4 |
| Artemisia frigida | 8 | 9 | 19 | 27 | 31 | 18.8 |
| Calamagrostis purpurascens | 18 | 15 | 21 | 12 | 21 | 17.4 |
| Agropyron yukonense | 4 | 1 | 2 | 7 | 10 | 4.8 |
| Salix glauca | 7 | 6 | 2 | 2 | 9 | 5.2 |
| Oxytropis viscida | 3 | 1 | 5 | 1 | | 2.0 |
| Arctostaphylos uva-ursi | 3 | 3 | | 2 | 5 | 2.6 |
| Picea glauca | 1 | | | | 1 | 0.4 |
| Tortula ruralis | 1 | 7 | | | 1 | 1.8 |
| Achillea borealis | 1 | | | 1 | | 0.4 |
| Pulsatilla patens | 1 | | | | | 0.2 |
| Aster alpinus | 1 | | | | | 0.2 |
| Juniperus communis | | 1 | | | 1 | 0.4 |
| Bromus pumpellianus | | 1 | 3 | 1 | | 1.0 |
| Eurotia lanata | | 1 | 1 | | | 0.4 |
| Juniperus horizontalis | | 1 | 1 | | 1 | 0.6 |
| Poa glauca | | | 1 | | | 0.2 |
| Populus balsamifera | | | 1 | | | 0.2 |
| Solidago multiradiata | | | 1 | | | 0.2 |
| Artemisia rupestris | | | 1 | 4 | | 1.0 |
| Lappula myosotis | | | 1 | | | 0.2 |
| Rosa acicularis | | | 1 | 1 | 2 | 0.8 |
| Artemisia dracunculus | | | | 1 | | 0.2 |
| Erigeron caespitosus | | | | | 1 | 0.2 |
| Potentilla hookeriana | | | | | 1 | 0.2 |
| Dryas integrifolia | | | | | 2 | 0.4 |
| Astragalus nutzotinensis | | | | | 1 | 0.2 |
| Grasses (Unidentified) | 14 | 20 | 9 | 15 | 4 | |
| Forbs (Unidentified) | 8 | 4 | 0 | 8 | 0 | |
| Browse (Unidentified) | 2 | 4 | 0 | 0 | 0 | |
| Mosses and Lichens (Unidentified) | 0 | 0 | 3 | 0 | 0 | |
| | 100% | 100% | 100% | 100% | 100% | |
| Grasses (total) | 64 | 63 | 67 | 53 | 44 | 58.2 |
| Forbs (total) | 22 | 15 | 28 | 42 | 36 | 28.6 |
| Browse (total) | 13 | 15 | 5 | 5 | 19 | 11.4 |
| Mosses and Lichens | 1 | 7 | 0 | 0 | 1 | 1.8 |
| | 100% | 100% | 100% | 100% | 100% | 100% |

*Values expressed as percent frequency.

of the diet or less.

Feeding conditions in general were still good and comparable to January, but there was already an obvious reduction in the utilization of preferred forages and a corresponding increase in the taking of less palatable species. Reduced rates of usage were recorded for the following species: Agropyron yukonense 7.7% vs. 9.5%, Artemisia hyperborea: 0.4% vs. 1.0%, Oxytropis huddelsonii: 0.1% vs. 0.5%, Oxytropis viscida: 1.3% vs. 1.8%, Eurotia lanata: 1.0% vs. 4.1%, and Astragalus williamsii: 0.1% vs. 1.5%. Increased use was noted in Arctostaphylos uva-ursi: 2.2% vs. 1.7%, and Juniperus horizontalis: 1.4% vs. 0.8%.

There still was some utilization of leaves of browse plants that had not dropped yet (Salix glauca: 3.1% and Populus tremuloides: 0.9% of the total monthly forage).

The species taken during February can be broken down into the following broad forage classes: Grasses and grasslike vegetation: 61.2%, forbs: 27.1%, browse: 10.8%, and moses and lichens: 0.9% (Table 38).

These percentages are similar to those observed during January, except for a fairly large increase of utilization of mosses (0.9% vs. 0.1%), the highest rate for any month during the winter. Three of the five rumen samples contained the moss Tortula ruralis, but in one of them (#5) this moss made up 7%. Such a high percentage might indicate "intentional" feeding on this species. While direct feeding on any moss was not observed during this study, Murie (1944) reported some utilization of mosses by sheep in Mt. McKinley Park, and so did Egorov (1967) for sheep in Yakuta (U.S.S.R.).

Range Use During March:

This month was cold and calm. The average temperature (10.4 F) was about 5 F lower than that for February (15.2 F). The range was 77 , with a maximum of +35 F and a minimum of -42 F. It was one of the calmest months of the year, the average wind speed being 6.0 miles per hour, and with only 3 days of strong north winds and 3 days of strong west winds. The average snow depth of all plant associations in the boreal zone was 22 cm. Table 33 (Part 1 of thesis) reveals that this month had the heaviest snow conditions in the annual cycle of build-up and thawing, even though many grassland associations were usually windswept and bare (Figure 4).

The vegetation was dried up and dormant as during the past four months.

The average band size increased to 7.9 sheep per band, while 29% of the bands observed were mixed.

The distribution of sheep was mapped on 21 days. The average number of sheep on the mountain was with 131.5 animals the highest for the year (r = 107 to 153). This high number resulted in the highest number of sheep days mapped (2761) for any month. Figure 14 shows the distribution of grazing pressure over the mountain.

Sheep were more concentrated than at any other time of the winter. Only 16 sections were utilized, and only 9 of them provided for 90% of the grazing (Table 21). The average grazing intensity per quadrat utilized was with 6.3 sheep days per acre per month, also the highest. The quadrat with the greatest grazing pressure was #4D.54 with 27.9 sheep days per acre per month (Table 21, Figure 14). In comparison to February there was an average downward movement of about 200 feet, with a resulting distribution of range use very similar to that of January. Very little use was made of east slope

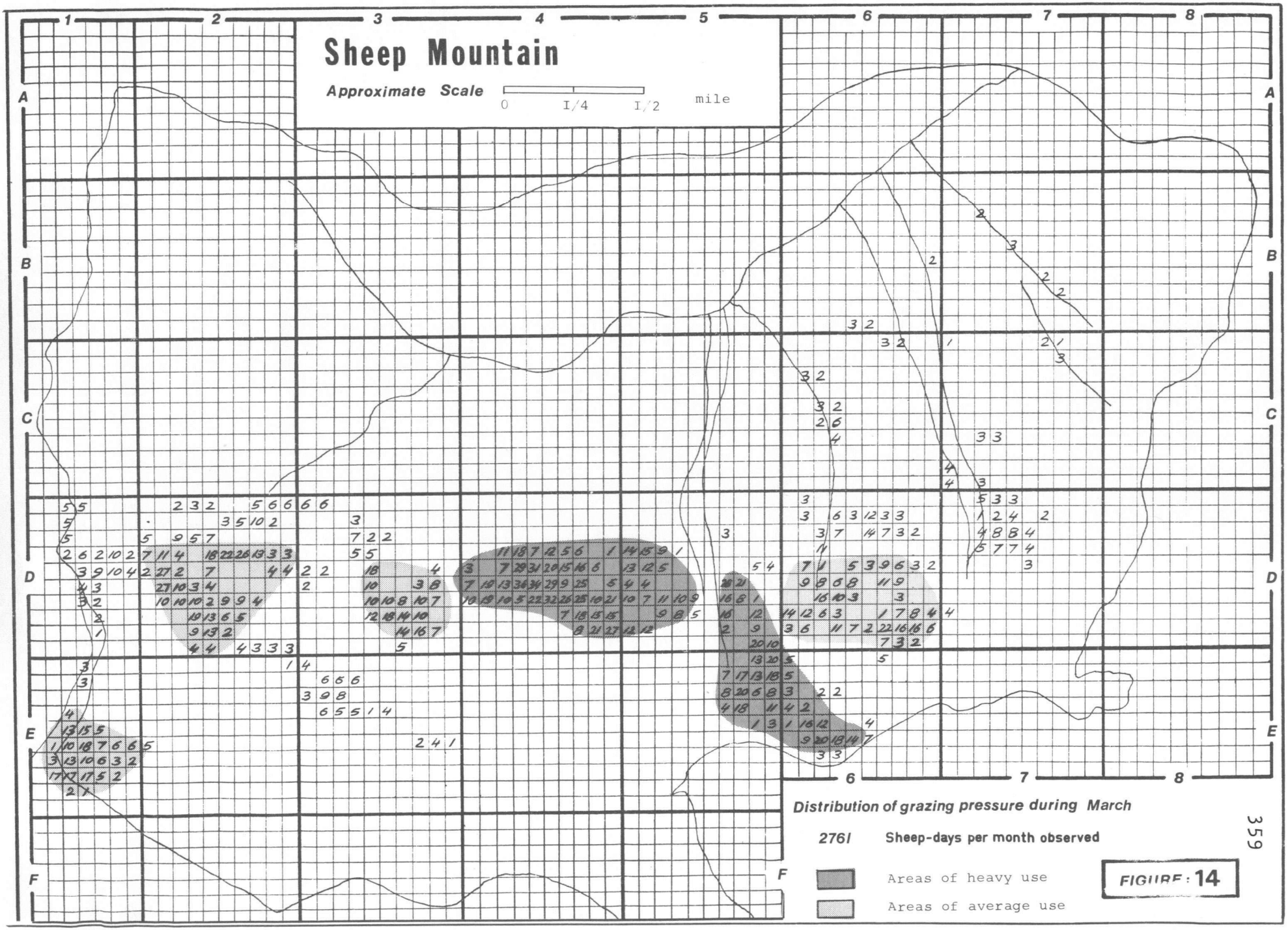



FIGURE: 14

359

sites and sub-alpine elevations and all the lowest elevation winter ranges were used again. This downward trend is reflected in the utilization of plant communities of the three altitudinal biogeoclimatic zones. The boreal zone provided for 82.3% of the grazing, the sub-alpine zone for 16.5% and the alpine zone for only 1.2%, the lowest utilization rate for any month. The concentration of sheep during March is also reflected in their utilization of various plant associations. While a total of 12 associations were used as in the previous two months, only 3 of them provided 90% of the forage [Pentstemono (garmanii) - Artemisio (frigidae) - Agropyretum yukonensis: 56.7%, Agropyro (yukonensis) - Artemisietum frigidae - rupestris: 24.6%, and Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi: 10.5%]. Two trends in sheep feeding behaviour came into being during this month and continued through the remainder of winter. Firstly, there is a marked increase in the utilization of the association Agropyro (yukonensis) - Artemisietum frigidae - rupestris, whose dominant Artemisia rupestris is largely avoided at other times; secondly, there is an increase of utilization of such associations as Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi and Roso (acicularis) - Shepherdio (canadensis) Populetum tremuloidis, in spite of the fact that they had 20 to 40 cm. of snow cover. It can be argued that these associations are used equally heavy at other times of the year, but at those times the snow conditions are no problem and as the discussions on forage selections reveal, the forage taken at these times differs considerably from that taken in late winter. Both these observations point to the fact that at this time of the year preferred forage plants are becoming scarce. Sheep either have to use "secondary" species, or - if they want something special - have to dig into snow.

Figure 14 shows the concentration areas of grazing, which as an

inspection of Figure 12 will reveal, are very similar to those observed in January. The utilization rate of the 6 sites are as follows: #1 (1E): 5.0 sheep days per acre per month, #2 (2D): 4.9; #3 (3D): 5.3; #4 (4-5D): 8.0, #5 (5-6E): 5.8, and #6 (6D): 3.7 sheep days per acre per month respectively. These utilization rates are very similar to those of January.

Forage Use During March:

During March the feeding of sheep was observed on 8 days and 44,515 interactions were recorded. The concentration of sheep at lower elevations fasciiitated the accummulation of feeding data during March, furthermore the sheep had by this time got accustomed to the daily presence of the investigator. Five rumen samples became available for analyses (Table 26).

Sheep utilized at least 35 species, only 3 of them provided 60.9% of the forage (Calamagrostis purpurascens: 26.8%, Artemisia frigida: 22.4%, and Carex filifolia: 11.7%), while 9 were only utilized to an extent of 0.1% or less.

Feeding conditions were at their worst for the winter. Preferred forages had been removed from exposed, windblown ridges, and deep snow conditions prevented heavy utilization of other plant associations. There was a marked shift within the proportional utilization of the five most important, "stable", forage species. A notable reduction of utilization was found in the three preferred species (Carex filifolia: 11.7% vs. 25.5%, Agropyron yukonense: 4.6% vs. 7.7%, and Salix glauca: 1.1% vs. 3.1%), and

TABLE: 26

Rumen sample anallysis for March



| SPECIES | Sample # 9 | 10 | 11 | 12 | 13 | Mean |
|---|---|---|---|---|---|---|
| Carex filifolia | 18* | 11 | 9 | 12 | 8 | 11.6 |
| Artemisia frigida | 23 | 15 | 29 | 18 | 15 | 20.0 |
| Calamagrostis purpurascens | 20 | 35 | 15 | 28 | 40 | 27.6 |
| Agropyron yukonense | 3 | 4 | 8 | 1 | | 3.4 |
| Salix glauca | 7 | 5 | 1 | 1 | | 2.8 |
| Bromus pumpellianus | 8 | 1 | | | | 1.8 |
| Juniperus horizontalis | 4 | | | 3 | | 1.4 |
| Juniperus communis | 2 | | | 1 | | 0.6 |
| Arctostaphylos uva-ursi | 4 | 2 | 1 | 8 | 9 | 4.6 |
| Picea glauca | 1 | | | 1 | | 0.4 |
| Solidago multiradiata | 1 | | | | 1 | 0.4 |
| Erigeron caespitosus | 1 | | | | | 0.2 |
| Eurotia lanata | | 3 | | | | 0.6 |
| Pentstemon gormani | | 2 | | | | 0.4 |
| Erigeron humilis | | 6 | | | | 1.2 |
| Aster alpinus | | 1 | | | | 0.2 |
| Rosa acicularis | | 2 | | | 2 | 0.8 |
| Salix reticulata | | 1 | | | | 0.2 |
| Artemisia rupestris | | 1 | 3 | 5 | | 1.8 |
| Plantago canescens | | 1 | 1 | | | 0.4 |
| Linnaea borealis | | | 1 | | | 0.2 |
| Poa glauca | | | 1 | | | 0.2 |
| Erigeron compositus | | | 1 | | | 0.2 |
| Oxytropis viscida | | | | 1 | | 0.2 |
| Achillea boreale | | | | | 1 | 0.2 |
| | | | | | | 81.4 |
| Grasses (unidentified) | 8 | 5 | 20 | 12 | 17 | |
| Forbs (unidentified) | 0 | 2 | 7 | 8 | 5 | |
| Browse (unidentified) | 0 | 0 | 3 | 1 | 0 | |
| Mosses & Lichens(unidentified) | 0 | 3 | 0 | 0 | 2 | |
| | 100% | 100% | 100% | 100% | 100% | |
| Grasses (total) | 56 | 56 | 52 | 53 | 65 | 56.4 |
| Forbs (total) | 25 | 32 | 43 | 32 | 22 | 30.8 |
| Browse (total) | 19 | 9 | 5 | 15 | 11 | 11.8 |
| Mosses & Lichens (total) | 0 | 3 | 0 | 0 | 2 | 1.0 |
| | 100% | 100% | 100% | 100% | 100% | 100.0% |

*Values expressed as percent frequency.

a corresponding increase of the other two species, (Calamagrostis purpurascens: 26.8% vs. 20.6%, and Artemisia frigida: 22.4% vs. 19.1%). Up to 80% of the Calamagrostis purpurascens fragments in the rumen samples consisted of stem portions. Preferred legumes (Oxytropis viscida: 0.3%, Oxytropis huddelsonii: 0%, Astragalus williamsii: 0.1% and Hedysarum mackenzii: 0%) and other forbs (Artemisia dracunculus: 0.3% and Archillea lanulosa: 0.1%), had virtually been eliminated from the range, and those that were utilized had to be dug out under considerable snow in the associations: Calamagrostida (purpurascentis) - Arctostaphyletum - uvae-ursi (30 cm.) and Roso (acicularis) - Shepherdio (canadensis) - Populetum tremuloides (40 cm.).

Significant increases were observed in a number of unpalatable species, which are largely ignored at other times of the year: Arctostaphylos uva-ursi: 6.1% vs. 2.2%, Juniperus horizontalis: 6.9% vs. 1.4%, Artemisia rupestris: 3.8% vs. 1.5%, Juniperus communis: 0.9% vs. 0.3%, and Erigeron caespitosus: 0.8% vs. 0.2%).

Very little use was made during March of willows and poplars, since practically all leaves had dropped by then (Salix glauca: 1.1%, Populus tremuloides: 0.1%, Salix lanata: 0%, Populus balsamifera: 0%).

The species taken during March can be broken down into the following broad forage classes: Grasses and grasslike vegetation: 49.9%, Forbs: 33.8%, browse: 16.0% and mosses: 0.3%.

The reduction of use of grasslike vegetation compared to February is largely due to the decrease in available Carex filifolia and Agropyron yukonense, while the increase in use of forbs is due to more Artemisia frigida and Artemisia rupestris being taken. Even though there was a decrease in use of willows and poplars, the heavy utilization of bearberry and

juniper resulted in an increase of browse taken compared to February.

Range Use During April:

This month was mild but windy. The average temperature was 26.9 F., with a range between minimum and maximum of 57 F. (+47 F. to -10 F.). With an average wind speed of 10.6 miles/hour per month it was one of the windiest months that year. Strong west winds were blowing on 9 days. Even though snow fell on 5 days, totalling 17 cm., the average snow depth in the boreal zone associations declined because of the mild weather and frequent chinooks to 5 cm.

The mild temperatures and retreating snow line initiated the first plant phenological response for the year. In the latter part of April several willow species had developed open catkins and during the last few days of the month the first open flowers of Pulsatilla patens were observed.

The average band size was with 7.2 sheep per band similar to that observed during March, while there was a slight increase in the percentage of mixed bands to 32%. This increase arises from convergence upon the licks by both rams and members of nursery bands (Figure 15), with considerable mixing of sexes there. Areas which are used as licks are located in the central eastern portion of Section 5E, and in the northwestern portion of section 3E.

The distribution of grazing sheep was mapped for 18 days. The average number of sheep on the mountain per day was 126.5, the range was

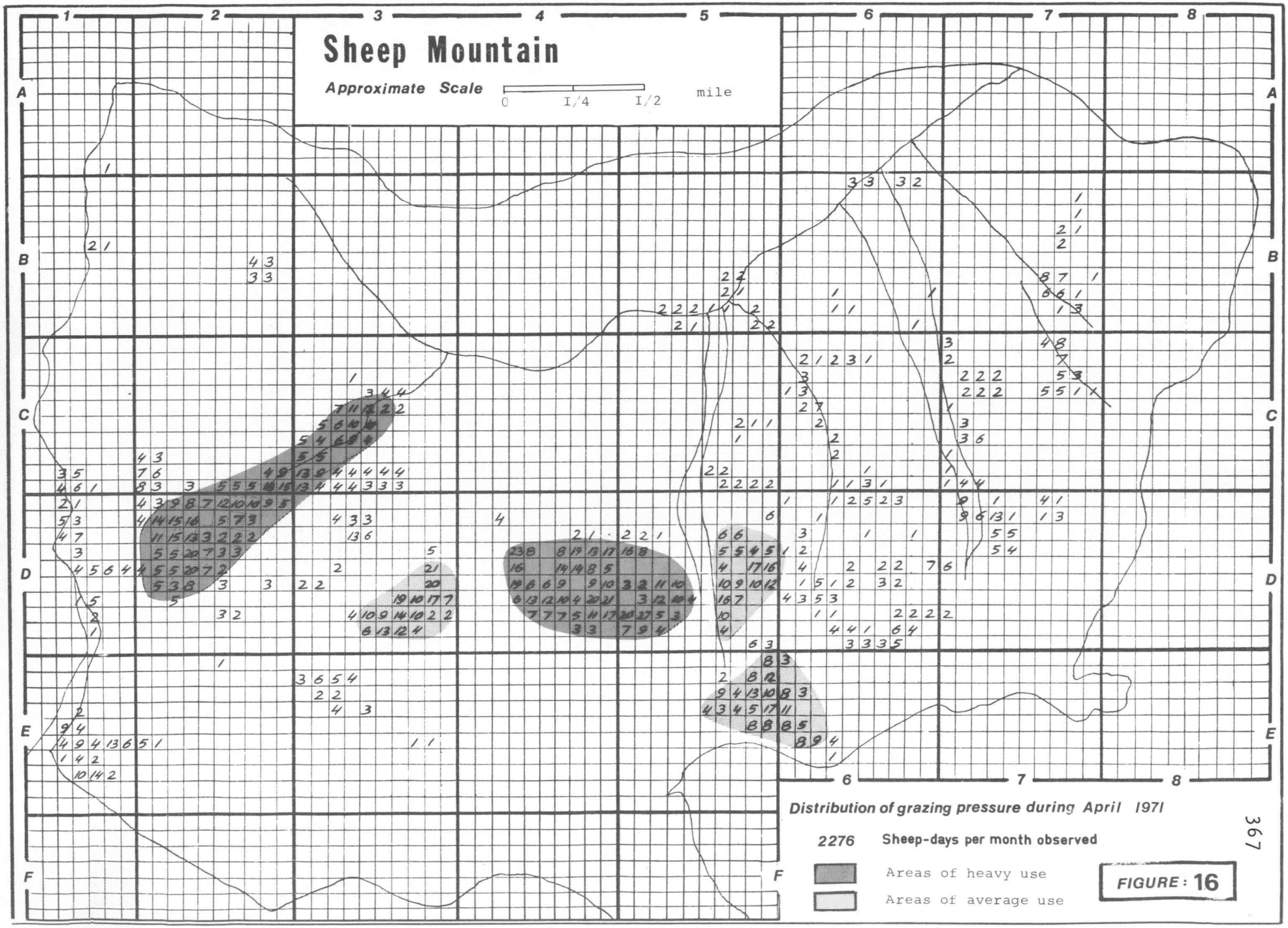
Figure 15: Sheep utilizing mineral lick at base of Sheep Mountain.

Figure 17: Sheep feeding on Calamagrostis purpurascens and Artemisia frigida, two 'stable' forage species of late winter.

67 to 164 (Table 21). Figure 16 shows the distribution of 2276 sheep days. During this month sheep began to spread out over the mountain following the retreating snow.

A total of 24 sections were utilized, with 16 of them providing for 90% of the grazing sites (Table 21). The average grazing intensity per quadrat utilized was 4.7 sheep days per acre per month, the maximum being 23.3 (quadrat: HL.72). These statistics indicate a considerable reduction in grazing pressure on heavily used areas compared to those of previous months of the winter. There was an average uphill movement of both sexes, averaging about 250 feet compared to March. A number of sub-alpine and alpine sites were utilized for the first time this year (Figure 16). The distribution of utilization of the three altitudinal biogeoclimatic zones showed a reduction for the boreal zone compared to data for March (66.5% vs. 82.3%), and an increase for the sub-alpine (20.8% vs. 16.5%), and the alpine (12.7% vs. 1.2%) zones respectively.

While the utilization of different plant associations during the month increased by only 1 to 13, there was a considerable spreading out of intensity of use compared to March. During this month, 6 associations provided 90% of the forage compared to only 3 for the previous months. Associations most heavily utilized during March, Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis and Agropyro (yukonensis) - Artemisietum frigidae - rupestris, showed a considerable reduction in grazing pressure of 11.2% (56.7% vs. 45.5%) and 6.1% (24.6% vs. 18.5%) respectively while the following increases were observed in grazing of sub-alpine and alpine associations: Arctostaphylo (rubrae - uva-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae 3.8% (6.9% vs. 2.7%); Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetum spicati




*Distribution of grazing pressure during April 1971*

2276 Sheep-days per month observed

Areas of heavy use

Areas of average use

**FIGURE: 16**

367

4.7% (4.7% vs. 0.1%); Agropyretum violacei (scree slopes) 2.7% (3.8% vs. 1.1%); and Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae 2.0% (2.0% vs. 0.0%) (Table 20).

Figure 16 shows the 5 areas on which grazing pressure was concentrated during March. It should be pointed out that "concentration" is a relative term and changes from month to month as the actual rates of usage will reveal.

These rates are as follows for the five sites: #1 (2D - 3C): 5.2 sheep days per acre per month, #2 (3D): 6.5; #3 (4 - 5D): 6.5; #7 (5D): 4.9, and #5 (5 - 6E): 4.5 sheep days per acre per month, respectively. A comparison of Figure 16 to Figure 14 for March will reveal that there was a gradual uphill movement of grazing sites.

Forage Use During April:

In April feeding sheep were observed on 12 days, resulting in the documentation of 34,390 interactions. Six rumen samples became available for analyses (Tables 22 and 27).

Sheep were found to utilize 33 species of forage plants, which is a smaller number than in any other month of the year. The five most utilized forage plants contributed together 71.5% of the diet, but among these are now such unpalatable ones as Arctostaphylos uvae-ursi: 10.5% and Juniperus horizontalis: 6.3%. Calamagrostis purpurascens (25.6%) and Artemisia frigida (20.3%) continued to be the most heavily utilized species (Figure 17), while there were further reductions compared to March of use of Carex filifolia (8.8% vs. 11.7%), and Agropyron yukonense 1.8% vs. 4.6%.

Feeding conditions for sheep continued to deteriorate compared to March as far as availablity of preferred forage plants was concerned,

TABLE: 27



Rumen sample analysis for April

| SPECIES | Sample # | 14 | 15 | 16 | 17 | 18 | 19 | Mean |
|---|---|---|---|---|---|---|---|---|
| Carex filifolia | | 2 | 9 | 14 | 5 | 1 | 7 | 6.3 |
| Artemisia frigida | | 14 | 17 | 11 | 26 | 15 | 21 | 17.2 |
| Calamagrostis purpurascens | | 47 | 41 | 23 | 18 | 35 | 30 | 32.3 |
| Agropyron yukonense | | 1 | 3 | | | | | 0.7 |
| Salix glauca | | 1 | | 1 | 1 | 1 | 3 | 1.2 |
| Oxytropis viscida | | 1 | 1 | 2 | 1 | | | 0.8 |
| Arctostaphylos uva-ursi | | 16 | 11 | 8 | 25 | 17 | 3 | 13.3 |
| Picea glauca | | 3 | | | 1 | 2 | | 1.0 |
| Juniperus horizontalis | | 7 | 5 | | 3 | 2 | 2 | 3.2 |
| Juniperus communis | | 3 | | | 1 | 1 | 1 | 0.8 |
| Achillea borealis | | 1 | | | | 1 | | 0.3 |
| Rosa acicularis | | 3 | | | 2 | 2 | | 1.2 |
| Pulsatilla patens | | 1 | | | | | | 0.2 |
| Artemisia rupestris | | | 3 | 4 | 1 | 3 | 5 | 2.7 |
| Plantago canescens | | | 1 | | | | | 0.2 |
| Erigeron caespitosus | | | 1 | | | | 1 | 0.3 |
| Bromus pumpellianus | | | 1 | | | | 1 | 0.3 |
| Pentstemon gormani | | | 1 | | | | | 0.2 |
| Betula glandulosa | | | | 1 | | 1 | | 0.3 |
| Poa glauca | | | | 1 | | | | 0.2 |
| Artemisia hyperborea | | | | 2 | | | | 0.3 |
| Dryas integrifolia | | | | 1 | | | | 0.2 |
| Shepherdia canadensis | | | | | | 1 | 1 | 0.3 |
| Salix reticulata | | | | | | 1 | | 0.2 |
| Galium boreale | | | | | | | 1 | 0.2 |
| Linum perenne | | | | | | | 1 | 0.2 |
| | | | | | | | | 84.1 |
| Grasses (unidentified) | | 0 | 3 | 15 | 11 | 15 | 20 | |
| Forbs (unidentified) | | 0 | 1 | 10 | 5 | 1 | 0 | |
| Browse (unidentified) | | 0 | 2 | 7 | 0 | 1 | 3 | |
| Mosses & Lichens (unidentified) | | 0 | 0 | 0 | 0 | 0 | 0 | |
| | | 100% | 100% | 100% | 100% | 100% | 100% | |
| Grasses (total) | | 50 | 57 | 53 | 34 | 51 | 58 | 50.5 |
| Forbs (total) | | 17 | 25 | 31 | 33 | 21 | 29 | 26.0 |
| Browse (total) | | 33 | 18 | 16 | 33 | 28 | 13 | 23.5 |
| Mosses & Lichens (total) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 100% | 100% | 100% | 100% | 100% | 100% | 100.0% |

however some advantages were provided through the retreating snow line. Sheep made use of this by foraging more in alpine and sub-alpine elevations, as well as by using sites in the boreal zone which had previously been covered by too much snow. Increased use was recorded for the following species, some of which are preferred forages: Artemisia hyperborea: 2.9% vs. 0.7%, Trisetum spicatum: 0.6% vs. 0.0%, Oxytropis viscida: 1.9% vs. 0.3%, Dryas integrifolia: 3.2% vs. 0.2%, Festuca altaica: 0.4% vs. 0.0%, Carex scirpoidea: 1.2% vs. 0.0%, and Poa glauca: 1.9% vs. 0.4%.

The distribution of use of broad forage classes for April was as follows: Grasslike vegetation: 44.2%, forbs: 35.5%, browse: 20.3%, and mosses: 0.0% (Figure 39). These proportions are very similar to those observed in March.

Range Use During May:

This month was characterized by frequent strong west winds on 12 days; with an average monthly wind speed of 13.3 miles per hour, by far the highest for any month. The average temperature was 34.4 F. with a range of only 28 F. (22 F. minimum, 50 F. maximum). This was also the month with the highest precipitation (3.5 cm.); most of it fell as rain. The snow line continued to retreat throughout the month, leaving only an average of 4 cm. and 18 cm. in the plant associations of the boreal and alpine biogeoclimatic zones respectively.

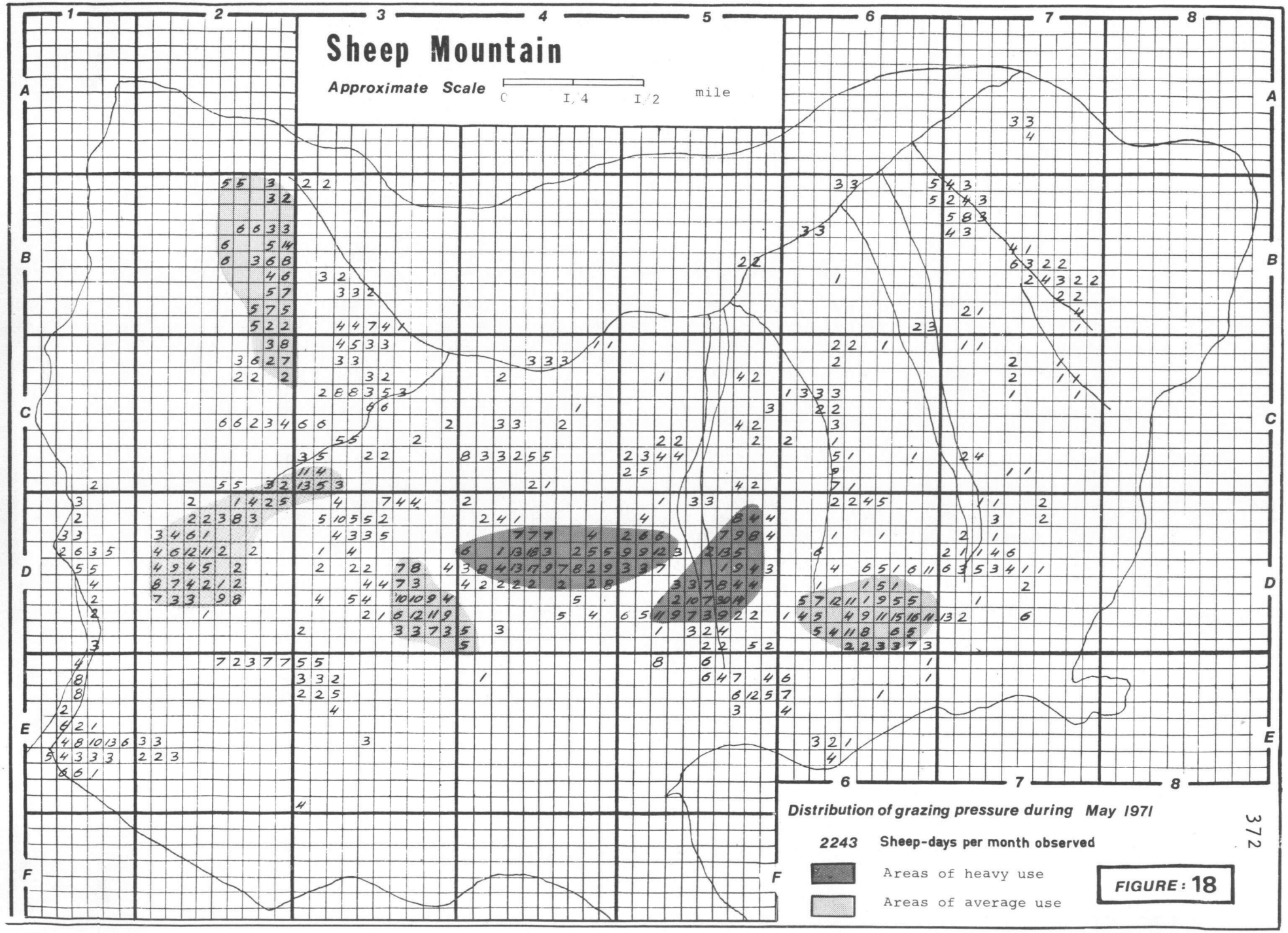
Except for restricting the use of certain plant associations through deep snow cover, climatic factors had no longer any influence on the feeding distribution of sheep, and will therefore not further be mentioned until the following winter. From now on the feeding behaviour of sheep appeared to be primarily influenced by plant phenological phenomena.

By the middle of May many forage plants have resumed vegetative growth, and by the end of the month some of the most advanced species like Carex filifolia and Oxytropis viscida have completed half of their annual growth at altitudes of the boreal zone. During this month up to 14 vascular plants have come into bloom, and during this last week of the month Salix spp. and Populus spp. have expanded young leaves.

The average band size was 4.5 sheep per band (r = 3.1 to 6.0), the lowest for the year. Many ewes isolate themselves from the nursery bands for the purpose of giving birth to new lambs during May. The percentage of mixed bands was reduced to 12.1% (r = 0.0% to 37%), a trend indicative of summer conditions when the sexes are essentially segregated.

This month is transitional in nature in that its first week is a continuation of late winter conditions with essentially no green vegetation available, while during its last week plant phenology has advanced to a degree allowing sheep to feed exclusively on new growth. This rather sudden change in diet is reflected in the droppings of sheep. Those from early May are the solid pellet types characteristic for winter conditions, while those of late May are rather soft and amorphous. At this time many of the sheep show evidence of diarrhea.

The grazing distribution was mapped on 19 days (Figure 18), for




*Distribution of grazing pressure during May 1971*

**2243** Sheep-days per month observed

Areas of heavy use

Areas of average use

**FIGURE: 18**

372

2243 sheep days (Table 21). The average number of sheep on the mountain per day was 117.9, with a range of 63 to 146. At no other time of the year were the sheep more widely dispersed over the area mapped.

A total of 26 sections were utilized, 16 of them providing for 90% of the foraging (Table 21). The average grazing intensity per quadrat utilized was 3.3 sheep days per acre per month, the highest was 22.9 sheep days per acre per month (4D - 67). This is a considerable reduction in intensity of range use compared to winter conditions, and it is comparable to summer grazing pressure (Table 21). There was a general uphill movement, particularly of rams following the retreating snow line, averaging 750 feet in altitude over the distribution during April. This is reflected in the utilization of plant communities of the three altitudinal zones as follows: boreal zone 57.4%, sub-alpine zone 22.8%, and alpine zone 19.8%. In particular the grazing in the alpine elevations increased by 50% over the previous month.

During this month 17 plant associations were utilized - an increase of four over April, eight of them provided 90% of the forage. The most significant changes compared to April were the reduction of utilization of low altitude grassland associations [Pentemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis: 34.5% vs. 45.5%; and Agropyro (yukonensis) - Artemisietum frigidae - rupestris: 8.9% vs. 18.5%], and increases in utilization of sub-alpine and alpine vegetation [Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae: 13.4% vs. 6.9%; and Agropyretum violacei: 6.3% vs. 3.8%]. Increased use was also made of the "forest edge" by feeding on expanding willow and poplar leaves [Roso (acicularis) - Shepherdio (canadensis) - Populetum tremuloidis: 3.1% vs. 0.7%, and Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi: 13.4% vs. 10.0%]. The great increase in utilization of cliff habitat (6.5%

vs. 2.2%) can be explained by the fact that pregnant ewes seek these areas to give birth (Table 20).

Areas which received heavy grazing pressure during May are shown in Figure 18 through shading. The actual rate of usage of these sites were as follows: #1 (2B): 2.7 sheep days per acre per month; #2 (2D): 3.5; #3 (3D): 4.9; #4 (4D): 4.4; #5 (5D): 5.3; and #6 (6D): 4.6 sheep days per acre per month respectively. Comparison to April statistics reveal that there was a further reduction of intensity of range use.

Forage Use During May:

During this month the feeding of sheep was observed for 10 days, which resulted in the recording of 34,255 interactions. Five rumen samples became available for analyses (Tables 22 and 28).

The transitional nature of this month with respect to range use and foraging has already been referred to and is reflected in the great increase in species utilized to 57 from 33 for April. Of these, five contributed together 66.2% of the forage (Carex filifolia: 23.0%, Calamagrostis purpurascens: 17.4%, Agropyron yukonense: 11.2%, Artemisia frigida: 10.7%, and Salix glauca: 3.9%), while 18 species contributed only 0.1% or less each. These summaries, however, are somewhat misleading in that great differences were observed between the beginning of May and the end. Table 28, which divides the rumen sample analyses into early and late May portions, reflects some of the differences observed.

The first week of May is essentially a continuation of late winter conditions as shown for April. At this time species like Calamagrostis purpurascens, Artemisia frigida, Arctostaphylos uva-ursi, and Juniperus horizontalis, are the most important forages. During mid-May a considerable

TABLE: 28



Rumen sample analysis for May

| SPECIES | Sample # | Early May 20 | Early May 24 | Late May 21 | Late May 22 | Late May 23 | Mean |
|---|---|---|---|---|---|---|---|
| Carex filifolia | | 8 | 11 | 12 | 16 | 46 | 18.6 |
| Artemisia frigida | | 29 | 14 | 2 | 8 | 5 | 11.6 |
| Calamagrostis purpurascens | | 26 | 24 | 19 | 27 | 9 | 21.0 |
| Agropyron yukonense | | 2 | 1 | 4 | 7 | 10 | 4.8 |
| Salix glauca | | 1 | 3 | 22 | 5 | 12 | 8.6 |
| Oxytropis viscida | | 1 | 2 | 2 | 4 | 5 | 2.8 |
| Arctostaphylos uva-ursi | | 6 | 9 | | 1 | | 3.2 |
| Juniperus horizontalis | | 4 | 2 | | 1 | | 1.4 |
| Juniperus communis | | 1 | 1 | | | | 0.4 |
| Linnaea borealis | | 2 | | | 2 | | 0.8 |
| Rosa acicularis | | 1 | 1 | | | | 0.4 |
| Artemisia rupestris | | 1 | | | | | 0.2 |
| Bromus pumpellianus | | | 1 | | | | 0.2 |
| Aster alpinus | | | 1 | | | | 0.2 |
| Achillea borealis | | | 1 | | | | 0.2 |
| Shepherdia canadensis | | | 1 | | | | 0.2 |
| Salix polaris | | | | 5 | | | 1.0 |
| Salix reticulata | | | | 6 | | | 1.2 |
| Dryas integrifolia | | | | 2 | | 1 | 0.6 |
| Populus tremuloides | | | | 3 | | 2 | 1.0 |
| Pulsatilla patens | | | | 2 | 4 | 2 | 1.6 |
| Chamaerhodos erecta | | | | 2 | | 1 | 0.6 |
| Tortula ruralis | | | | 1 | | 1 | 0.4 |
| Pentstemon gormani | | | | 1 | | | 0.2 |
| Eurotia lanata | | | | 1 | 2 | | 0.6 |
| Cetraria tilesii | | | | 1 | | | 0.2 |
| Anemone parviflora | | | | | 1 | | 0.2 |
| Astragalus aboriginum | | | | | 1 | | 0.2 |
| Potentilla hookeriana | | | | | 1 | | 0.2 |
| | | | | | | | 83.6 |
| Grasses (unidentified) | | 10 | 12 | 10 | 12 | 6 | |
| Forbs (unidentified) | | 0 | 7 | 1 | 3 | 0 | |
| Browse (unidentified) | | 8 | 8 | 2 | 5 | 0 | |
| Mosses & Lichens (unidentified) | | 0 | 1 | 3 | 0 | 0 | |
| | | 100% | 100% | 100% | 100% | 100% | |
| Grasses (total) | | 46 | 49 | 44 | 62 | 71 | 54.4 |
| Forbs (total) | | 33 | 25 | 26 | 26 | 14 | 24.8 |
| Browse (total) | | 21 | 25 | 25 | 12 | 14 | 19.4 |
| Mosses & Lichens (total) | | 0 | 1 | 5 | 0 | 1 | 1.4 |
| | | 100% | 100% | 100% | 100% | 100% | 100.0% |

amount of new growth emerges and there is a very sudden shift to this green vegetation. At this time Carex filifolia is used more than any other species, followed by a number of less abundant forbs (Oxytropis viscida, Chamaerhodos erecta, Pulsatilla patens, Carex concinna, and Anemone parviflora). By late May the grasses (Agropyron yukonense, Calamagrostis purpurascens and Poa glauca) have emerged and some willows and poplars begin to have expanding leaves. While all these are utilized at this time Agropyron yukonense is used more than any other species. Artemisia frigida, which by this time has also developed considerable green matter is largely avoided.

Considering the month as a whole, there was a drastic reduction of utilization of those species which during the latter part of the winter contributed the bulk of the forage (Artemisia frigida: 10.7% vs. 20.3%, Calamagrostis purpurascens: 17.4% vs. 25.6%, Arctostaphylos uva-ursi: 4.7% vs. 10.5%, Juniperus horizontalis: 2.0% vs. 6.3%, and Artemisia rupestris: 0.2% vs. 4.4%); there was a corresponding increase of use of such species, which had largely been removed by late winter (Carex filifolia: 23.0% vs. 8.8%, Agropyron yukonense: 11.2% vs. 1.8%, and Oxytropis viscida: 2.9% vs. 0.3%). In addition, heavy use was made during the last week of May of new growth of the following species: Salix glauca: 3.9%, Populus tremuloides: 0.9%, Populus balsamifera: 1.0%, Pulsatilla patens: 1.0%, Chamaerhodos erecta: 0.7% as well as a number of less important ones.

The division of May forages into broad classes reveals the following distribution: Grasses and grasslike vegetation: 62.3%, forbs: 22.1%, browse: 14.2%, and lichens and mosses: 1.4% (Figure 39).

The utilization of grasslike vegetation (62.3% of the forage) is higher than at any other month and needs to be further discussed. Carex filifolia, which has been very heavily utilized throughout winter, is the

first species to develop green forage and is a great attraction in mid-May. It was observed that those Carex clumps, which had been clipped down to ground level by winter feeding, were also kept short at this time (Figure 19), while other Carex clumps, which were left untouched during winter, remained untouched at this time. A logical explanation for this observation would be that the craving by sheep for new growth is so great that they try to only utilize sites where the forage intake consists largely of green matter. Figure 20 shows a comparison of two Carex filifolia clumps, one heavily grazed and one not utilized, at the same phenological stage. As is obvious from these photographs, it would be very difficult for sheep to utilize the new growth of the untouched plant, without ingesting an equal amount of dried matter. The same observation was made in the sheeps' utilization of Calamagrostis purpurascens (Figure 21). On the other hand, the emerging shoots of Agropyron yukonense are all available to sheep (Figure 22). This species is not a bunch grass, it also has relatively soft and fragile leaves and stems. Those plants which have not been grazed down by the end of winter are tramped down, or have eroded and disintegrated. There is no protection of new growth by winter carry-over.

Range Use During June:

During this month most snow disappeared except in certain shady, north-facing depressions at alpine elevations, occupied by the associations: Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris and Salico

Figure 19: Ram grazing on Carex filifolia clump.

Figure 22: Sheep feeding on the emerging shoots of Agropyron yukonense.

Figure 20a: Grazed clump of Carex filifolia. Notice that emerging new growth is readily available to sheep.

Figure 20b: Ungrazed clump of Carex filifolia, at the same phenological stage as in Figure 20a. Notice that new growth is "protected" by old vegetative matter.

Figure 21a:

Grazed Calamagrostis purpurascens bunch. Notice emerging green shoots are readily available to sheep.

Figure 21b:

Ungrazed bunch of Calamagrostis purpurascens at the same phenological stage. Notice that 'winter carry-over' protects new growth.

(reticulatae) - Cassiopo (tetragonae) - Dryadetum integrifoliae. Here it took till early July until it was all melted.

During this month growth resumed in all those associations where it had not already begun during May, except for snow patch sites, as pointed out above. At least 30 species of forage plants reached the blooming stage, and advanced species like Carex filifolia, Pulsatilla patens, Anemone parviflora and Carex concinna reached their full annual growth in the latter part of June at low elevations (up to 3300 feet). During the course of the month the willow species of the sub-alpine zone (Salix glauca, S. lanata, S. myrtillifolia) developed leaves.

The band size increased again to an average of 5.7 sheep per band, since the lambing period had virtually ceased by early June. Only 4.7% of the bands observed had mature rams along with female and young.

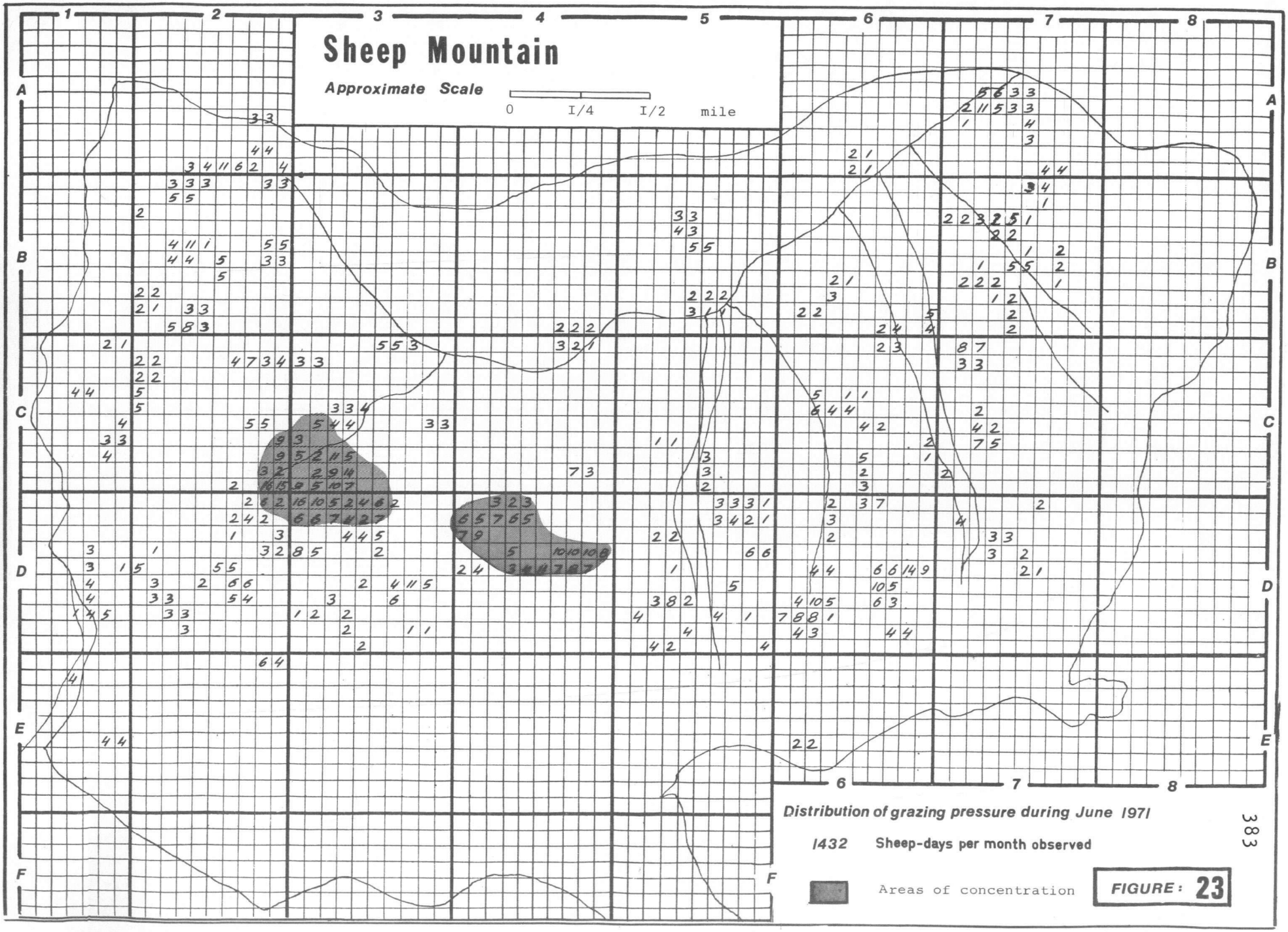
This month is characterized by a very pronounced vertical migration following the phenological advance of vegetation. Many rams which had followed the retreating snow line and used newly exposed forage in the latter half of May descended again in early June to make use of new green forage and subsequently followed the altitudinal march of plant development. During this vertical migration rams were slower than ewes and made extensive use of the willow community in the sub-alpine shrub zone, while nursery bands appeared to be in a hurry to reach alpine elevation. One possible explanation for this difference in feeding behaviour between sexes may be that ewes are now accompanied by young lambs and may want to be in close proximity to escape terrain, which consists largely of cliffs at alpine elevations.

This month is also characterized by sheep departing from the mountain for the summer months. The last rams were observed on June 17/71 and none returned until fall, while the last nursery bands left the area on

June 21/71, but were seen again during the last days of the month in the alpine associations on Sheep Mountain's north slope (Section 4B, 5B). The grazing distribution was mapped on 20 days (Figure 23) for 1432 sheep days. The average number of sheep on the mountain per day was 71.6, with a range from 0 to 124.

In no other month was the use more uniformly distributed over the mountain. A total of 25 sections were utilized, twenty of these providing for 90% of the range use. The average grazing intensity per quadrat utilized was 3.1 sheep days per acre per month (together with July the lowest for the year), the highest intensity was 11.2 sheep days per acre (quadrat 20.99) (Table 21). At no other time of the year was the use of plant association more equally divided between the three altitudinal zones: boreal (32.1%), sub-alpine (51.1%), and alpine (16.8%).

During the month the sheep used 17 plant associations and took 90% of their forage from 8 of them (Table 20). The major differences compared to May were the following: There was a great reduction in use of grasslands in the boreal zone [Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis: 16.8% vs. 34.5%; Agropyro (yukonensis) - Artemisietum frigidae - rupestris: 5.4% vs. 8.9%; and Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi: 7.7 % vs. 13.4%]; and a great increase of use of the sub-alpine willow communities [Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae: 37.0% vs. 13.4%; Arctostaphylo (rubrae) - Cassiope (tetragonae) - Salicetum reticulatae - lanatae - glaucae: 6.1% vs. 1.1%; and Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae: 0.7% vs. 0.1%]. There was some use of most alpine associations, except for those which were set back in vegetative development because of longer duration of snow cover.




*Distribution of grazing pressure during June 1971*

*1432* **Sheep-days per month observed**

Areas of concentration

**FIGURE: 23**

Because of the uniform distribution of range use over the mountain during June, it was difficult to locate "concentration areas". The ones shown on Figure 23 received only slightly greater grazing than many others of equal size. The exact rate for the two areas are: #1 (3C, 3D): 3.0 and #2 (4D): 3.1 sheep days per acre per month respectively. These rates are characteristic for "summer grazing pressure".

Forage Use During June:

During June feeding sheep were observed for 10 days, which resulted in the recording of 30,890 feeding interactions. These direct observations were supplemented through the analyses of three rumen samples (Table 30).

This month was characterized by vertical migration of the population, during which extensive use was made of the sub-alpine shrub zone. Sheep were found to feed upon at least 50 different species, however, only one, Salix glauca, contributed the bulk of the monthly forage with 29.6%. Ten different species contributed 74.4% of the forage, which is indicative of the trend observed throughout the summer months, in that the feeding is spread out more uniformly over more species than during winter, when usually as few as 4 or 5 species contributed three-quarters of the diet. As many as 20 species were utilized as little as 0.1% or less each.

Characteristic for June is the heavy use of browse species particularly by rams migrating upward along the drainage of Sheep Creek, as the following statistics will show: Salix glauca: 29.6%, Populus tremuloides: 5.0%, Salix lanata: 4.8%, Populus balsamifera: 1.4%, Salix myrtillifolia: 1.8% and Salix alaxensis: 0.2% (Figure 24). Late winter "emergency forages" like bearberry and juniper are ignored now (sum 1.0%) and grazing shifted from the boreal to the sub-alpine and alpine zones.

TABLE: 29 Feeding observations during summer and early fall

| SPECIES: | June | July | August | September |
|---|---|---|---|---|
| Salix glauca | 28.3 | 0.3 | 0.5 | 32.0 |
| Salix lanata | 5.4 | <0.1 | 0.3 | 5.3 |
| Populus tremuloides | 4.9 | | | 0.2 |
| Populus balsamifera | 1.9 | | | <0.1 |
| Carex filifolia | 8.2 | 6.0 | 7.2 | 7.7 |
| Artemisia frigida | 3.0 | 0.5 | 1.8 | 3.8 |
| Agropyron yukonense | 1.2 | <0.1 | <0.1 | 0.3 |
| Calamagrostis purpurascens | 6.8 | 3.1 | 3.5 | 2.7 |
| Arctostaphylos uva-ursi | 0.3 | | | |
| Juniperus horizontalis | 0.1 | | | |
| Festuca altaica | 3.6 | 4.7 | 5.2 | 3.3 |
| Carex scirpoidea | 4.2 | 5.0 | 3.8 | 1.7 |
| Dryas integrifolia | 5.5 | 3.2 | 4.3 | 2.4 |
| Arctostaphylos rubra | 3.9 | 1.4 | 6.1 | 1.2 |
| Salix reticulata | 1.8 | 14.1 | 11.5 | 2.7 |
| Anemone parviflora | 0.5 | 0.5 | <0.1 | |
| Artemisia hyperborea | 3.7 | 7.4 | 6.5 | 5.7 |
| Artemisia rupestris | 0.3 | | | |
| Salix myrtillifolia | 2.4 | | 1.5 | 1.2 |
| Salix arctica | 1.5 | 0.3 | <0.1 | <0.1 |
| Oxytropis viscida | 2.8 | 5.1 | 4.3 | 5.0 |
| Trisetum spicatum | 1.8 | 16.8 | 13.8 | 7.1 |
| Dryas drummondii | 1.1 | | | |
| Artemisia alaskana | 0.1 | 2.8 | 1.5 | 1.2 |
| Eurotia lanata | 0.1 | | | 0.3 |
| Oxytropis huddelsonii | 0.8 | 11.7 | 10.4 | 4.7 |
| Linnaea borealis | <0.1 | | | |
| Bromus pumpellianus | 0.3 | | | |
| Poa glauca | 3.0 | 5.0 | 3.2 | 3.7 |
| Agropyron violaceum | 0.2 | 3.7 | 2.6 | 1.2 |
| Epilobium latifolium | 0.1 | 2.2 | 2.1 | 0.5 |
| Pulsatilla patens | 0.4 | <0.1 | | |
| Chamaerhodos erecta | <0.1 | | | |
| Carex concinna | 0.2 | | | |
| Pentstemon gormani | 0.1 | | | |
| Salix alaxensis | 0.2 | | | |
| Betula glandulosa | 0.1 | | | 0.7 |
| Potentilla fruticosa | 0.2 | 0.1 | | 0.1 |
| Kobresia myosuroides | 0.2 | 0.6 | 1.2 | 0.4 |
| Empetrum nigrum | 0.1 | 0.2 | 0.2 | 0.7 |
| Vaccinium uliginosum | 0.3 | 0.3 | 0.1 | 0.4 |
| Vaccinium vitis-idaea | 0.2 | | 0.1 | 0.3 |
| Zygadenus elegans | 0.1 | 0.1 | <0.1 | |
| Artemisia arctica | 0.1 | 0.8 | 1.2 | 1.2 |
| Hedysarum alpinum | <0.1 | 0.2 | 0.3 | 0.6 |
| Salix polaris | <0.1 | 1.4 | 2.8 | 0.2 |
| Mertensia paniculata | <0.1 | 0.2 | 0.5 | |
| Artemisia tilesii | | 0.1 | 0.2 | 0.1 |
| Salix rotundifolia | | 0.4 | 0.2 | 0.2 |
| Saussurea viscida | | 0.1 | 0.1 | |
| Erigeron compositus | | 0.1 | <0.1 | |
| Festuca brachyphylla | | 1.6 | 2.1 | 1.2 |
| Astragalus nutzotinensis | | <0.1 | 0.2 | <0.1 |
| Anemone drummondii | | <0.1 | 0.1 | <0.1 |
| Salix barrattiana | | <0.1 | 0.4 | <0.1 |
| Potentilla hookeriana | | <0.1 | | |
| Claytonia sarmentosa | | <0.1 | | |
| Erigeron humilis | | <0.1 | | |
| Myosotis alpestris | | <0.1 | | |
| Lupinus arcticus | | <0.1 | | <0.1 |
| Polemonium boreale | | | <0.1 | <0.1 |
| Senecio conterminus | | | <0.1 | |
| Arnica lessingii | | | <0.1 | |
| Valeriana capitata | | | <0.1 | |
| Senecio lugens | | | <0.1 | |
| Melandrium apetalum | | | <0.1 | |
| Castilleja hyperborea | | | <0.1 | |
| Aster sibiricus | | | <0.1 | <0.1 |
| Sedum rosea | | | 0.1 | |
| Equisetum variegatum | | | 0.1 | |
| Grasses (total) | 29.7 | 46.5 | 42.6 | 29.3 |
| Forbs (total) | 24.7 | 52.5 | 54.6 | 30.8 |
| Browse (total) | 45.6 | 1.0 | 2.8 | 39.9 |
| Mosses & Lichens (total) | 0 | 0 | 0 | 0 |
| | 100.0% | 100.0% | 100.0% | 100.0% |

TABLE: 30



Rumen sample analysis for June

| SPECIES | Sample # | 25 | 26 | 27 | Mean |
|---|---|---|---|---|---|
| Salix glauca | | 18 | 23 | 62 | 34.3 |
| Carex filifolia | | 24 | 11 | 3 | 12.7 |
| Calamagrostis purpurascens | | 10 | 16 | 2 | 9.3 |
| Populus tremuloides | | 6 | 2 | | 2.7 |
| Artemisia frigida | | 5 | 7 | 1 | 4.3 |
| Bromus pumpellianus | | 6 | | 1 | 2.3 |
| Oxytropis viscida | | 3 | 3 | | 2.0 |
| Dryas integrifolia | | 2 | 7 | 1 | 3.3 |
| Picea glauca | | 1 | | 1 | 0.7 |
| Juniperus horizontalis | | 1 | | | 0.3 |
| Arctostaphylos uva-ursi | | 1 | | | 0.3 |
| Linnaea borealis | | 1 | | | 0.3 |
| Pulsatilla patens | | 2 | 1 | | 1.0 |
| Pentstemon gormani | | 1 | | | 0.3 |
| Potentilla hookeriana | | 1 | 2 | | 1.0 |
| Salix reticulata | | | 1 | 1 | 0.7 |
| Festuca altaica | | | 2 | 3 | 1.7 |
| Artemisia hyperborea | | | 8 | | 2.7 |
| Pedicularis kanei | | | 1 | | 0.3 |
| Salix arctica | | | 1 | | 0.3 |
| Anemone parviflora | | | 1 | | 0.3 |
| Carex scirpoidea | | | 1 | 3 | 1.3 |
| Artemisia alaskana | | | | 1 | 0.3 |
| Salix lanata | | | | 1 | 0.3 |
| Cetraria tilesii | | | | 1 | 0.3 |
| Arctostaphylos rubra | | | | 1 | 0.3 |
| Trisetum spicatum | | | | 1 | 0.3 |
| Poa glauca | | | | 1 | 0.3 |
| Oxytropis huddelsonii | | | | 1 | 0.3 |
| Epilobium latifolium | | | | 1 | 0.3 |
| | | | | | 84.8 |
| Grasses (unidentified) | | 5 | 2 | 4 | |
| Forbs (unidentified) | | 3 | 11 | 4 | |
| Browse (unidentified) | | 10 | 0 | 6 | |
| Mosses & Lichens (unidentified) | | 0 | 0 | 0 | |
| | | 100% | 100% | 100% | |
| Grasses (total) | | 45 | 32 | 18 | 31.7 |
| Forbs (total) | | 18 | 43 | 12 | 24.3 |
| Browse (total) | | 37 | 25 | 69 | 43.7 |
| Mosses & Lichens (total) | | 0 | 0 | 1 | 0.3 |
| | | 100% | 100% | 100% | 100.0% |

This resulted in a decreased use of such species as Carex filifolia: 9.2% vs. 23.0%, Artemisia frigida: 3.3% vs. 10.7%, Calamagrostis purpurascens: 7.3% vs. 17.4% and Agropyron yukonense: 0.9% vs. 11.2%, and an increase of grazing on Artemisia hyperborea: 3.5% vs. 1.2%, Oxytropis huddelsonii: 0.7% vs. 0.0%, Carex scirpoidea: 3.5% vs. 0.6%, and Poa glauca: 2.5% vs. 1.0%.

The categories of forage species taken during June are: Grasses and grasslike vegetation: 30.4%, Forbs: 24.9%, browse: 44.6%, and mosses and lichens: 0.1%. The great increase in utilization of browse (only 14.2% in May), has already been referred to and resulted in a corresponding decrease in use of grasslike vegetation (62.3% in May). At no other month of the year is such a high percentage of the forage contributed by browse species (Figures 24, 39).

Range Use During July:

Early in July the last snow had melted away - in an average year - and growth had resumed in all alpine plant associations. In a phenological sense July in the alpine zone is somewhat comparable to June in the boreal zone, since most alpine flowering plants come into bloom at this time, while at altitudes of the boreal zone the climax of flowering has already passed and the last grass and composite species begin to flower. During July "advanced" species like Carex filifolia and Oxytropis viscida reach the maximum of their annual growth at alpine elevations, while most other alpine plants do not reach this stage until early August.

Figure 24: Heavy utilization of browse species during June: a) Salix glauca, b) Populus tremuloides.

Figure 24c: Populus balsamifera saplings.

Sheep were observed on 21 days and 515 sheep days were mapped. The average number of sheep on the mountain was 24.7, the range being 0 to 75. During 7 of the 21 observation days sheep did not use the area as summer range.

During the summer months there is a strict separation of sexes with rams and nursery bands each having their own distinct summer ranges with only occasional overlapping. The north slope of Sheep Mountain (Sections 3B, 4B, 5B, 6A) is part of the ewes' summer range and no ram was observed here during July and August. As already pointed out, the entire summer range of this population is a fairly large area extending northward to Congdon Creek and Sheep Mountain's north slope is only a fraction of it, but it is a much-used fraction and it is representative as far as plant associations go. Therefore statistics such as intensity of use may not be relevant to the summer range as a whole; on the other hand, our observations indicate that the proportional use of various plant associations as well as forage selection were comparable between sheep that used Sheep Mountain during summer and those that ranged further away.

Even though sheep are more widely dispersed in summer than in winter, individual band sizes were larger. In nursery bands the average size for July was 20.0 animals (r = 4 to 96); on the other hand, the band size for rams was 8.0 (r = 1 to 12), which was very similar to winter conditions.

During July the nursery bands reached the highest altitude for the year ($\bar{x}$ = 6012') and 97.7% of the areas used were alpine associations.

Of the mapped area 10 sections were used, and 5 provided 90% of the feeding sites. The average intensity of range use of utilized areas was 3.1 sheep days per acre per month, the highest observed was 11.3 in quadrats (5B.57 and 5B.85). During the month 17 plant associations were used, 8 of

them provided 90% of the feeding sites (Table 21).

The most obvious difference between June and July was a complete shift from the sub-alpine and boreal zones in June to that of the alpine zone (97.7%) during July.

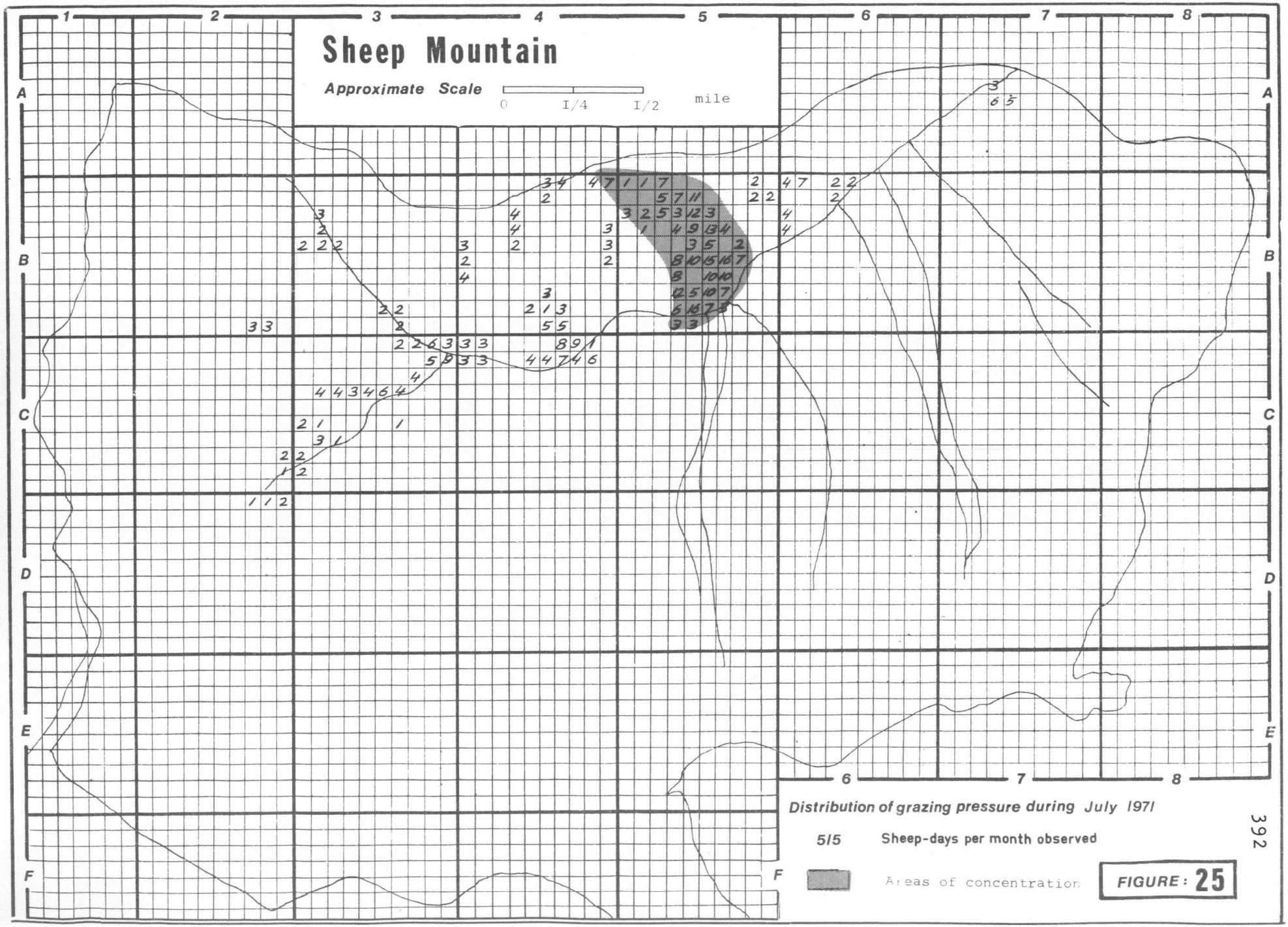
All alpine associations were used with the emphasis on those occupying dry or mesic sites. The dominant associations were Salico (reticulatae) Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae providing 44.1% of the feeding areas, while vegetation occupying exposed dry ridges [Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati and Oxytropo (huddelsonii) - Salicetum dodgeanae] provided 20.3% and 10.3%, respectively of the forage. Fairly heavy use was also made of the scree slope association Agropyretum violacei with 7.9%.

Only one area of concentration (5B) is indicated in Figure 25. Its rate of use was 3.6 sheep days per acre per month. This is high for summer grazing and it was observed on only very few areas of the total summer range.

Forage Use During July:

Feeding was observed on 8 days yielding 7,540 feeding interactions. During July sheep are dispersed over a very large area, are much more difficult to approach closely, and the alpine plant associations are more complex in species diversity, making the documentation of utilization of individual species more difficult. Four rumen samples were available (Table 31).

In July sheep used 53 species, ten of these provided 75.5% of the forage, and 19 species 0.1% or less each (Table 22). In this month both species availability and diversity of use were at their greatest. Variation


Sheep Mountain
Approximate Scale
0 I/4 I/2 mile
1 2 3 4 5 6 7 8
A B C D E F
Distribution of grazing pressure during July 1971
5/5 Sheep-days per month observed
Areas of concentration
FIGURE: 25

Rumen sample analysis for July



| SPECIES | Sample # 28 | 29 | 30 | 31 | Mean |
|---|---|---|---|---|---|
| Oxytropis huddelsonii | 31 | 13 | 11 | 6 | 15.3 |
| Agropyron violaceum | 12 | 7 | 10 | 12 | 10.3 |
| Trisetum spicatum | 6 | 26 | 22 | 18 | 18.0 |
| Poa glauca | 4 | | | 4 | 2.0 |
| Carex scirpoidea | 4 | 5 | 7 | 5 | 5.3 |
| Carex filifolia | 1 | 2 | 1 | | 1.0 |
| Dryas integrifolia | 3 | 4 | 3 | 1 | 2.8 |
| Salix reticulata | 6 | 11 | 7 | 20 | 11.0 |
| Salix rotundifolia | 1 | 1 | | 1 | 0.8 |
| Salix polaris | 2 | 4 | 3 | 7 | 4.0 |
| Salix glauca | 1 | 2 | 1 | | 1.0 |
| Equisetum scirpoides | 3 | 2 | | 1 | 1.5 |
| Artemisia hyperborea | 4 | 2 | 7 | 1 | 3.5 |
| Festuca altaica | 2 | | | 2 | 1.0 |
| Saussurea viscida | 1 | 1 | | 1 | 0.8 |
| Erigeron compositus | 1 | 1 | 1 | 1 | 1.0 |
| Senecio lugens | | 1 | | | 0.3 |
| Equisetum variegatum | | 1 | | | 0.3 |
| Arnica alpina | | 1 | | | 0.3 |
| Oxyria digyna | | 1 | | | 0.3 |
| Artemisia arctica | | 2 | | 1 | 0.8 |
| Parnassia kotzebuei | | 1 | 1 | | 0.5 |
| Cetraria tilesii | | 1 | 1 | 2 | 1.0 |
| Festuca brachyphylla | | | 2 | 1 | 0.8 |
| Poa alpina | | | 1 | | 0.3 |
| Mertensia paniculata | | | 1 | 1 | 0.5 |
| Kobresia myosuroides | | | 1 | 1 | 0.5 |
| Arctostaphylos rubra | | | 1 | 1 | 0.5 |
| Anemone parviflora | | | | 1 | 0.3 |
| Epilobium latifolium | | | | 1 | 0.3 |
| Empetrum nigrum | | | | 1 | 0.3 |
| Vaccinium uliginosum | | | | 1 | 0.3 |
| Artemisia tilesii | | | | 1 | 0.3 |
| Astragalus nutzotinensis | | | | 1 | 0.3 |
| Polemonium boreale | | | | 1 | 0.3 |
| | | | | | 87.5 |
| Grasses (unifentified) | 8 | 4 | 5 | 2 | |
| Forbs (unidentified) | 8 | 6 | 12 | 3 | |
| Browse (unidentified) | 0 | 0 | 1 | 0 | |
| Mosses & Lichens (unidentified) | 2 | 1 | 1 | 1 | |
| | 100% | 100% | 100% | 100% | |
| Grasses (total) | 37 | 44 | 49 | 45 | 43.8 |
| Forbs (total) | 60 | 52 | 48 | 52 | 53.0 |
| Browse (total) | 1 | 2 | 1 | 0 | 1.0 |
| Mosses & Lichens (total) | 2 | 2 | 2 | 3 | 2.2 |
| | 100% | 100% | 100% | 100% | 100.0% |

in feed selection was also higher than in any other month. This variation was not restricted to the selection of preferred plants at the end of feeding periods - but was also found in the utilization of "stable" forages (dominant or fairly abundant species) (Table 31). All 4 sheep were taken in the same area, yet each one had eaten a different combination of stable forage as well as selected items. Four different species (Oxytropis huddelsonii, Agropyron violaceum, Trisetum spicatum and Salix reticulata) appeared as the most important forage plants. Two of the most widely distributed alpine plants (Dryas integrifolia and Salix polaris) are little used by sheep (3.1% and 2.3%, respectively). This is in contrast to winter conditions when the dominant species (Artemisia frigida, Calamagrostis purpurascens, Carex filifolia) are also the most important forage items.

During July, particularly during the first half of the month, most feeding took place along dry ridges occupied by alpine grasslands, on scree slopes, and on adjacent mesic sites occupied by various communities dominated by Dryas integrifolia (Figures 26, 27). There was therefore a fairly heavy utilization of such species as: Trisetum spicatum: 17.1%, Oxytropis huddelsonii: 12.8%, Poa glauca: 4.0%, Artemisia hyperborea: 6.1% and Oxytropis viscida: 3.4% of alpine grasslands; Agropyron violaceum: 5.8% and Artemisia alaskana: 1.9% of scree slopes, and Salix reticulata: 12.9% and Dryas integrifolia: 3.1% of adjacent mesic sites.

Broad forage classes for July were: Grasses and grasslike vegetation: 45.6%, forbs: 52.7%, browse: 1.0%, and lichens: 0.7%. In contrast to June (Browse: 44.6%) the utilization of browse species had virtually ceased, since sheep were most of the time at alpine elevations well over 5000' elevation which is the approximate altitudinal limit of tall shrubs.

Figure 26: Not only sheep but also goats in Bullion Creek drainage make heavy use of dry alpine grasslands in early summer.

Figure 27: Sheep utilizing Dryas and Salix barrattiana sites in early July. Notice the large band size characteristic for the summer months.

Range Use During August:

During this month there were two heavy snow falls, but the snow disappeared again within two days.

At alpine elevations the vegetation growth reach the annual maximum and many species began to dry up in the latter part of the month. No signs of a colour change of leaves was yet observed in the willows of the sub-alpine zone, but a number of dry grassland species of the sub-alpine and boreal zone were drying up. Since the temperatures throughout this month were still favourable for continued growth, the onset of dormancy of such species as Carex filifolia, Agropyron yukonensis, Calamgrostis purpurascens, and Poa glauca, can perhaps be explained on the basis of moisture deficiency.

Sheep were observed on 20 days and the grazing distribution for 709 sheep days was mapped (Table 21). The average number of sheep on the mountain was 35.4 animals, the range was 0 to 80. There was still a complete separation of sexes and the band size continued to be high, its average being 18.2 sheep per band, the range 2 to 63 (Figure 28).

The average altitude of nursery bands (5924') was similar to that of July (6012'), alpine plant associations were used by sheep 93.4%, sub-alpine ones in 6.6% of the feeding. No use was made of boreal vegetation.

More use was made of Sheep Mountain during this month than in July. Grazing was observed in 12 sections, 6 of them provided 90% of the feeding sites (Table 21).

There was a slight increase in grazing intensity to 3.4 sheep days per acre per month, with a maximum observed of 11.6 sheep days per acre per month. The latter part of August marked the beginning of the migration back to winter ranges of nursery bands.

Fourteen plant associations were used, 7 of these provided 90% of the forage. The dominant alpine association of mesic sites [Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae] continued to be the most heavily used one (52.3%). However, there was a marked change in the use of the associations which provided the remainder of the feeding sites. Exposed, dry ridge tops, heavily used during July, received less grazing pressure during August [Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati: 13.7% vs. 20.3%, and Oxytropo (huddelsonii) - Salicetum dodgeanae: 6.2% vs. 10.3%]; on the other hand, associations occupying moist sites with deep snow cover during winter, were preferred at this time, e.g.: Saxifrago (oppositifoliae) - Oxyrio (digynae) - Salicetum polaris: 4.4% vs. 2.1%, and Artemisio (arcticae) - Salico (reticulatae) - Festucetum altaicae: 4.4% vs. 2.3%. These associations were at a phenological "younger" state, since deep snow and water-saturated soils during run-off set them back during early summer. When ewes first returned to Sheep Mountain's south slopes in late August, fairly heavy use was also made of the sub-alpine scree slope communities Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae: 1%, and Artemisietum alaskanae: 0.7% in Section 4C.

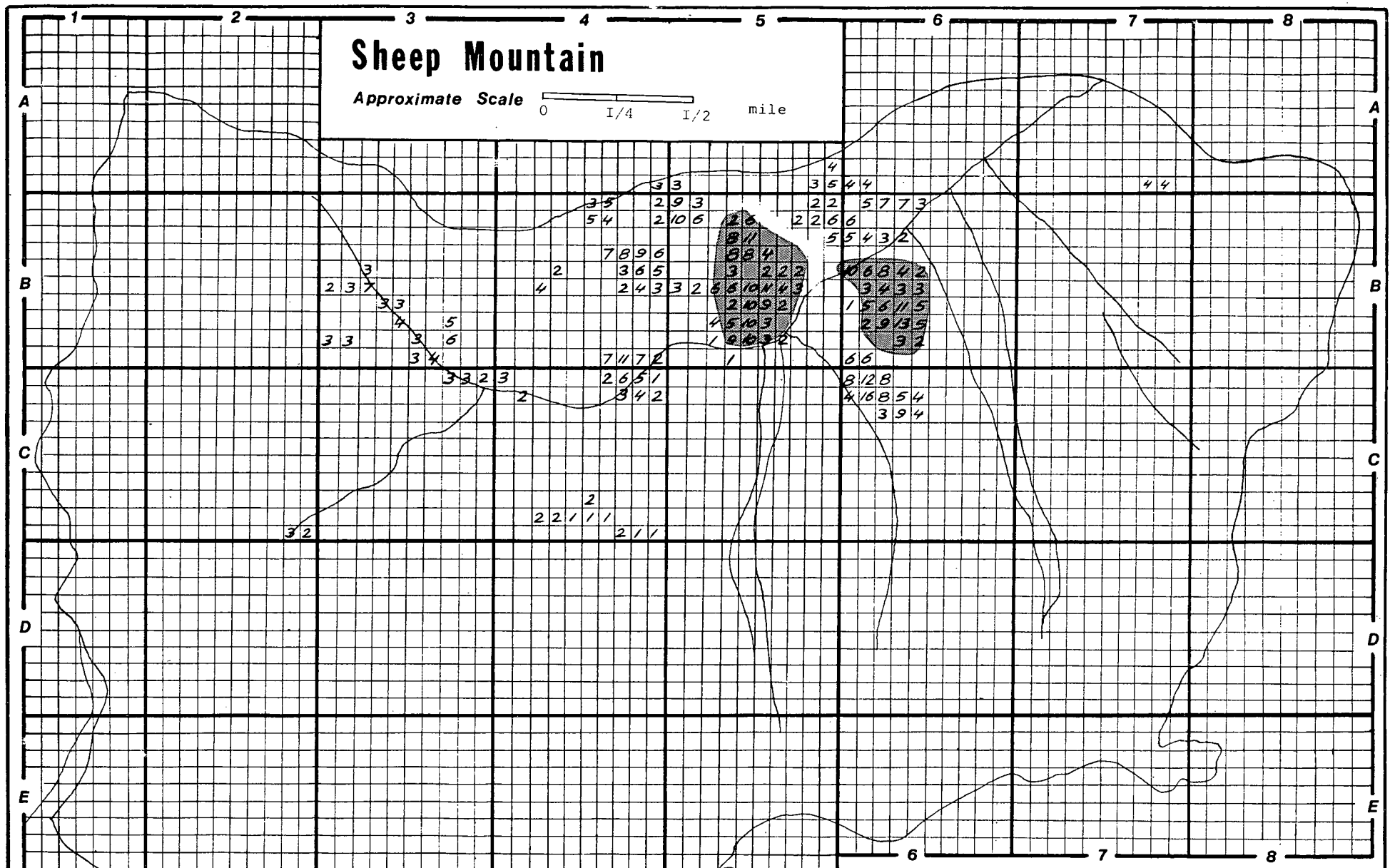
Figure 30 shows two areas in which there was a concentration of grazing during August. Site #1 (5B) was used at a rate of 3.5 sheep days per acre per month, while Site #2 (6B) was grazed at a rate of 3.3 sheep days per acre.

Forage Use During August:

Sheep were observed on 8 days, resulting in the recording of 8,670 feeding interactions. Two rumen samples were available (Tables 22, 32).

Figure 28: Nursery band utilizing moist, shady, north-facing slope in early August (Salix polaris stands). Notice the large band size characteristic for the summer months.

Figure 29: By late August and early September much of the alpine vegetation has dried up.




*Distribution of grazing pressure during August 1971*

709 Sheep-days per month observed

Areas of concentration

**FIGURE: 30**

TABLE: 32

Rumen sample analysis for August

| SPECIES | Sample # | #32 | #33 | Mean |
|---|---|---|---|---|
| Oxytropis huddelsonii | | 16 | 11 | 13.5 |
| Salix reticulata | | 13 | 11 | 12.0 |
| Dryas integrifolia | | 8 | 2 | 5.0 |
| Cetraria tilesii | | 7 | 14 | 10.5 |
| Salix polaris | | 5 | 3 | 4.0 |
| Carex scirpoidea | | 6 | 1 | 3.5 |
| Artemisia hyperborea | | 5 | 2 | 3.5 |
| Trisetum spicatum | | 6 | 5 | 5.5 |
| Artemisia artica | | 3 | | 1.5 |
| Oxytropis viscida | | 2 | | 1.0 |
| Dactylina arctica | | 2 | | 1.0 |
| Cetraria nivalis | | 2 | 5 | 3.5 |
| Cladonia pocillum | | 2 | | 1.0 |
| Salix rotundifolia | | 1 | | 0.5 |
| Anemone parviflora | | 1 | | 0.5 |
| Erigeron purpuratus | | 1 | | 0.5 |
| Carex membranacea | | 1 | | 0.5 |
| Erigeron compositus | | 1 | | 0.5 |
| Antennaria monocephala | | 1 | | 0.5 |
| Gentiana propinqua | | 1 | | 0.5 |
| Carex filifolia | | 1 | 2 | 1.5 |
| Castilleja hyperborea | | 1 | | 0.5 |
| Cetraria richardsonii | | 1 | 3 | 2.0 |
| Festuca brachyphylla | | 1 | 2 | 1.5 |
| Salix glauca | | 1 | 2 | 1.5 |
| Parnassia kotzebuei | | | 1 | 0.5 |
| Poa alpina | | | 3 | 1.5 |
| Poa glauca | | | 3 | 1.5 |
| Thamnolia subuliformis | | | 1 | 0.5 |
| Festuca altaica | | | 5 | 2.5 |
| Potentilla hookeriana | | | 1 | 0.5 |
| Epilobium latifolium | | | 1 | 0.5 |
| Equisetum scirpoides | | | 1 | 0.5 |
| Equisetum variegatum | | | 1 | 0.5 |
| Hedysarum alpinum | | | 1 | 0.5 |
| Artemisia tilesii | | | 1 | 0.5 |
| | | | | 86.5 |
| Grasses (unidentified) | | 1 | 5 | |
| Forbs (unidentified) | | 5 | 10 | |
| Browse (unidentified) | | 0 | 0 | |
| Mosses & Lichens (unidentified) | | 5 | 3 | |
| | | 100% | 100% | |
| Grasses (total) | | 16 | 26 | 21.0 |
| Forbs (total | | 64 | 46 | 55.0 |
| Browse (total) | | 1 | 2 | 1.5 |
| Mosses & Lichens (total) | | 19 | 26 | 22.5 |
| | | 100% | 100% | 100.0% |

At least 63 species were used, the highest number for any month. The use of 13 different species contributed 76.5% of the diet, and as many as 22 species were utilized to a degree of 0.1% or less (Table 22). Plant selection by different animals differed greatly (Table 32). The rumen samples were from two rams, members of the same band, which were observed to feed almost side by side for nearly two hours before they were shot. Their plant selection was remarkably different.

The large number of feed species (63) arises in part from grazing in early part of August on sites with northern and eastern aspects (Figure 28), little used in July, because the vegetation was still in early growth; in addition, toward the end of August some nursery sheep began their vertical descent onto sub-alpine areas (Figure 29).

This shift of emphasis in feeding sites is reflected in the contribution of various forage plants to the total diet. The following "dry land" species showed a reduction of use: Trisetum spicatum: 12.1% vs. 17.1%, Oxytropis huddelsonii: 11.0% vs. 12.8%, Carex scirpoidea: 3.7% vs. 5.1%, Poa glauca: 2.9% vs. 4.0%, and Agropyron violaceum: 0.9% vs. 2.1%. On the other hand, the following species which grow in moister sites, showed an increase in utilization: Festuca altaica: 4.7% vs. 2.7%, Dryas integrifolia: 4.5% vs. 3.1%, Arctostaphylos rubra: 4.8% vs. 1.1%, Salix polaris: 3.0% vs. 2.3%, and Artemisia arctica: 1.3% vs. 0.8%.

Interesting is the high rate of utilization of lichens (Cetraria tilesii, C. ruralis, C. richardsonii, total : 2.3%) during August. However, since it is primarily based on only two rumen samples, it is inconclusive, because of the great variations in feeding behaviour observed at this time.

The distribution of forages for August into broad categories was as follows: Grasses and grasslike vegetation: 38.3%, forbs: 54.7%,

browse: 2.5% and lichens: 4.5%. These proportions are very similar to those found for July, except for the increase in lichen use already referred to.

Range Use During September:

This month is a transition period; into it is concentrated the entire season of autumn. During the first week of this month essentially summer conditions prevailed; the trees and shrubs had green leaves and only a few grass and sedge species had dried up. In the course of the month the leaves of willows, poplars and birches turned colour and by the end of the month about 50% of them had dropped. By that time the temperatures at night dropped below the freezing point and there was a continuous snow cover at alpine elevations. At this time only very few species (Artemisia frigida, Artemisia rupestris, Artemisia dracunculus, Oxytropis viscida, and Oxytropis huddelsonii among others) were still green.

Sheep were observed on 19 days and the grazing distribution was mapped for 2119 sheep days. The average number of sheep on the mountain was 111.5, the range was 21 to 142. There was still a complete segregation of sexes, and no mature rams had returned to the mountain by the end of the month. Band size continued to be fairly high with 9.4 sheep per nursery band (r = 7.0 to 12.6). These band sizes were computed for days when the bands were separated and spread over the mountain. For reasons as yet unexplained, large "social gatherings" took place during this month when

practically all sheep on the mountains met at the centre of the large south-east facing slope (Section 4.D) (Figure 31).

A total of 16 sections were used during September, nine of them provided 90% of the feeding sites (Table 21). The average grazing intensity for those quadrats that were used was 5.0 sheep days per acre per month, the highest intensity was observed in quadrat 4D.44 with 22.2 sheep days.

During September there was a very pronounced vertical descent of nursery bands averaging 1500 feet, with a shift of emphasis from feeding on alpine associations during August to one of heavy utilization of the sub-alpine vegetation during September. During this month the distribution of feeding over the three altitudinal zones was as follows: alpine zone 15.4%, sub-alpine zone 49.9%, and boreal zone 34.7%. At no other month of the year was the sub-alpine zone as heavily used.

Sheep used 18 plant associations during September, seven of which provided 90% of the forage (Table 20). There was abrupt reduction in the use of alpine vegetation and a corresponding increase in grazing of boreal and sub-alpine grasslands, and particularly of browsing on sub-alpine shrubs. The willow communities Arctostaphylo (rubrae - uvae-ursi) - Festuco (altaicae) - Salicetum reticulatae - glaucae (31.1%), and Artemisio (hyperboreae - alaskanae) - Salicetum myrtillifoliae (1.7%) provided 32.8% of the feeding for the month as a whole, and well over 70.0% during the first two weeks of September.

During this vertical descent in September the nursery bands behaved differently than the rams, in that they came down into the sub-alpine zone and used it heavily when the vegetation was still green and most likely more nutritious than dried up vegetation at higher altitudes. Some ewes and all mature rams stayed in the alpine zone for another 4 to 6 weeks, in spite of

Figure 31: Large "social gathering" of nursery bands, characteristic for September.

the virtual absence of green forage there. When they finally returned to lower elevations during October, most of the vegetation was also dried up here.

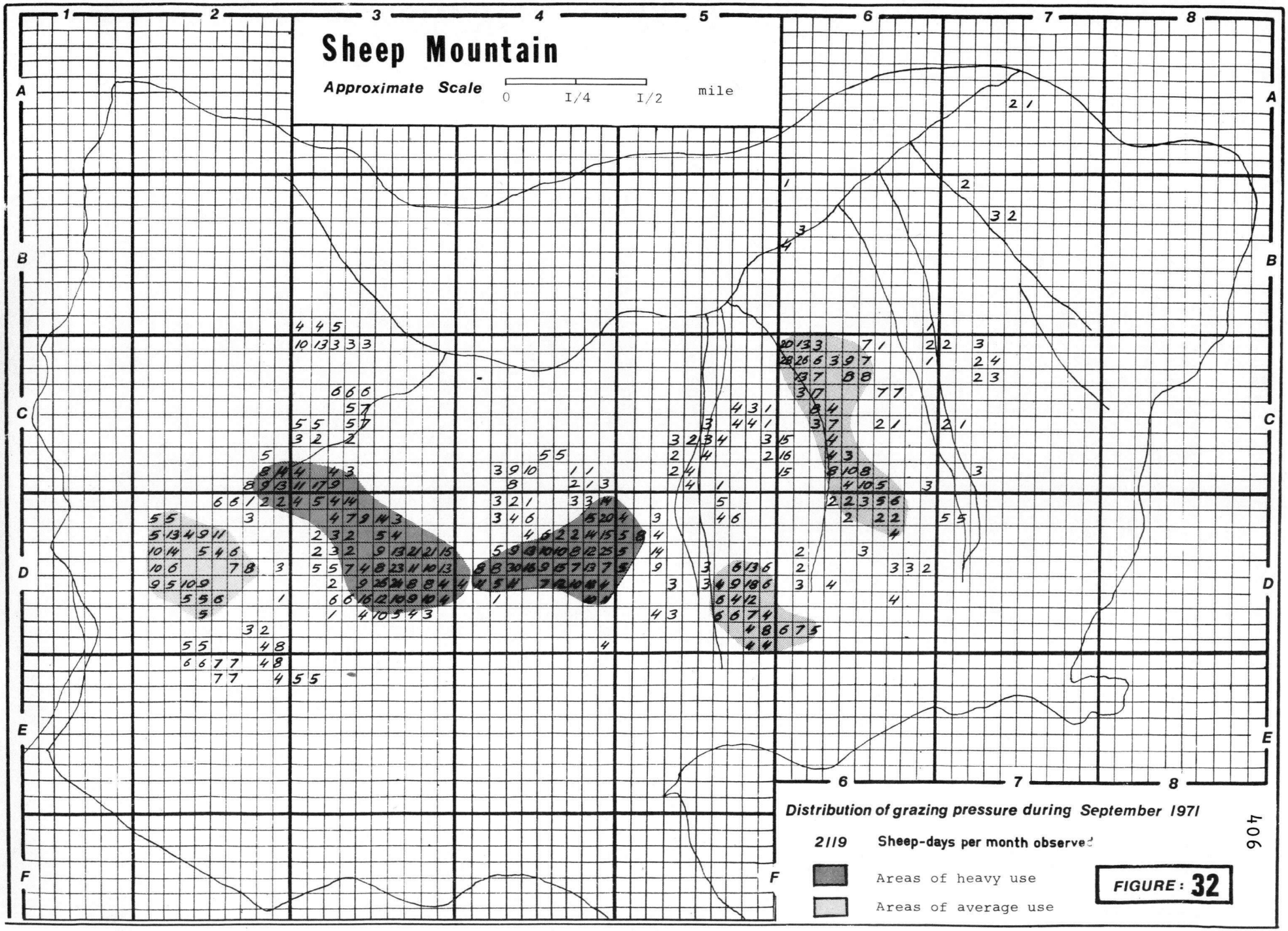
The use of the sub-alpine shrub zone was very different for the two sexes, and is the reverse of the upward movement of the spring, when these willow communities were primarily utilized by rams.

Figure 32 shows the area on which grazing was concentrated during September. The utilization rates of the 5 sites were as follows: #1 (2D): 4.2 sheep days per acre; #2 (3D): 6.0; #3 (4D): 7.3; #4 (5D): 4.2, and #5 (6C): 4.1 sheep days per acre per month respectively. Some of these areas are essentially the same major winter concentration areas (Figures 12, 13, and 14).

Forage Use During September:

Sheep were observed on 10 days and 9100 feeding interactions were recorded. Five rumen samples were available (Table 33).

Fifty-four different plant species were used, eleven made up 75.6% of the monthly forage. Twenty-one species contributed only 0.1% or less each. This month was similar to June in that heavy use was made of sub-alpine shrub species: Salix glauca: 28.4%, Salix lanata: 2.9%, Salix myrtillifolia: 0.8% and Betula glandulosa: 0.7%. In rumen sample #36, Salix glauca leaves made up 45% frequency. Figures 33 and 34 show the utilization of willows, which continued through the first two weeks of September. After this most leaves were yellow and many had dropped and extensive use was made again of herbaceous vegetation. This shift in emphasis of feeding from the alpine zone to the sub-alpine one by nursery bands resulted in a reduction of use of the following important alpine forages: Trisetum spicatum: 7.8% vs. 12.1%, Oxytropis huddelsonii: 4.9% vs. 11.0%, Salix reticulata: 2.9% vs. 11.6%, and Salix


Sheep Mountain
Approximate Scale
0 I/4 I/2 mile
1 2 3 4 5 6 7 8
A B C D E F
Distribution of grazing pressure during September 1971
2/19 Sheep-days per month observed
Areas of heavy use
Areas of average use
FIGURE: 32
604

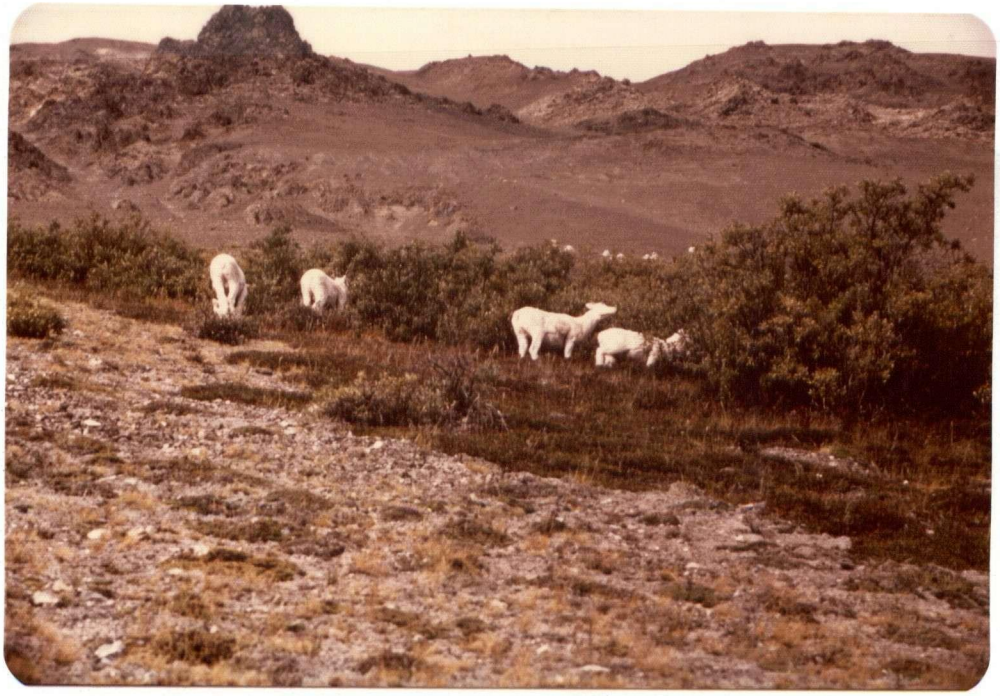


Figure 33: Sheep feeding on Salix glauca in early September.

Figure 34: Sheep feeding on Salix myrtillifolia in early September.

TABLE: 33

Rumen Sample Analysis for September



| SPECIES | Sample # 34 | 35 | 36 | 37 | 38 | Mean |
|---|---|---|---|---|---|---|
| Salix glauca | 14 | 9 | 45 | 18 | 15 | 20.2 |
| Festuca altaica | 15 | 4 | 2 | | | 4.2 |
| Oxytropis huddelsonii | 6 | 13 | | 5 | 2 | 5.2 |
| Trisetum spicatum | 12 | 17 | | 2 | 12 | 8.6 |
| Dryas integrifolia | 9 | 3 | 5 | 6 | 2 | 5.0 |
| Artemisia hyperborea | 7 | 12 | | 5 | 3 | 5.4 |
| Calamagrostis purpurascens | 4 | 2 | 3 | 3 | 2 | 2.8 |
| Oxytropis viscida | 2 | | | | 2 | 0.8 |
| Carex filifolia | 2 | 5 | 8 | 8 | 10 | 6.6 |
| Artemisia alaskana | 2 | | | 4 | 1 | 1.4 |
| Cetraria tilesii | 2 | 1 | | | | 0.6 |
| Salix polaris | 1 | 3 | | 3 | | 1.4 |
| Cetraria richardsonii | 1 | 1 | | | | 0.4 |
| Carex scirpoidea | 1 | 1 | 12 | 1 | 2 | 3.4 |
| Artemisia arctica | 1 | | | | | 0.2 |
| Castilleja hyperborea | 1 | | | 1 | | 0.4 |
| Salix reticulata | 2 | 2 | 4 | 5 | | 2.6 |
| Equisetum scirpoides | 1 | | | 2 | 1 | 0.8 |
| Potentilla hookeriana | 1 | 1 | | | | 0.4 |
| Erigeron caespitosus | 1 | | | | | 0.2 |
| Poa glauca | | 3 | | | | 0.6 |
| Polemonium boreale | | 1 | | | | 0.2 |
| Salix lanata | | | 5 | 1 | 3 | 1.8 |
| Artemisia frigida | | | 4 | 22 | 16 | 8.4 |
| Anemone parviflora | | | 1 | | | 0.2 |
| Betula glandulosa | | | 2 | 1 | | 0.6 |
| Potentilla fruticosa | | | 1 | | | 0.2 |
| Linnaea borealis | | | 1 | | | 0.2 |
| Salix alaxensis | | | 1 | 2 | | 0.6 |
| Bromus pumpellianus | | | 1 | | | 0.2 |
| Salix rotundifolia | | | | 1 | | 0.2 |
| Agropyron yukonense | | | | 1 | | 0.2 |
| Vaccinium uliginosum | | | | | 1 | 0.2 |
| Arctostaphylos uva-ursi | | | | | 1 | 0.2 |
| Agropyron violaceum | | | | | 1 | 0.2 |
| Poa glauca | | | | | 3 | 0.6 |
| Equisetum variegatum | | | | | 2 | 0.4 |
| Vaccinium vitis-idaea | | | | | 1 | 0.2 |
| Empetrum nigrum | | | | | 1 | 0.2 |
| | | | | | | 86.0 |
| Grasses (unidentified) | 2 | 1 | 3 | 1 | 4 | |
| Forbs (unidentified) | 2 | 5 | 0 | 8 | 5 | |
| Browse (unidentified) | 10 | 15 | 2 | 0 | 10 | |
| Mosses & Lichens (unidentified) | 1 | 1 | 0 | 0 | 0 | |
| | 100% | 100% | 100% | 100% | 100% | |
| Grasses (total | 35 | 33 | 29 | 16 | 34 | 29.4 |
| Forbs (total) | 37 | 40 | 15 | 62 | 38 | 38.4 |
| Browse (total) | 24 | 24 | 56 | 22 | 28 | 30.8 |
| Mosses & Lichens (total) | 4 | 3 | 0 | 0 | 0 | 1.4 |
| | 100% | 100% | 100% | 100% | 100% | 100% |

polaris: 0.6% vs. 3.0%.

In the latter part of September fairly high use was made of the following species, which at the time still contained a high proportion of green matter: Artemisis frigida: 5.3%, Artemisia hyperborea: 5.8%, Oxytropis viscida: 3.6% and Artemisia alaskana: 1.4%. Rams continued to feed at alpine altitudes throughout the months, where practically no green vegetation was left at the end of September.

The distribution of forage classes for September was: grasslike vegetation: 29.3%, forbs: 33.3%, browse: 36.9%, and lichens with 0.5%; which is very similar to that observed during June (Figure 39).

Range Use During October:

This month marked the onset of the winter with all sheep returning to winter ranges during the course of it. The average temperature was 24.3 F., with a maximum of 54 F. and a minimum of -2 F. (r = 56 F.). A total of 3.1 cm. (1.25 inches) precipitation fell mostly as snow, and snow began to accumulate reaching an average depth in the alpine zone of 10 cm., and in the boreal zone of 5 cm. However, west winds and occasional melting temperatures resulted in many areas on exposed ridges or south-facing slopes not having any snow.

The average band size for the month was 9.0 (r = 6.0 to 12.7), with an average percentage of mixed bands of 20%. This is entirely the result of progressive mixing of bands in the second half of October, since rams did not show up on the mountain until October 13/70, when the first 8 mature rams

appeared.

Heavy frost during the middle of the month terminated the availability of any green forage, except for "evergreen" species. Until then a considerable amount of the standing crop of certain legumes and sages (Artemisia frigida, Artemisia dracunculus, Artemisia alaskana, Oxytropis huddelsonii, Oxytropis viscida) still consisted of green matter. The leaves of willows and poplars, which had dried up during September, continued to fall, and by the end of the month less than 10% of the leaves remained on the branches.

Sheep were observed on 22 days and the grazing distribution was mapped for 2546 sheep days. The average number of sheep on the mountain was 115.5, the range 55 to 150. Sheep were more widely dispersed over the study area than during September. Rams began to reappear during the latter part of the month and descended down from alpine through sub-alpine elevations to meet the nursery bands. Twenty-two sections were used, but intensive feeding was concentrated on as few as 6, which provided 90% of the feeding areas. The average intensity of use was 5.3 sheep days per acre per month, the maximum 21.5 (Section 5D.32). This average rate differs little from that of the winter months (Table 21).

During October nursery sheep descended further down into the boreal zone by an average of 350 feet, and concentrated use in boreal plant associations; while rams used alpine and sub-alpine vegetation in the first half of October, later they descended by an average of 1600 feet into boreal areas.

The combined use of vegetation in the three altitudinal zones was: boreal zone 63.7%; sub-alpine zone 21.2%, and alpine zone 15.1%.

Some sheep descended to very low elevations and utilized the lick areas in Section 5E. Because of sex differences in distribution, the population

as a whole used 18 plant associations. However, only 6 associations were extensively grazed and provided 90% of the forage taken (Table 20).

The use of alpine associations by rams was restricted to those which had the least snow cover: Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae: 6.3%; Agropyretum violacei: 6.1%, and Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati: 0.7%. Considering the population as a whole, most grazing was done in the two associations which were also most heavily used in the winter: Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis: 45.1%, and Agropyro (yukonensis) - Artemisietum frigidae - rupestris: 18.2% (Table 26, Figure 35).

The utilization rates for these 5 sites were as follows: #1 (2D): 4.1 sheep days per acre per month, #2 (3D): 3.6, #3 (4-5D): 6.7, #4 (5E): 6.2, and #5 (6D): 5.3 sheep days per acre per month, respectively. These rates are comparable to those encountered throughout the remainder of the winter.

Forage Use During October:

The grazing of sheep was observed on 10 days, yielding 9,214 feeding interactions. There was one rumen sample (#39) (Table 34).

Sheep used 44 different species during October, 10 less than in September and 19 less than August. Only 6 species made up 75.8% of the forage, while 16 other species were used to 0.1% or less each.

At the beginning of the month fairly heavy use was made of species which still contained green matter: Artemisia frigida: 19.7%, Artemisia hyperborea: 4.4% and Oxytropis viscida: 2.3%. Throughout the month the leaves of Salix glauca (13.2%) continued to be an important forage item.

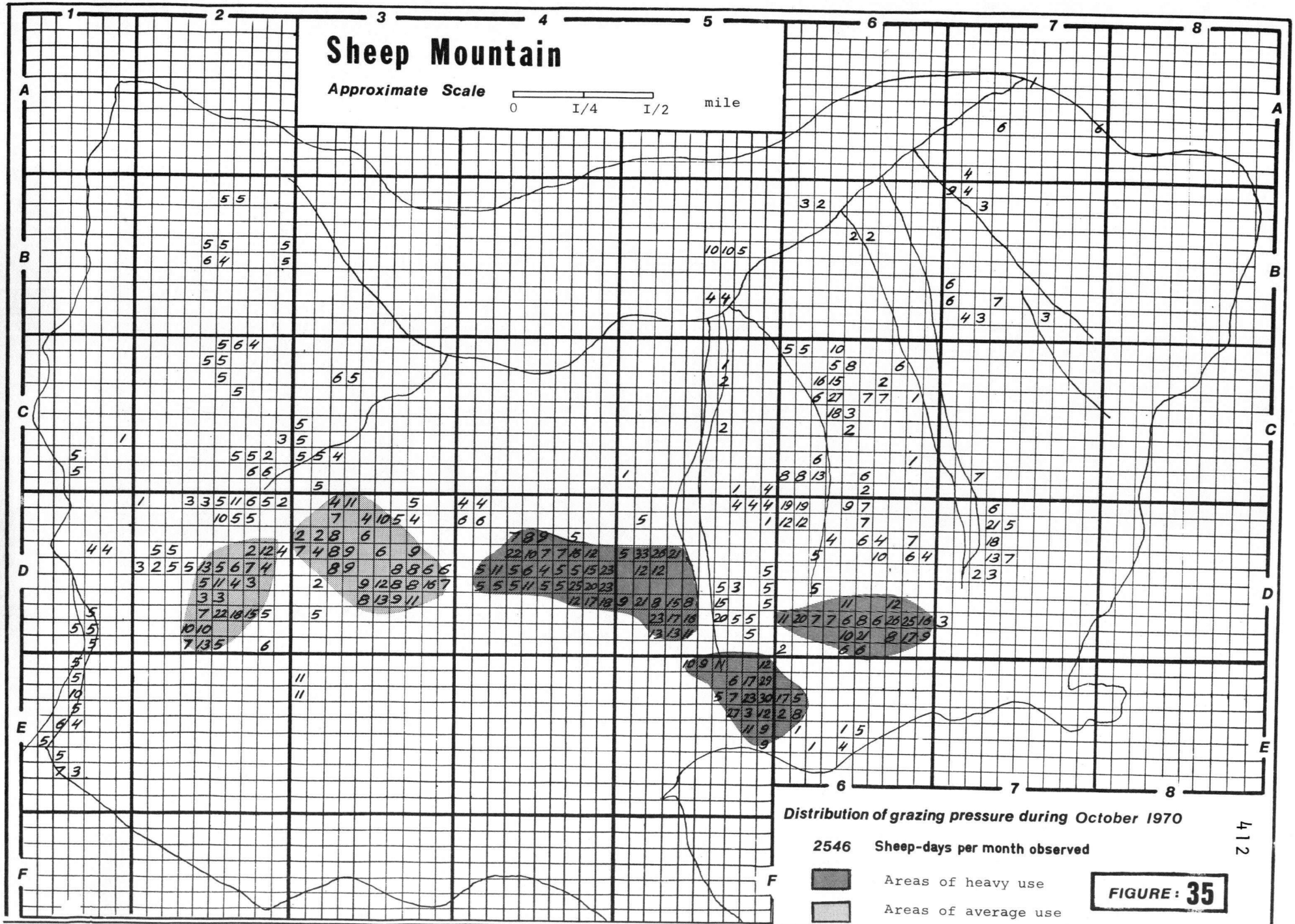

Sheep Mountain
Approximate Scale
0 I/4 I/2 mile
1
2
3
4
5
6
7
8
A
B
C
D
E
F
Distribution of grazing pressure during October 1970
2546 Sheep-days per month observed
Areas of heavy use
Areas of average use
FIGURE: 35

TABLE: 34

Rumen sample analysis for October and November

| SPECIES | Sample # | October 39 | November 40 |
|---|---|---|---|
| Salix glauca | | 21 | 7 |
| Artemisia frigida | | 15 | 34 |
| Calamagrostis purpurascens | | 8 | 12 |
| Carex filifolia | | 7 | 20 |
| Salix reticulata | | 4 | |
| Betula glandulosa | | 3 | |
| Dryas integrifolia | | 3 | |
| Bromus pumpellianus | | 2 | |
| Populus tremuloides | | 1 | |
| Salix alaxensis | | 1 | |
| Salix lanata | | 1 | |
| Eurotia lanata | | 1 | 2 |
| Achillea borealis | | 1 | |
| Artemisia dracunculus | | 1 | |
| Ledum palustre | | 1 | |
| Carex scirpoidea | | 1 | |
| Artemisia hyperborea | | 1 | |
| Artemisia alaskana | | 1 | |
| Astragalus mackenzii | | 1 | |
| Oxytropis viscida | | 1 | |
| Agropyron yukonense | | | 1 |
| Poa glauca | | | 1 |
| Grasses (unidentified) | | 10 | 7 |
| Forbs (unidentified) | | 12 | 10 |
| Browse (unidentified) | | 3 | 4 |
| Mosses & Lichens (unidentified) | | 0 | 2 |
| | | 100% | 100% |
| Grasses (total) | | 28 | 41 |
| Forbs (total) | | 41 | 46 |
| Browse (total) | | 31 | 11 |
| Mosses & Lichens (total) | | 0 | 2 |
| | | 100% | 100% |

TABLE: 35

Feeding observations during fall and early winter.

| SPECIES: | October | November | December |
|---|---|---|---|
| Artemisia frigida | 20.2 | 21.6 | 29.7 |
| Carex filifolia | 24.5 | 26.2 | 22.9 |
| Salix glauca | 12.2 | 6.7 | 3.8 |
| Agropyron yukonense | 5.2 | 7.0 | 6.2 |
| Calamagrostis purpurascens | 9.5 | 10.9 | 18.4 |
| Astragalus mackenzii | 5.4 | 0.2 | 0.6 |
| Artemisia hyperborea | 4.7 | 2.5 | 1.2 |
| Juniperus horizontalis | 1.3 | 1.2 | 1.0 |
| Eurotia lanata | 1.4 | 2.5 | 1.4 |
| Artemisia rupestris | 0.8 | 1.5 | 3.1 |
| Oxytropis viscida | 2.4 | 2.1 | 0.6 |
| Poa glauca | 1.1 | 0.1 | |
| Dryas integrifolia | 2.1 | 3.4 | 0.1 |
| Bromus pumpellianus | 0.8 | 1.4 | 0.9 |
| Potentilla hookeriana | 0.4 | 0.6 | 0.2 |
| Carex scirpoidea | 0.3 | 0.7 | |
| Agropyron violaceum | 0.2 | 0.7 | 0.5 |
| Artemisia dracunculus | 0.4 | 0.8 | 1.4 |
| Arctostaphylos uva-ursi | 0.8 | 2.1 | 1.8 |
| Erigeron caespitosus | <0.1 | | 0.5 |
| Pentstemon gormani | 0.2 | | |
| Plantago canescens | 0.1 | | <0.1 |
| Festuca altaica | 2.2 | 1.6 | |
| Salix arctica | 0.2 | | 1.1 |
| Artemisia alaskana | 0.5 | 1.5 | 1.9 |
| Oxytropis huddelsonii | 0.8 | 1.9 | 0.3 |
| Oxytropis nutzotinensis | <0.1 | 0.4 | |
| Achillea borealis | 0.2 | <0.1 | 0.3 |
| Salix lanata | 0.5 | 0.8 | <0.1 |
| Salix myrtillifolia | 0.1 | <0.1 | |
| Arctostaphylos rubra | <0.1 | | |
| Trisetum spicatum | 0.6 | <0.1 | <0.1 |
| Senecio lugens | 0.1 | | |
| Betula glandulosa | 0.2 | 0.6 | 0.1 |
| Vaccinium uliginosum | 0.1 | | |
| Potentilla fruticosa | <0.1 | | 0.2 |
| Hedysarum alpinum | <0.1 | | |
| Artemisia arctica | <0.1 | | |
| Rosa acicularis | 0.5 | 0.7 | 0.6 |
| Pulsatilla patens | <0.1 | | |
| Hedysarum mackenzii | <0.1 | | |
| Galium boreale | | 0.1 | 0.3 |
| Mertensia paniculata | | 0.2 | |
| Populus tremuloides | | <0.1 | |
| Shepherdia canadensis | | <0.1 | <0.1 |
| Epilobium angustifolium | | 0.1 | 0.3 |
| Saxifraga tricuspidata | | | <0.1 |
| Linum perenne | | | <0.1 |
| Juniperus communis | | | 0.4 |
| Anemone multifida | | | 0.2 |
| Solidago multiradiata | | | <0.1 |
| | 100% | 100% | 100% |
| Grasses (total) | 44.4 | 48.5 | 48.9 |
| Forbs (total) | 39.9 | 39.4 | 43.1 |
| Browse (total | 15.7 | 12.1 | 8.0 |
| Mosses & Lichens | 0 | 0 | 0 |
| | 100.0% | 100.0% | 100.0% |

The high rate of utilization of Carex filifolia (23.9%) compared to Calamagrostis purpurascens (9.3%) at this time of the year when both are abundant, indicates that this sedge is the preferred forage. Also heavily used at this time, considering its very restricted distribution to forest edges, is Astragalus williamsii (5.0%). Whenever sheep were observed feeding on portions of their winter range not yet grazed this year, this Astragalus williamsii appeared to be the first plant they selected.

Distribution of use of broad forage types in October was: grasses and grasslike vegetation: 42.9%, forbs: 40.0%, browse: 17.1%.

Range Use During November:

An over-riding factor in the distribution of sheep over the mountain and in their use of various plant associations during November was the rutting season.

The average monthly temperature was 16.5 F., the minimum and maximum were -14 F. and +49 F. respectively, giving a range of 63 F. The average wind speed was only 5.4 miles per hour with strong west winds and north winds being limited to 3 days each. A total of 2.3 cm. (0.9 inches) precipitation fell resulting in a build-up of average snow depths in the alpine zone to 21 cm. and in the boreal zone to 12 cm.

Snow and wind chill (indices IV and V) had no influence on sheep distribution until late November (28th and 29th).

The average band size was 6.9 sheep per band (r = 2.9 to 10.0),

and - taking the month as a whole - 74.1% of the bands observed were mixed. These percentages reached 100% around the height of the rutting season, but were only around 30% at the beginning of November.

No further mentioning of plant phenological phenomena is necessary, since all plants are dormant now and green matter is restricted to the following "evergreens": Picea glauca, Juniperus communis, Juniperus horizontalis, Arctostaphylos uva-ursi, Vaccinium vitis-idaea, Linnaea borealis, Equisetum scirpoides, and Equisetum variegatum. In addition the basal portions of leaves of some grasses (Festuca altaica) and sedges were still green; certain alpine species appeared to be frozen in a green state, and alpine lichens did not appear to undergo great seasonal changes, as far as could be judged from their colours. However, most of these species were covered by deep snow, and therefore of very limited importance as forage for sheep.

Sheep were observed on 18 days and the grazing distribution was mapped for 1460 sheep days. The average number of sheep on the mountain was 80.9, the range 17 to 131. This was a reduction of about 30% of the range use of September and October, largely because some of the rutting activity takes place on portions of the sheep's range (Mt. Wallace, Williscroft Creek area) beyond the boundaries of the area mapped.

To get to these areas at this time of the year requires the traversing of areas with snow depths up to 30 cm. Most rutting activity took place at altitudes above timberline, the average altitude for the month being 4200 feet, only slightly higher than during October.

Sheep used 18 sections of the mapped area, but only 9 received considerable usage and provided 90% of all forage sites. The average rate of use of the foraging sites was 5.3 sheep days per acre per month, the highest

was 25.1 in section 4D.58 (Table 21).

In comparison to October there was a slight reduction in the use of alpine vegetation (10.8% vs. 15.1%), and a corresponding increase of use of the sub-alpine vegetation (26.9% vs. 21.2%). The use of the boreal zone did not change (62.3% vs. 63.7%). The trend established in October, that a few grassland associations provided the great bulk of the forage was continued during November and throughout the winter.

During November, the following three associations contributed 71.5% at all feeding sites: Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis: 41.0%, Agropyro (yukonensis) - Artemisietum frigidae - rupestris: 22.3%; and Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Carixetum filifoliae: 8.2%. The use of alpine communities was confined to those with the least snow cover [Salico (reticulatae) - Sileno (acaulis) - Carixo (scirpoideae) - Dryadetum integrifoliae: 4.1%; Agropyretum violacei: 4.4%, and Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati: 0.3%]. The utilization of cliffs (2%) in spite of considerable snow depths can be explained by the rutting turmoil (Table 20).

Figure 36 shows the areas on which grazing was concentrated during November. The smaller number of sheep on the mountain resulted in a reduction in usage rates compared to October. The statistics are as follows for the five concentration areas: #1 (2D): 4.5 sheep days per acre per month, #2 (3D): 5.1, #3 (4-5D): 5.9, #4 (6D): 3.2, and #5 (6C): 5.0 sheep days per acre per month, respectively.

Forage Use During November:

Grazing of sheep was monitored on 9 days, yielding 6,295 feeding

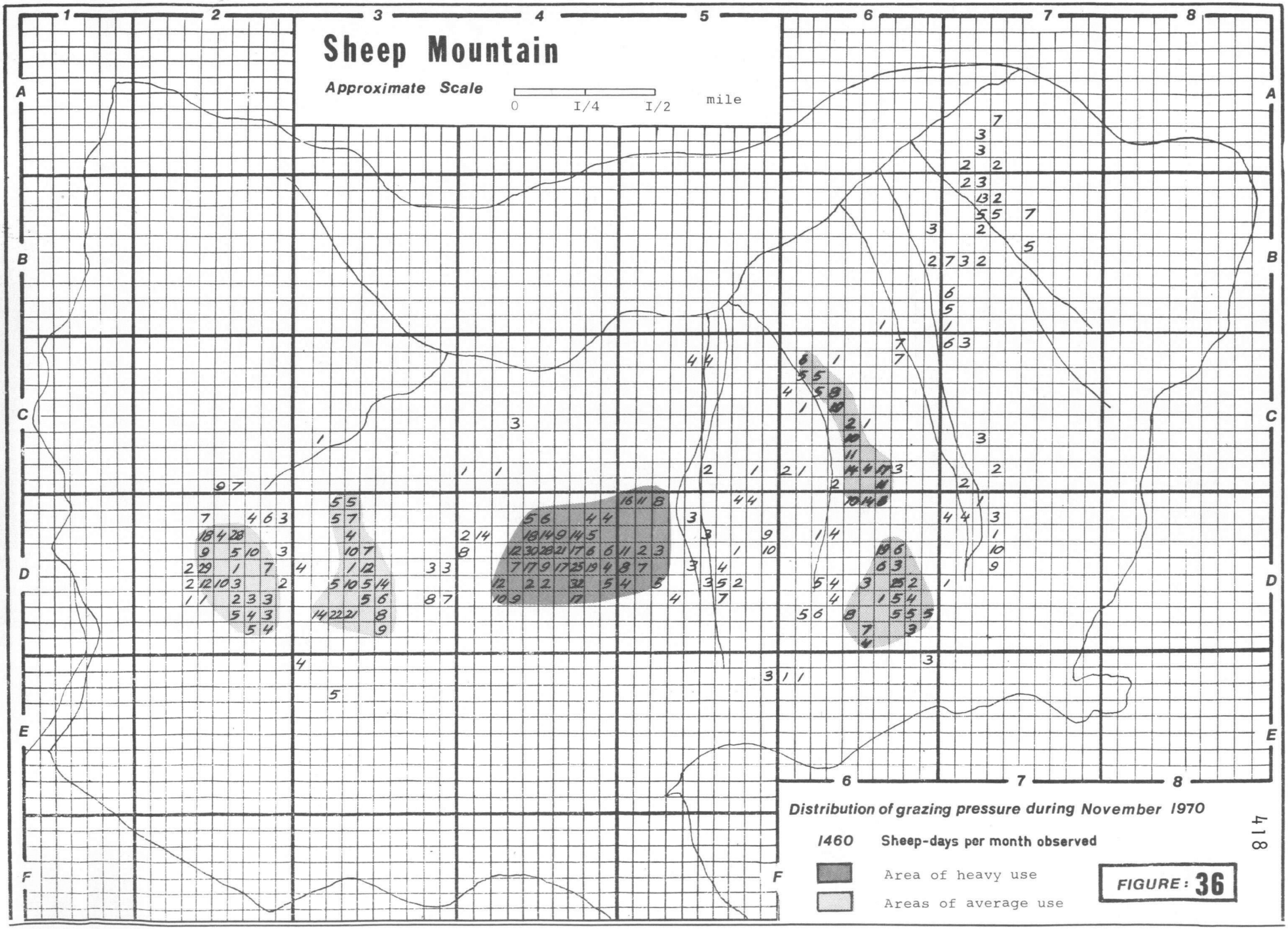

Sheep Mountain
Approximate Scale
0 I/4 I/2 mile
1 2 3 4 5 6 7 8
A B C D E F
Distribution of grazing pressure during November 1970
1460 Sheep-days per month observed
Area of heavy use
Areas of average use

FIGURE: 36

interactions. There was only one rumen sample (Table 34).

At least 34 species of forage plants were used in November, six of which provided 75.4% of all forage and a further 8 species providing 0.1% or less each.

This month marked the beginning of typical winter feeding conditions, in that three important, abundant species (Carex filifolia: 25.5%, Artemisia frigida: 22.8%, and Calamagrostis purpurascens: 11.0%) provided the bulk of the forage. Three other species were used in greater proportion than their abundance: Agropyron yukonense: 6.4%, Artemisia hyperborea: 2.3% and Eurotia lanata: 2.4%. Preferred forages, whose availability declines as winter progresses, but which are still utilized in reasonable amounts at this time include: Oxytropis huddelsonii: 1.7%, Artemisia alaskana: 1.3%, Astragalus williamsii: 0.3%, Poa glauca: 0.1%, Artemisia dracunculus: 0.7%, Achillea lanulosa: 0.1%, and Astragalus nutzotinensis: 0.4%. The utilization of Salix glauca - the only abundant tall shrub in the area - depends entirely on the number of leaves remaining on the branches. During November it was still a significant item in the diet with 6.7%.

Forage classes used during November were similar to October: grasses and grasslike vegetation: 47.8%, forbs: 40.1%, browse: 12.0%, and lichens and mosses: 0.1%. Use of browse was reduced (12.0% vs. 17.1%) and grasses increased in proportion (47.8% vs. 42.9%).

Range Use During December:

This month was cold and relatively calm. The mean temperature was -2.4 F., the range 92 F. (minimum -46 F., maximum +46 F.). The average wind speed was 6.4 miles per hour, with only three days of strong north winds and

three days with mild southwest winds, which only reached 20 miles per hour. Even though only 3 cm. of snow fell during the month, the heavy snowfalls of late November lasted because of the absence of any pronounced chinook until late in December. Because of this sheep had to feed in snow-covered areas more than at any other month of the winter.

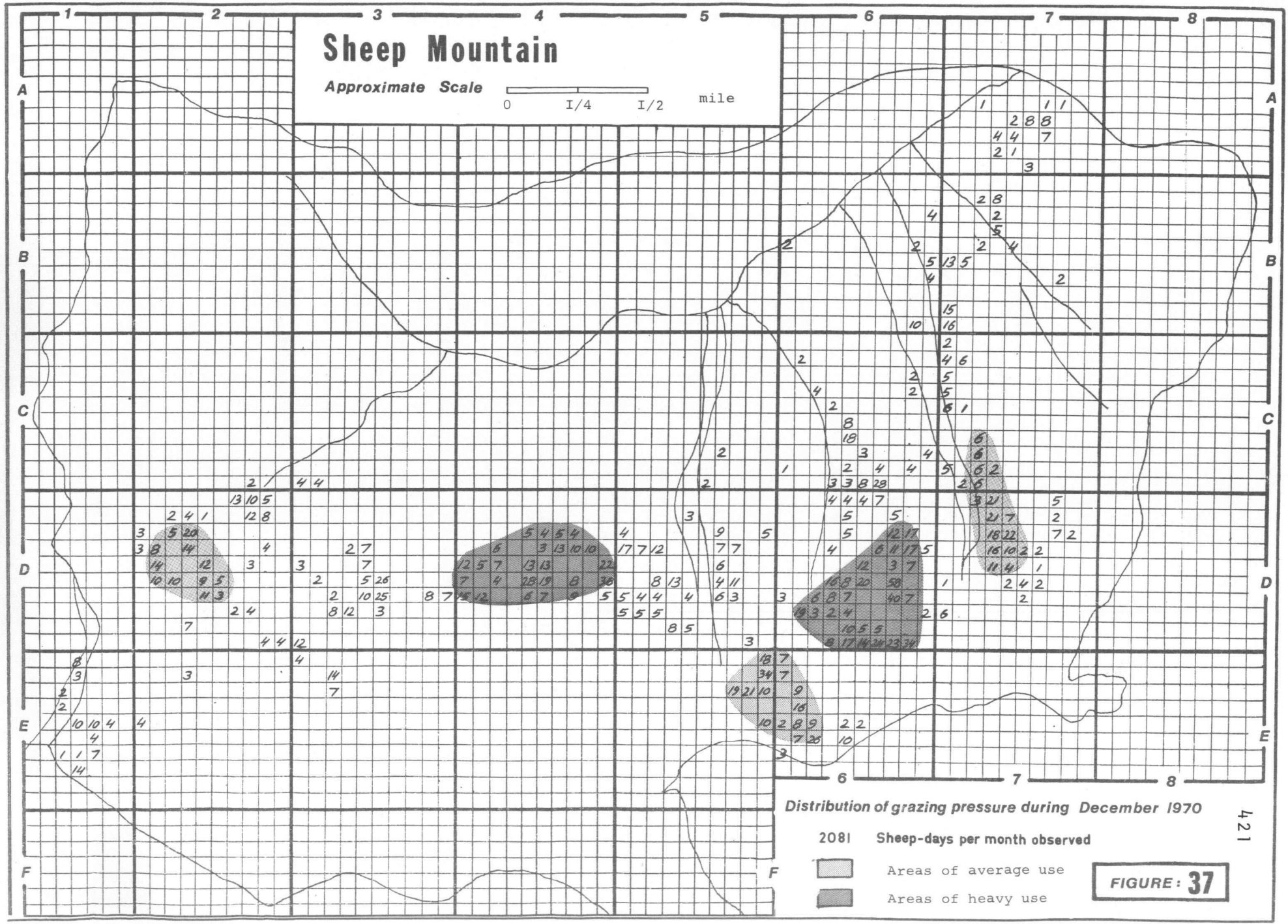
The average band size for December was 6.8 sheep per band (r = 5.9 to 8.5), and there was still 49% of the bands mixed, since some rutting activity was observed till December 10th.

Sheep were observed on 22 days, and the distribution of grazing was mapped for 2081 sheep days. The average number of sheep on the mountain was 94.6 (r = 72 to 114), an increase of 20% over November. The rutting season was over and sheep concentrated on the winter range.

Nineteen sections were used, of which 13 provided 90% of the feeding sites (Table 21, Figure 37). Average rate of use was 5.2 sheep days per acre per month, maximum 38.2, which is also the annual maximum of grazing pressure in a single quadrat per month (quadrat 6D.58).

In comparison to November the use of alpine (6.3% vs. 10.8%) and sub-alpine vegetation (21.2% vs. 26.9%), was reduced and there was a corresponding increase of grazing in associations of the boreal zone (72.5% vs. 62.3%). This reflected a general downward movement of sheep during the month, averaging 300 feet for nursery bands, and 650 feet for rams.

During December sheep used 13 different plant associations, 5 of them providing 90% of all feeding sites (Table 20). The associations used were unchanged from November, except that limited grazing also took place at the forest edge in Hypno (procerrimi) - Abietinello (abietinae) - Piceetum glaucae (0.5%). However, as already pointed out there was greater emphasis on feeding in boreal associations and a reduction of feeding above the 4000


Sheep Mountain
Approximate Scale
0 I/4 I/2 mile
1 2 3 4 5 6 7 8
A B C D E F
Distribution of grazing pressure during December 1970
2081 Sheep-days per month observed
Areas of average use
Areas of heavy use
FIGURE: 37

foot elevations. One grassland association provided almost half of the forage during this month: Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis: 49.9% (Table 20).

Figure 37 shows the areas on which grazing was concentrated during December. The utilization rates for the five sites were as follows: #1 (2D): 4.0 sheep days, #2 (4D): 4.7, #3 (5-6E): 5.8, #4 (6D): 6.1, and #5 (7C-D): 4.8 sheep days per acre per month, respectively.

Forage Use During December:

Sheep were observed on 7 days, providing 12,695 feeding interactions. There were three rumen samples (Table 36).

The number of forage species utilized increased to 40 over 34 in November. Five much used plants provided 77.0% of all forage, and the number of little-used species (0.1% or less) increased to 15 (Table 22). The pasture sage Artemisia frigida provided 29.6% of all forage, which is the heaviest utilization recorded for any species per month; second was Carex filifolia with 23.1% followed by Calamagrostis purpurascens: 14.7%, Agropyron yukonense: 5.4%, and Salix glauca: 4.2%. A reduction was recorded in the availability of certain preferred forages: Artemisia hyperborea: 1.5% vs. 2.3%, Oxytropis huddelsonii: 0.2% vs. 1.7%, and Oxytropis viscida: 1.2% vs. 2.0%.

The proportional distribution of use of broad forage classes was: grasses and grasslike vegetation: 47.0%, forbs: 44.8%, browse: 8.1%, and mosses: 0.1%. Compared to November there was a further reduction in the utilization of browse species (8.1% vs. 12.0%), and an increase in the use of forbs (44.8% vs. 40.1%). This increase is due to heavier grazing on Artemisia frigida.

TABLE: 36

Rumen sample analysis for December

| SPECIES | SAMPLE # 41 | 42 | 43 | Mean |
|---|---|---|---|---|
| Artemisia frigida | 28 | 37 | 23 | 29.3 |
| Carex filifolia | 24 | 14 | 33 | 23.7 |
| Calamagrostis purpurascens | 9 | 11 | 8 | 9.3 |
| Salix glauca | 5 | 3 | 5 | 4.3 |
| Artemisia hyperborea | 5 | 2 | | 2.3 |
| Eurotia lanata | 4 | 7 | 1 | 4.0 |
| Agropyron yukonense | 4 | 3 | 1 | 2.7 |
| Oxytropis viscida | 3 | 4 | 1 | 2.7 |
| Artemisia rupestris | 2 | 3 | | 1.7 |
| Pulsatilla patens | 1 | | | 0.3 |
| Salix reticulata | 1 | | | 0.3 |
| Picea glauca | 1 | | | 0.3 |
| Pentstemon gormani | 1 | | | 0.3 |
| Rosa acicularis | 1 | | 1 | 0.7 |
| Achillea borealis | 1 | | 1 | 0.7 |
| Erigeron caespitosis | | 1 | | 0.3 |
| Solidago multiradiata | | 1 | | 0.3 |
| Artemisia dracunculus | | 1 | | 0.3 |
| Poa glauca | | 1 | | 0.3 |
| Arctostaphylos uva-ursi | | | 1 | 0.3 |
| Epilobium angustifolium | | | 1 | 0.3 |
| Juniperus horizontalis | | | 1 | 0.3 |
| | | | | 84.7 |
| Grasses (unidentified) | 8 | 5 | 7 | |
| Forbs (unidentified) | 2 | 5 | 10 | |
| Browse (unidentified) | 0 | 2 | 5 | |
| Mosses & Lichens (unidentified) | 0 | 0 | 1 | |
| | 100% | 100% | 100% | |
| Grasses (total) | 45 | 34 | 49 | 42.7 |
| Forbs (total) | 48 | 61 | 37 | 48.7 |
| Browse (total) | 7 | 5 | 13 | 8.3 |
| Mosses & Lichens (total) | 0 | 0 | 1 | 0.3 |
| | 100% | 100% | 100% | 100% |

General discussion on the utilization of forages:

The relevant statistics on forage utilization are summarized in Tables 22 and 38, and the broad forage classes have been diagrammed in Figure 39.

Feeding sheep were observed over the annual cycle at an average rate of 9 days per month totalling 109 observation days for the year. The numbers of successful documentations of forage use, expressed as interactions per plant species, varied greatly from month to month. They were highest in late winter (March: 44515, April: 34390, May: 34255), when the sheep were concentrated in plant associations with a relatively poor species diversity and low cover values, and when the sheep had become used to the constant presence of the investigator. They were lowest during mid summer (July: 7540, August: 8650) when the sheep were dispersed over a very large area, feeding in plant communities of a fairly complex composition, and were - because of the presence of newly born lambs - more difficult to approach. Successful observations were fewer during November (6295), since rams fed very little at this time and ewes were being chased about. Over the annual cycle a total of 227,409 interactions were recorded (Table 28).

During the observation year sheep were found to use 110 different plant species. This number must be considered conservative, because of the relatively poor success rate of feeding observation during mid summer, when the greatest number of potential food plants are available. The number of species utilized per month varies greatly and is a reflection of a number of factors, among them: vertical migrations, greater species diversity of alpine association compared to boreal ones, selective grazing in early winter, concentration in winter on relatively few plant associations, and behavioural phenomena as rutting season and differential range utilization between sexes

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salix glauca | 5.0 | 3.1 | 1.1 | 0.4 | 3.9 | 29.0 | 0.9 | <0.1 | <0.1 | 0.3 | 4.7 | 6.4 | 5.4 | 4.4 | 5 |
| Agropyron yukonense | 9.5 | 7.7 | 4.6 | 1.8 | 11.2 | 0.9 | <0.1 | <0.1 | 0.3 | 4.7 | 6.4 | 5.4 | 4.4 | 5 |
| Trisetum spicatum | <0.1 | | | 0.6 | 1.0 | 1.4 | 17.1 | 12.1 | 7.8 | 0.5 | <0.1 | <0.1 | 3.4 | 6 |
| Artemisia hyperborea | 1.6 | 0.4 | 0.7 | 2.9 | 1.2 | 3.5 | 6.1 | 5.9 | 5.8 | 4.4 | 2.3 | 1.5 | 3.0 | 7 |
| Oxytropis huddelsonii | 0.5 | <0.1 | | | | 0.7 | 12.8 | 11.0 | 4.9 | 0.7 | 1.7 | 0.2 | 2.6 | 8 |
| Arctostaphylos uva-ursi | 1.7 | 2.2 | 6.1 | 10.5 | 4.7 | 0.3 | | | 0.1 | 0.7 | 1.9 | 1.4 | 2.5 | 9 |
| Salix reticulata | | | 0.1 | 0.1 | 1.0 | 1.5 | 12.9 | 11.6 | 2.9 | | | 0.1 | 2.5 | 10 |
| Oxytropis viscida | 1.8 | 1.3 | 0.3 | 1.9 | 2.9 | 2.5 | 3.4 | 3.4 | 3.6 | 2.3 | 2.0 | 1.2 | 2.2 | 11 |
| Dryas integrifolia | 0.2 | 0.2 | 0.2 | 3.2 | 1.4 | 5.0 | 3.1 | 4.5 | 3.3 | 2.2 | 3.0 | <0.1 | 2.2 | 12 |
| Festuca altaica | 0.1 | <0.1 | | 0.4 | 3.9 | 3.2 | 2.7 | 4.7 | 3.8 | 2.0 | 1.4 | | 1.9 | 13 |
| Carex scirpoidea | 2.3 | <0.1 | 0.7 | 1.2 | 0.6 | 3.5 | 5.1 | 3.7 | 2.3 | 0.4 | 0.6 | | 1.7 | 14 |
| Juniperus horizontalis | 0.8 | 1.4 | 6.9 | 6.3 | 2.0 | 0.1 | | | | 1.2 | 1.1 | 0.9 | 1.7 | 15 |
| Artemisia rupestris | 2.4 | 1.5 | 3.8 | 4.4 | 0.2 | 0.2 | | | | 0.7 | 1.4 | 2.7 | 1.5 | 16 |
| Poa glauca | 0.4 | 0.8 | 0.4 | 1.9 | 1.0 | 2.5 | 4.0 | 2.9 | 2.7 | 1.0 | 0.1 | 0.1 | 1.5 | 17 |
| Rosa acicularis | 1.9 | 1.5 | 0.3 | 0.4 | 0.1 | | | | | 0.4 | 0.6 | 0.6 | 1.3 | 18 |
| Eurotia lanata | 4.1 | 1.0 | 1.4 | 0.8 | <0.1 | <0.1 | | | 0.2 | 1.3 | 2.4 | 2.2 | 1.1 | 19 |
| Salix lanata | 0.2 | <0.1 | | | 0.2 | 4.8 | <0.1 | 0.2 | 2.9 | 0.5 | 0.7 | <0.1 | 0.8 | 20 |
| Arctostaphylos rubra | <0.1 | | | | 0.1 | 3.0 | 1.1 | 4.8 | 0.8 | <0.1 | | | 0.8 | 21 |
| Agropyron violaceum | | 0.1 | | | | 0.1 | 5.8 | 2.1 | 0.9 | 0.2 | 0.6 | 0.4 | 0.8 | 22 |
| Artemisia alaskana | | | | | <0.1 | 0.1 | 1.9 | 1.2 | 1.4 | 0.5 | 1.3 | 1.4 | 0.7 | 23 |
| Astragalus williamsii | 1.5 | <0.1 | <0.1 | | | | | | | 5.0 | 0.3 | 0.4 | 0.6 | 24 |
| Populus tremuloides | 0.2 | 0.9 | <0.1 | | 0.9 | 5.0 | | | 0.1 | <0.1 | 0.1 | | 0.6 | 25 |
| Bromus pumpellianus | 0.3 | 0.7 | 1.1 | 0.1 | 0.1 | 0.8 | | | 0.1 | 0.8 | 1.3 | 0.8 | 0.5 | 26 |
| Salix polaris | | | | | 0.6 | <0.1 | 2.3 | 3.0 | 0.6 | | | | 0.5 | 27 |
| Festuca brachyphylla | | | | | 0.6 | | 1.1 | 2.0 | 0.9 | | | | 0.4 | 28 |
| Epilobium latifolium | | <0.1 | <0.1 | | | 0.1 | 1.6 | 1.8 | 0.3 | | | | 0.3 | 29 |
| Cetraria tilesii | | | | | <0.1 | 0.1 | 0.7 | 2.1 | 0.2 | | | | 0.3 | 30 |
| Salix myrtillifolia | | | | | | 1.8 | | 1.2 | 0.8 | 0.1 | <0.1 | | 0.3 | 31 |
| Artemisia arctica | | | | | | 0.1 | 0.8 | 1.3 | 1.0 | <0.1 | | | 0.3 | 32 |
| Artemisia dracunculus | 0.8 | 0.4 | 0.3 | | | | | | | 0.5 | 0.7 | 1.1 | 0.3 | 33 |
| Salix arctica | 0.5 | | | | 0.6 | 1.2 | 0.2 | <0.1 | <0.1 | 0.2 | | 1.0 | 0.3 | 34 |
| Achillea lanulosa | 1.0 | 0.2 | 0.1 | 0.2 | 0.1 | | | | | 0.2 | 0.1 | 0.4 | 0.2 | 35 |
| Erigeron caespitosus | 0.3 | 0.2 | 0.8 | 0.1 | <0.1 | | | | <0.1 | <0.1 | | 0.4 | 0.2 | 36 |
| Juniperus communis | 0.1 | 0.3 | 0.9 | 1.0 | 0.2 | | | | | | | 0.3 | 0.2 | 37 |
| Populus balsamifera | | | | | 1.0 | 1.4 | | | 0.1 | | | | 0.2 | 38 |
| Potentilla hookeriana | 0.5 | 0.3 | 0.2 | | <0.1 | 0.2 | <0.1 | 0.2 | 0.1 | 0.4 | 0.5 | 0.1 | 0.2 | 39 |
| Epilobium angustifolium | 0.4 | | 0.2 | | | | | | | | 0.1 | 0.3 | 0.1 | 40 |
| Linnaea borealis | 0.3 | | 0.1 | | 0.3 | 0.1 | | | 0.1 | | | | 0.1 | 41 |
| Pentstemon gormani | 0.2 | | 0.2 | 0.1 | 0.1 | 0.1 | | | | 0.2 | | 0.1 | 0.1 | 42 |
| Tortula ruralis | 0.1 | 0.9 | | | 0.2 | | | | | | | | 0.1 | 43 |
| Astragalus nutzotinensis | | 0.2 | | | | | 0.1 | 0.2 | <0.1 | <0.1 | 0.4 | | 0.1 | 44 |
| Picea glauca | | 0.2 | 0.1 | 0.6 | | | | | | | | 0.1 | 0.1 | 45 |
| Pulsatilla patens | | 0.1 | | <0.1 | 1.0 | 0.5 | <0.1 | | | <0.1 | | 0.2 | 0.1 | 46 |
| Vaccinium uliginosum | | | | <0.1 | | 0.3 | 0.3 | 0.1 | 0.3 | <0.1 | | | 0.1 | 47 |
| Betula glandulosa | | | | <0.1 | | <0.1 | | | 0.7 | 0.1 | 0.5 | <0.1 | 0.1 | 48 |
| Cetraria islandica | | | | | 1.0 | | | | | | | | 0.1 | 49 |
| Dryas drummondii | | | | | <0.1 | 0.8 | | | | | | | 0.1 | 50 |
| Anemone parviflora | | | | | 0.1 | 0.4 | 0.4 | 0.2 | 0.1 | | | | 0.1 | 51 |
| Kobresia myosuroides | | | | | | 0.1 | 0.6 | 0.9 | 0.3 | | | | 0.1 | 52 |
| Empetrum nigrum | | | | | | 0.1 | 0.2 | 0.1 | 0.5 | | | | 0.1 | 53 |
| Mertensia paniculata | | | | | | <0.1 | 0.3 | 0.4 | | | 0.2 | | 0.1 | 54 |
| Salix rotundifolia | | | | | | | 0.5 | 0.3 | 0.1 | | | | 0.1 | 55 |
| Equisetum scirpoides | | | | | | | 0.5 | 0.2 | 0.4 | | | | 0.1 | 56 |
| Cetraria nivalis | | | | | | | | 0.7 | | | | 0.1 | <0.1 | 57 |
| Solidago multiradiata | <0.1 | <0.1 | 0.2 | | | | | | | | | | <0.1 | 58 |
| Hedysarum mackenzii | <0.1 | | | | | | | | | <0.1 | | | <0.1 | 59 |
| Ledum palustre | <0.1 | | | <0.1 | | | | | | <0.1 | | | <0.1 | 60 |
| Plantago canescens | 0.2 | <0.1 | 0.4 | 0.1 | <0.1 | | | | | 0.1 | | <0.1 | <0.1 | 61 |
| Aster alpinus | 0.1 | <0.1 | 0.1 | | 0.1 | | | | | | | | <0.1 | 62 |
| Shepherdia canadensis | 0.1 | | | <0.1 | 0.1 | | | | | | <0.1 | <0.1 | <0.1 | 63 |
| Linum perenne | 0.1 | | | <0.1 | | | | | | | | <0.1 | <0.1 | 64 |
| Lappula myosotis | | 0.1 | | | | | | | | | | | <0.1 | 65 |
| Anemone multifida | | | <0.1 | | | | | | | | | 0.1 | <0.1 | 66 |
| Erigeron humilis | | | 0.5 | | | | | | | | | | <0.1 | 67 |
| Erigeron compositus | | | 0.1 | | | | | | | | | | <0.1 | 68 |
| Cassiope tetragona | | | | <0.1 | | | | | | | | | <0.1 | 69 |
| Galium boreale | | | | <0.1 | | | | | | | <0.1 | 0.3 | <0.1 | 70 |
| Chamaerhodos erecta | | | | | 0.7 | <0.1 | | | | | | | <0.1 | 71 |
| Carex concinna | | | | | <0.1 | 0.2 | | | | | | | <0.1 | 72 |
| Lupinus arcticus | | | | | <0.1 | | <0.1 | | 0.1 | | | | <0.1 | 73 |
| Astragalus aboriginum | | | | | <0.1 | | | | | | | | <0.1 | 74 |
| Salix alaxensis | | | | | | 0.2 | | | 0.2 | <0.1 | | | <0.1 | 75 |
| Potentilla fruticosa | | | | | | 0.1 | 0.1 | | 0.1 | <0.1 | | 0.1 | <0.1 | 76 |
| Vaccinium vitis-idaea | | | | | | 0.1 | | 0.1 | 0.3 | | | | <0.1 | 77 |
| Zygadenus elegans | | | | | | 0.1 | 0.1 | <0.1 | | | | | <0.1 | 78 |
| Hedysarum alpinum | | | | | | <0.1 | 0.2 | 0.2 | 0.4 | <0.1 | | | <0.1 | 79 |
| Pedicularis kanei | | | | | | 0.1 | | | | | | | <0.1 | 80 |
| Artemisia tilesii | | | | | | | 0.2 | 0.3 | 0.1 | | | | <0.1 | 81 |
| Saussurea viscida | | | | | | | 0.4 | <0.1 | | | | | <0.1 | 82 |
| Erigeron compositus | | | | | | | 0.4 | 0.2 | | | | | <0.1 | 83 |
| Anemone drummondii | | | | | | | <0.1 | <0.1 | <0.1 | | | | <0.1 | 84 |
| Salix barrattiana | | | | | | | <0.1 | 0.3 | <0.1 | | | | <0.1 | 85 |
| Claytonia sarmentosa | | | | | | | <0.1 | | | | | | <0.1 | 86 |
| Erigeron humilis | | | | | | | <0.1 | | | | | | <0.1 | 87 |
| Myosotis alpestris | | | | | | | <0.1 | | | | | | <0.1 | 88 |
| Senecio lugens | | | | | | | 0.1 | <0.1 | | <0.1 | | | <0.1 | 89 |
| Equisetum variegatum | | | | | | | 0.1 | 0.2 | 0.1 | | | | <0.1 | 90 |
| Arnica alpina | | | | | | | 0.1 | | | | | | <0.1 | 91 |
| Oxyria digyna | | | | | | | 0.1 | | | | | | <0.1 | 92 |
| Parnassia kotzebuei | | | | | | | 0.2 | 0.1 | | | | | <0.1 | 93 |
| Poa alpina | | | | | | | 0.1 | 0.4 | | | | | <0.1 | 94 |
| Polemonium boreale | | | | | | | 0.1 | <0.1 | 0.1 | | | | <0.1 | 95 |
| Senecio conterminus | | | | | | | | <0.1 | | | | | <0.1 | 96 |
| Arnica lessingii | | | | | | | | <0.1 | | | | | <0.1 | 97 |
| Valeriana capitata | | | | | | | | <0.1 | | | | | <0.1 | 98 |
| Melandrium apetalum | | | | | | | | <0.1 | | | | | <0.1 | 99 |
| Castilleja hyperborea | | | | | | | | <0.1 | 0.1 | | | | <0.1 | 100 |
| Aster sibiricus | | | | | | | | <0.1 | <0.1 | | | | <0.1 | 101 |
| Sedum rosea | | | | | | | | 0.1 | | | | | <0.1 | 102 |
| Thamnolia subuliformis | | | | | | | | 0.2 | | | | | <0.1 | 103 |
| Cetraria richardsonii | | | | | | | | 0.4 | 0.1 | | | | <0.1 | 104 |
| Gentiana propinqua | | | | | | | | 0.1 | | | | | <0.1 | 105 |
| Antennaria monocephala | | | | | | | | 0.1 | | | | | <0.1 | 106 |
| Carex membranacea | | | | | | | | 0.1 | | | | | <0.1 | 107 |
| Erigeron purpuratus | | | | | | | | 0.1 | | | | | <0.1 | 108 |
| Cladonia pocillum | | | | | | | | 0.2 | | | | | <0.1 | 109 |
| Dactylina arctica | | | | | | | | 0.2 | | | | | <0.1 | 110 |

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | X̄ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unidentified grasses | 3.2% | 6.2% | 4.7% | 4.0% | 3.3% | 0.8% | 1.5% | 0.6% | 0.7% | 1.0% | 0.7% | 2.0% | 2.4 |
| Unidentified forbs | 0.4% | 2.0% | 1.7% | 1.1% | 0.7% | 1.4% | 2.2% | 1.5% | 1.3% | 1.2% | 1.0% | 1.7% | 1.4 |
| Unidentified browse | 0.3% | 0.6% | 0.3% | 0.8% | 1.5% | 1.2% | 0.1% | 0.0% | 2.5% | 0.3% | 0.4% | 0.7% | 0.8 |
| Unidentified mosses & lichens | 0.0% | 0.3% | 0.4% | 0.0% | 0.3% | 0.0% | 0.4% | 0.8% | 0.1% | 0.0% | 0.2% | 0.1% | 0.2 |
| | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Grasses - total | 57.0% | 61.2% | 49.9% | 44.2% | 62.3% | 30.4% | 45.6% | 38.3% | 29.3% | 42.9% | 47.8% | 47.0% | 46.3 |
| Forbs - total | 32.7% | 27.1% | 33.8% | 35.5% | 22.1% | 24.9% | 52.7% | 54.7% | 33.3% | 40.0% | 40.1% | 44.8% | 36.8 |
| Browse - total | 10.2% | 10.8% | 16.0% | 20.3% | 14.2% | 44.6% | 1.0% | 2.5% | 36.9% | 17.1% | 12.0% | 8.1% | 16.1 |
| Lichens & Mosses - total | 0.1% | 0.9% | 0.3% | 0.0% | 1.4% | 0.1% | 0.7% | 4.5% | 0.5% | 0.0% | 0.1% | 0.1% | 0.8 |
| | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Number of species utilized per month | 40 | 36 | 35 | 33 | 57 | 50 | 53 | 63 | 54 | 44 | 34 | 40 | |

as for instance in September and October.

With this in mind it is obvious that the lowest number of species taken per month was in late winter (February: 36, March: 35, April: 33) when sheep were concentrated in relatively few plant associations and when certain preferred species had been largely eliminated from the range. The highest number was observed during August (63), when - theoretically - every species within the range of the population was available. High diversification of use of species was also documented for May (57), June (50), and September (54) because of the sheep's vertical migration during these months, allowing them to make use of species from a great number of plant associations (Table 22).

Similar variations between months were also observed for "stable forages", the few species that make up the bulk of the diet. If 75% of the total forage is used as a reference point (Table 22), then as few as 5 or 6 species added up to that amount during winter, and as many as 11 to 13 during summer.

The total number of species used per month, however, must not be interpreted as quality of forage available. As will be pointed out in the section on "selection", a number of preferred forages are virtually eliminated from the range in early winter and a number of "unpalatable" species become an important element in the diet in late winter. The latter species therefore serve in a compensatory manner, keeping the total number of species used per month at a similar level.

Of the 110 species used over the annual cycle as few as four made up half (51.2%) of the annual forage (Carex filifolia: 15.8%, Artemisia frigida: 14.2%, Calamagrostis purpurascens: 13.2%, and Salix glauca: 8.0%), and as few as 13 made up three-quarters of the annual diet (75.9%). The great

majority of species utilized (71) contributed trace amounts ( 0.1%) each.

Selection of forages:

It is not possible to discuss in detail the importance of each of the 110 species known to be taken by sheep. Attempts have been made to stress variations over the annual cycle in the monthly discussion. At this point only the general trend observed over the year will be dealt with.

Selection can be defined as the use of a species in greater proportion than its abundance (Hoefs, 1974). While this definition holds true when forage utilization is discussed on a monthly basis (particularly for the summer months), a number of other factors enter the equation if the annual trend is investigated. These factors include different phenological stages of different forage species, different rates of drying-up of forage plants in fall, and most of all unavailability of certain forages in winter through deep snow cover. It is therefore at certain times irrelevant how abundant a species is and how much preferred it is by sheep; it may not be available because of snow.

Our observations indicate that among the abundant or common forage species certain ones are preferred to others by all sheep. The use of a given species per month is very much influenced by the phenological stage of the species during that time, both in relation to its annual cycle of growth, flowering, fruiting and drying-up, as well as in relation to the phenological stage of other forage plants at the time. Among the less common species considerable variation between sheep was observed. The great majority of plant species that are eaten to only 0.1% or less (Table 38) fell into this category.

The general monthly picture was therefore as follows: Relatively

few species made up the bulk of the forage for all sheep, these were not necessarily the most abundant ones at the time, and very selective grazing, usually at the end of feeding periods, revealed great individual variation in preference between sheep and resulted in the utilization of a great number of different species to a very small degree. The forage plants of Sheep Mountain can be categorized with respect to their utilization and selection by sheep. This classification is based on several years observations of this herd and of captive animals, not only on the data revealed in Table 38.

a) Relatively few plant species can be referred to as "stable" forage, species that are eaten to a significant degree during most months, and together make up the bulk of the annual diet. In this category belong: Carex filifolia: 15.8%, Artemisia frigida: 14.2%, Calamagrostis purpurascens: 13.2%, and Salix glauca: 8.0%. Into this group also fall the following species, even though they were much less abundant: Agropyron yukonense: 4.4%, Artemisia hyperborea: 3.0%, Eurotia lanata: 1.1% and Rosa acicularis: 1.3%. On a monthly basis differential utilization among them has been discussed. For instance in June and September Salix glauca is preferred to any of the other stable forages. During winter, after vegetation has dried up, Carex filifolia, Agropyron yukonense, and Eurotia lanata are preferred to Artemisia frigida and Calamagrostis purpurascens, which resulted in their depletion near the end of the winter (March and April). In early winter, when much of the preferred forages are still available, only the relatively soft leaves of Calamagrostis purpurascens were taken. In late winter, even the coarse stems were grazed down to the level of the soil.

b) Another group of species can be referred to as "preferred" forages; they are selected far in excess to their abundance. Most of them are forbs and many

of them are members of the leguminosae family. Into this group belong: Oxytropis viscida, Oxytropis huddelsonii, Astragalus williamsii, Poa glauca, Pulsatilla patens, Achillea lanulosa, Artemisia dracunculus, Astragalus nutzotinensis, Hedysarum spp, and Epilobium angustifolium. Selective grazing for them varies between months. In early summer, when green vegetation first becomes available Pulsatilla patens and Oxytropis viscida are taken. During summer on alpine and sub-alpine ranges Oxytropis huddelsonii, Poa glauca, and Oxytropis viscida are heavily used. When returning to low elevations during fall and early winter Astragalus williamsii, Artemisia dracunculus and Achillea lanulosa are preferred forages. The grouping of these species as preferred forages is supported by the fact that they have virtually been eliminated from the range by late winter, and are largely absent from the diet at that time.

c) Another group of species contributes a significant portion to annual forage, particularly in certain months, but this relatively small contribution bears no relationship to the abundance of these plants. Into this category fall the following species: Dryas integrifolia, Salix reticulata, Salix lanata, Salix polaris, and Betula glandulosa. It cannot be said that these species are avoided; Dryas integrifolia for instance is utilized at every month of the year for an annual average of 2.2%. But Dryas integrifolia is the most abundant alpine plant, contributing an estimated 40% to 50% of the standing crop of alpine associations. Together with Salix reticulata and Salix polaris, these three probably make up 70% to 80% of the standing crop. On the other hand, these three species together contributed during August, the month of their highest utilization, only 19.1% of the monthly forage.

d) The following species can be classified as "emergency forages" since they are largely avoided over most of the year, but are fairly heavily taken in

late winter when more preferred plants have been depleted. Into this group belong: Arctostaphylos uva-ursi, Juniperus horizontalis, Artemisia rupestris, Erigeron caespitosus and Pentstemon gormani. All these plants are fairly common on winter ranges, some are co-dominants in certain associations. While some use takes place at other times of the year, this is largely accidental or restricted to certain parts of the plants (for instance, flowers), but in late winter (March and April) these unpalatable species are fairly heavily utilized and make up between 15% and 20% of the total forage.

e) A relatively small group of fairly common plants is completely avoided and any use of them was accidental in nature. These include Picea glauca, Juniperus communis, Shepherdia canadensis, Galium boreale and Linum perenne.

Utilization of broad forage types:

Over the annual cycle grasses and grasslike vegetation make up 46.3% of the forage, forbs: 36.8%, browse: 16.1% and lichens and mosses: 0.8%. In many previous studies - particularly if rumen samples have been the only source of information - a more detailed analysis of forage utilization was not possible. The annual trend in use of those broad forage types has therefore been graphically presented (Figure 39) for comparative purposes.

During the winter months, from October to April inclusive, the distribution of use of these broad forage types was relatively constant, with grasses making up 40% to 50%, forbs 30% to 40%, and browse 10% to 20% of the diet. The contribution of mosses and lichens at this time was negligible. At times of vertical migration (June and September), heavy use was made of willows in the sub-alpine shrub zone, which resulted in the great increase of browselike vegetation in Figure 39, at the expense of grasses and forbs. During mid summer (July and August) sheep utilized alpine elevations above the shrub

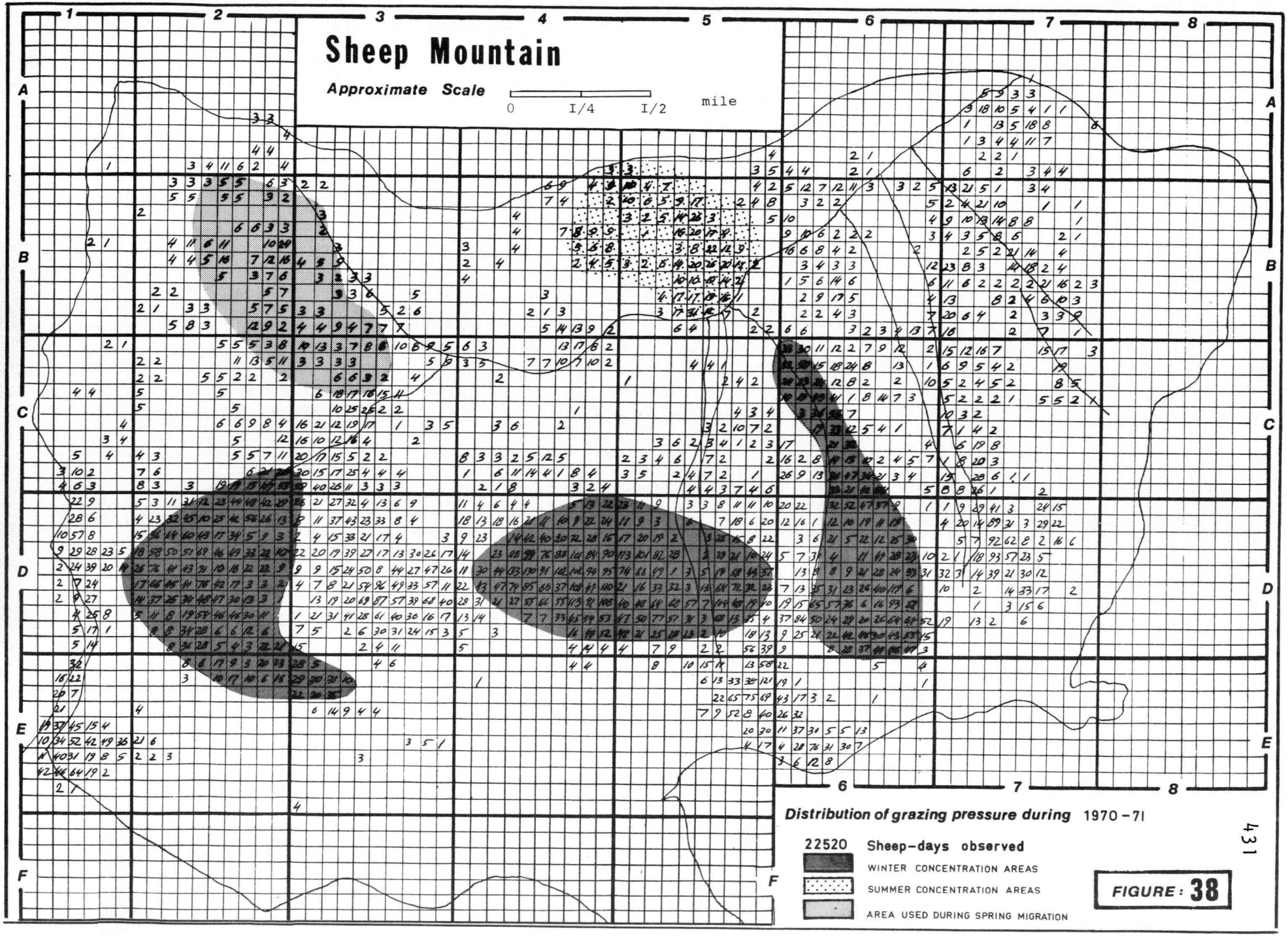
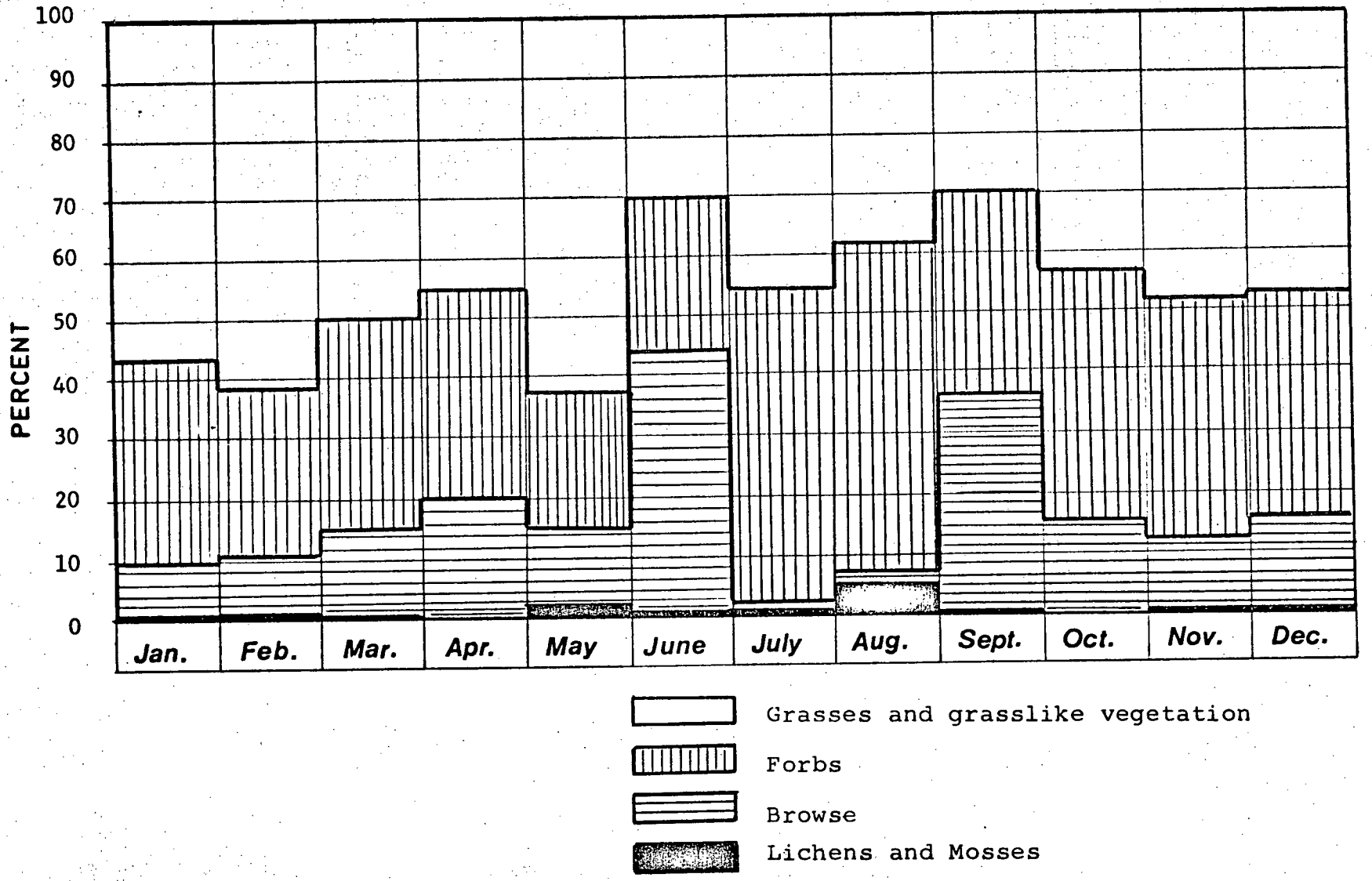

Sheep Mountain
Approximate Scale
0 I/4 I/2 mile
1
2
3
4
5
6
7
8
A
B
C
D
E
F
Distribution of grazing pressure during 1970 – 71
22520 Sheep-days observed
WINTER CONCENTRATION AREAS
SUMMER CONCENTRATION AREAS
AREA USED DURING SPRING MIGRATION

FIGURE: 38

**Figure: 39** **Dall sheep forage composition**



zones; there was therefore no significant use of browse at this time. During these months forbs were, with over 50% utilization, the single most important forage group. Only during August was the contribution of mosses and lichens significant (4.5%).

Comparisons to forage utilization studies in other areas:

The number of studies done on the range use and forage selection of other northern sheep populations is very limited.

The most detailed work was carried out by Dr. R. Hansen, Colorado State University, on contract to the Alaska Department of Fish and Game and has been published in Nichols and Heimer (1972).

Hansen determined forage selection from rumen samples as well as fecal pellets; he also analysed the vegetative composition of the range in order to determine forage selection. Unfortunately this detailed work was done on the Kenai Peninsula which has a milder and moister climate than the Kluane area and therefore a different plant cover. This makes comparisons difficult.

No mention is made of the five species (Carex filifolia, Artemisia frigida, Calamagrostis purpurascens, Salix glauca, and Agropyron yukonense) which make up three-quarters of the annual diet of Sheep Mountain sheep. On the other hand there is a fairly heavy use of such species as Hierochloe alpina, Festuca brachyphylla, Dryas octopetala, as well as mosses and Cladonia species on the Kenai area, while these are of no importance to the Sheep Mountain population or do not even occur in the area.

A few observations made by Hansen, however, are supported by this study. He found that sheep use many species (45) but that very few important ones made up the great bulk of the diet. Sheep are restricted to fewer forage

plants in winter compared to summer and some abundant species (for instance, Dryas spp.) are used very little by sheep.

Some work on forage utilization of Dall sheep was done by Murie (1944) who analysed 75 rumen samples of sheep that died from natural causes in Mt. McKinley Park, and also did direct observations on feeding sheep.

Many of the forage species taken by Mt. McKinley sheep are also part of the diet of Sheep Mountain animals. Murie (1944) found that during winter grasses and sedges made up an average of 81.5% of the diet, which is higher than on Sheep Mountain (50%). Willows were taken at an average monthly rate of 10.2% which is very similar for the Sheep Mountain population (16.1%). In both these areas a number of sages (Artemisia frigida, Artemisia arctica, Artemisia tilesii) are highly palatable, as are several legume species (Oxytropis and Hedysarum spp.). The utilization of berries (Blueberry, Cranberry) as observed by Murie (1944) could not be documented for the Sheep Mountain area. Also in contrast to Sheep Mountain animals those of McKinley Park take Dryas spp. very frequently during the summer months.

Viereck (1963) observed Dall sheep in the Tonzona River and Mt. Hayes area of Alaska from April to November. The forage species taken were only quantified into "occasionally, commonly or abundantly utilized". Viereck (1963) lists a total of 47 food plants, 20 of which were also observed to be taken on Sheep Mountain. Most of them are summer forages and include the following species: Epilobium latifolium, Artemisia arctica, Anemone parviflora, Poa alpina, Achillea borealis, Trisetum spicatum, Salix reticulata, Festuca altaica, and Kobresia myosuroides. A few species listed by Viereck also grow on Sheep Mountain, but their utilization could not be documented: Claytonia sarmentosa, Lloydia serotina, Arctagrostis latifolia, Dodecatheon frigidum and Silene acaulis.

Palmer (1941) lists a few forage plants of Alaskan Dall sheep from the Dry Creek area. Unfortunately, he only uses generic and common names, which makes it difficult to draw comparisons. The following is a direct citation of Palmer's (1941) report: "On spring range, especially cropped by sheep were holy grass (Hierochloe), bunch grass (Festuca), small bunch grass (Deschampsia), blue grass (Poa), awn grass (Trisetum), purple reed grass (Calamagrostis), willows (Salix) and sedges (Carex).

On winter range, plants grazed appeared to be Dryas, willows, ground birch, rose, alder, sage, fireweed, death camass tops, sedges and grasses.

Other plants palatable to sheep include: Rhododendron, boykinia, oxytrope, loco, horsetail, saxifrage, jointpod, blueberry and shrubby cinquefoil. Many other species are no doubt eaten to minor extent".

Detailed work on forage utilization was carried out by the writer (Hoefs, 1974) on a captive herd of Dall sheep over a one-year period. This study was meant to be a "pilot project" for the investigation reported on here. These captive sheep were confined to an enclosure which had a vegetation cover very similar to the Sheep Mountain winter ranges, but the sheep had no access to the sub-alpine shrub zone or to alpine summer ranges. Therefore only winter observations are comparable. During winter the diet of this captive herd was similar to that of the wild population, with the following species being important forage items: Poa glauca, Artemisia frigida, Agropyron yukonense, Calamagrostis purpurascens, Carex filifolia, Achillea lanulosa and Salix glauca. There was also agreement with respect to those species largely avoided by sheep: Shepherdia canadensis, Picea glauca, Betula glandulosa, Arctostaphylos uva-ursi and Galium boreale.

One significant difference was observed though, the captive sheep made considerable use of a moist meadow, whose species composition was similar

to some of the floodplain communities of the Slims River valley at the base of Sheep Mountain. Here they ate such species as Deschampsia caespitosa, Puccinellia deschampsioides and to a lesser degree Hordeum jubatum and Lomatogonium rotatum, all of which are also species of the floodplains. Snow depth was no hindrance, since many of these sites were also subject to removal of snow by strong west winds. The avoidance by sheep of the floodplains is perhaps best explained by the sheep's desire to stay close to escape terrain. On the other hand, the use of floodplains has been observed for Siberian Snow sheep by Egorov (1967) and the writer (Hoefs, 1973, 1974 b) has observed that sheep cross fairly wide river valleys in other areas of the Yukon, and feed while doing so.

Based on vegetation studies (Part 1 of thesis) it can be estimated that the carrying capacity of this winter range would increase by 15% to 20% if sheep would use the floodplain associations. On the other hand, there can be no doubt that this would also significantly increase their winter mortality through predation.

Comparisons with forage utilization by other types of sheep are of limited value, because of the different forage plants involved. However, a few comments dealing with generalities are appropriate.

Egorov (1967) investigated the diet of sheep of the Koryak Uplands (Siberia) through direct observations and anaylses of stomach contents. The following excerpts from this work are relevant for comparative purposes: "The greatest variety of plants (72) is consumed in summer. In spring, 40 different plants are consumed, in autumn, 33, and in winter only 28. Of these, only 11 are eaten throughout the year". These findings are remarkably similar to those made during the present study (Table 44).

Egorov (1967) continues: "...sheep feed throughout the year on

willows (Salix reptans, S. fumosa, S. cuneata, S. reticulata, S. pulchra and others), Ledum and cowberry...Gramineae are eaten mainly in late spring and early summer, until the stems harden...Sheep feed on Potentilla and Artemisia throughout the year...in early spring they eat only the flowers of Eriophorum and Pulsatilla....Table 37 shows that the list of plants eaten includes plants of all zones of vegetation from the floodplains to the mountain tundra".

The diet of these Siberian sheep differs considerably from that of the Sheep Mountain herd in that a number of coniferous species are utilized (Larix sp., Juniperus sp. and Pinus pumila), and in their very high utilization of lichens. Egorov (1967) notes: "...The diet of sheep in Yakutia is characterized by a high proportion of terrestial lichens...they are eaten intensively in autumn, spring and winter. They constitute more than 50% of the stomach contents examined during these seasons".

Judging from the description of the range of these Siberian sheep as well as from the fact that they use forests and floodplains to a considerable degree, it is reasonable to infer that they also come into contact with lichens much more often. The high degree of use of this forage type may therefore not necessarily indicate intentional searching for it.

Luckhurst (1973) determined the forage used by a herd of Stone sheep in northern British Columbia through rumen content analyses and comparisons between open (grazed) and fenced-in (protected) plots. Luckhurst (1973) worked out an "importance index" for forage species, which takes into consideration the abundance of a given species as well as its degree of utilization. The maximum value obtainable was 100. He found that Hordeae (Elymus innovatus and Agropyron subsecundum) achieved an index of 98, Poa spp. of 33.3, Festuca scabrella 0.38 and Kobresia myosuroides of 0.80. Of the forbs, Oxytropis sp. achieved the highest value with 26.0. Most of these species are of no importance

in the diet of Sheep Mountain animals, but Oxytropis spp. (O. viscida and O. huddelsonii) are among the most important forbs. No mention is made by Luckhurst (1973) of Artemisia frigida, perhaps it does not grow in the area. He also reported browse is used frequently in summer and fall, particularly Salix glauca, and the leaves and fruit of Vaccinium uliginosum, Vaccinium vitis-idaea, and Arctostaphylos uva-ursi.

Comparisons to range and forage investigations of Bighorn sheep are of little value, however, there are two aspects in which most researchers agree: Firstly, grasses and grasslike vegetation appears to be the most important forage group for sheep in general, and wherever pasture sage (Artemisia frigida) is an important component in the vegetation cover of a sheep range, it is also an important forage species (Berwick, 1968; Blood, 1967; Sugden, 1961; Cowan, 1947).

General Discussion on the Range Utilization over the Annual Cycle:

Over the cycle of one year from October 1970 to September 1971 the distribution of grazing by sheep was mapped for 22,520 sheep days. The relevant statistics on range utilization are summarized in Tables 21 and 37. Sheep were observed on the average for 20 days per month giving 242 observation days during the year. The average daily number of sheep on the mountain was 93.2, the highest daily average per month was 131.5 for March 1971 and the lowest was 24.7 for July 1971.

The highest number observed on a single day was 164 on April 7th, 1971, and there were a number of days during late June, July and early August when no sheep were using the mountain. The number of sheep days mapped per month varied accordingly being greatest in late winter and lowest in mid summer (Table 21).

Only 33 of the 45 sections mapped were used by the sheep. The use of these 33 sections, on a monthly basis, expressed as numbers of quadrats used per section as well as sheep days per section is given in Table 37. Of these 33 sections the four most heavily used ones provided 49.1% of the feeding areas, and as few as 16 provided 90.7% of the feeding sites.

As an inspection of the vegetation will reveal, the areas not used were: floodplain communities, forests and a few unvegetated steep cliffs in Sections 3B and A6. Table 3 (Part I of thesis) shows that the total size of the area mapped is about 5986 acres (about 9.3 square miles). Floodplain associations and spruce forests make up 510 and 1314 acres respectively, leaving 4162 acres (6.5 square miles) as actual sheep range.

The average density of sheep per month on the area as a whole was 93.2 sheep per 5986 acres (or 10 sheep per square mile). If only the area used is considered the density increases to 14.3 sheep per square mile on an

TABLE: 37 Statistics On Range Utilization (Summary)

| Section Number | January | | February | | March | | April | | May | | June | | July | | August | | September | | October | | November | | December | | Sum of Sheep Days | Percent of Total | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #qua. | #s.d. | #qua. | #s.d. | #qua. | #s.d. | #qua. | #s.d. | #qua. | #s.d. | #qua. | #s.d. | #qua. | #s.d. | #qua. | #s.d. | #qua. | #s.d. | #qua. | #s.d. | #qua. | #s.d. | #qua. | #s.d. | | | |
| 1A | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | 1 | ◇.1 | 30 |
| 2A | | | | | | | | | | | 10 | 48 | | | | | | | | | | | | | 48 | 0.2 | 27 |
| 4A | | | | | | | | | | | | | | | 1 | 3 | | | | | | | | | 3 | ◇.1 | 31 |
| 5A | | | | | | | | | | | | | | | 4 | 15 | | | | | | | | | 15 | 0.1 | 28 |
| 6A | | | | | | | | | | | 4 | 6 | | | 2 | 8 | | | | | | | | | 14 | 0.1 | 29 |
| 7A | 2 | 2 | 1 | 3 | | | | | 3 | 10 | 14 | 57 | 3 | 14 | 2 | 8 | 2 | 3 | 4 | 17 | 5 | 16 | 12 | 42 | 172 | 0.8 | 23 |
| 1B | | | | | | | 2 | 3 | | | | | | | | | | | | | | | | | 3 | ◇.1 | 32 |
| 2B | | | | | | | 4 | 13 | 26 | 132 | 28 | 106 | 2 | 6 | | | | | 8 | 40 | | | | | 297 | 1.3 | 18 |
| 3B | | | | | | | | | 12 | 37 | | | 8 | 17 | 14 | 52 | 3 | 13 | | | | | | | 119 | 0.5 | 25 |
| 4B | | | | | | | | | | | 3 | 6 | 20 | 64 | 22 | 110 | | | | | | | | | 180 | 0.8 | 22 |
| 5B | | | | | | | 14 | 24 | 2 | 4 | 12 | 34 | 41 | 263 | 44 | 219 | | | 5 | 33 | | | | | 577 | 2.6 | 11 |
| 6B | 2 | 5 | 2 | 5 | 3 | 7 | 9 | 16 | 9 | 28 | 9 | 25 | 7 | 25 | 31 | 159 | 4 | 9 | 4 | 9 | 3 | 6 | 6 | 27 | 321 | 1.4 | 17 |
| 7B | 11 | 28 | 17 | 55 | 4 | 9 | 13 | 41 | 27 | 82 | 25 | 57 | | | | | 3 | 7 | 9 | 45 | 15 | 80 | 11 | 73 | 477 | 2.1 | 13 |
| 1C | 1 | 2 | | | | | 5 | 19 | 1 | 2 | 8 | 25 | | | | | | | 3 | 11 | | | | | 59 | 0.3 | 26 |
| 2C | 1 | 6 | | | | | 14 | 90 | 17 | 71 | 19 | 105 | 2 | 3 | 2 | 5 | 6 | 57 | 13 | 67 | 2 | 16 | 1 | 2 | 422 | 1.9 | 15 |
| 3C | 3 | 16 | | | | | 34 | 191 | 31 | 141 | 25 | 130 | 20 | 68 | 3 | 8 | 23 | 139 | 8 | 40 | 1 | 1 | 2 | 8 | 742 | 3.3 | 10 |
| 4C | | | 2 | 6 | | | | | 18 | 51 | 5 | 16 | 12 | 55 | 18 | 41 | 11 | 48 | | | 3 | 5 | | | 222 | 1.0 | 20 |
| 5C | | | | | | | 10 | 17 | 17 | 48 | 5 | 10 | | | | | 19 | 54 | 6 | 11 | 4 | 11 | 2 | 4 | 155 | 0.7 | 24 |
| 6C | 11 | 44 | 25 | 166 | 9 | 27 | 18 | 38 | 19 | 51 | 15 | 45 | | | 11 | 81 | 40 | 326 | 24 | 187 | 23 | 146 | 17 | 98 | 1209 | 5.4 | 6 |
| 7C | 13 | 49 | 18 | 54 | 9 | 24 | 26 | 80 | 13 | 19 | 11 | 43 | | | | | 9 | 22 | 1 | 7 | 5 | 16 | 14 | 62 | 376 | 1.7 | 16 |
| 1D | 16 | 64 | 21 | 160 | 19 | 83 | 15 | 53 | 14 | 48 | 8 | 25 | | | | | | | 6 | 28 | | | | | 461 | 2.0 | 14 |
| 2D | 36 | 192 | 56 | 511 | 53 | 409 | 44 | 309 | 37 | 162 | 25 | 94 | 3 | 4 | | | 38 | 227 | 42 | 281 | 30 | 196 | 29 | 210 | 2595 | 11.5 | 2 |
| 3D | 10 | 56 | 30 | 173 | 29 | 226 | 26 | 220 | 43 | 216 | 32 | 175 | | | | | 52 | 433 | 36 | 264 | 25 | 200 | 16 | 139 | 2102 | 9.3 | 5 |
| 4D | 34 | 406 | 29 | 308 | 41 | 655 | 35 | 360 | 40 | 218 | 23 | 152 | | | | | 47 | 432 | 35 | 353 | 34 | 410 | 27 | 290 | 3584 | 15.9 | 1 |
| 5D | 29 | 252 | 35 | 320 | 33 | 325 | 40 | 320 | 57 | 320 | 24 | 76 | | | | | 35 | 215 | 32 | 354 | 24 | 137 | 26 | 170 | 2489 | 11.1 | 3 |
| 6D | 31 | 182 | 47 | 275 | 52 | 355 | 41 | 110 | 46 | 258 | 26 | 142 | | | | | 21 | 62 | 36 | 370 | 27 | 170 | 41 | 467 | 2391 | 10.6 | 4 |
| 7D | 34 | 360 | 28 | 134 | 17 | 74 | 16 | 75 | 23 | 73 | 8 | 29 | | | | | 4 | 10 | 8 | 78 | 8 | 33 | 23 | 171 | 1037 | 4.6 | 7 |
| 1E | 23 | 159 | 19 | 83 | 25 | 189 | 14 | 84 | 20 | 103 | 3 | 12 | | | | | | | 10 | 55 | | | 12 | 66 | 751 | 3.3 | 8 |
| 2E | 9 | 61 | 3 | 8 | 2 | 6 | 3 | 7 | 10 | 39 | 2 | 10 | | | | | 9 | 56 | | | | | 2 | 7 | 194 | 0.9 | 21 |
| 3E | 10 | 67 | 1 | 1 | 15 | 70 | 10 | 31 | 11 | 38 | | | | | | | 2 | 10 | 2 | 22 | 2 | 9 | 3 | 25 | 273 | 1.2 | 19 |
| 4E | | | 2 | 8 | | | | | 1 | 1 | | | | | | | | | | | | | | | 9 | ◇.1 | 33 |
| 5E | 4 | 31 | 5 | 25 | 15 | 167 | 15 | 115 | 10 | 61 | | | | | | | | | 17 | 230 | 1 | 3 | 6 | 112 | 744 | 3.3 | 9 |
| 6E | 14 | 87 | 2 | 5 | 19 | 135 | 10 | 60 | 10 | 30 | 2 | 4 | | | | | | | 9 | 44 | 3 | 5 | 13 | 108 | 478 | 2.1 | 12 |
| SUM | 292 | 2067 | 342 | 2300 | 344 | 2761 | 417 | 2276 | 517 | 2243 | 346 | 1432 | 118 | 515 | 153 | 709 | 326 | 2119 | 318 | 2546 | 215 | 1460 | 263 | 2081 | 22520 | 100% | |

#qua. = number of quadrat per section utilized.
#s.d. = number of sheep days per section observed.

annual basis.

These density figures per year, however, are unrealistic since the sheep used a much larger area during the summer and fall. It is therefore more appropriate to deal with winter densities, the time when up to 80% of the population is concentrated on the area mapped.

The six month period from December to May is the most realistic, since by early December sheep have returned to the mountain after the rutting period, and no major migration off the area has taken place by the end of May. The average number of sheep on the mountain during this interval was 113.2, giving densities of 12.2 sheep per square mile for the entire mapped area and 17.4 sheep per square mile for the area utilized for the six month winter period.

Sheep, however, were not uniformly distributed over the mountain, and as has been pointed out, almost 50% of all grazing was concentrated in four sections. The winter density on these four sections (4D, 2D, 5D, 6D) was determined to be 46 sheep per square mile for the six month period.

Figure 38 summarizes the distribution of grazing areas for the entire year. It shows the winter and summer concentration areas and also an area occupied by willow communities along Sheep Mountain's west slope, which is fairly heavily used by rams during the vertical spring migration in late May and throughout June.

Over the annual cycle sheep used a total of 23 plant associations, of which only 5 provided 90% of the forage (Table 20). Of these 23 associations, only 2 [Agropyretum violacei and Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Carietum filifoliae] were used every month of the year for an average rate of 4% each. These associations are at alpine and sub-alpine altitudes. Most alpine associations were used only from June to October, but

one [Salico (reticulatae) - Sileno (acaulis) - Carico (scirpoideae) - Dryadetum integrifoliae], which is most widely distributed and provided almost 50% of the grazing sites during July and August, received some utilization in every month except in March, and had an average grazing rate of 11.0% per year, the third most important community.

The sub-alpine willow associations receive some use every month, except during July and August when the sheep were found at higher elevations. During times of vertical migrations these willow sites provided 39.8% and 33.5% of the feeding areas during June and September respectively (Table 20). The willow association Arctostaphylo (rubrae - uva-ursi) - Festuco (altaicae) - Salicetum reticulatae - glauca was used at an average rate of 10.2% for the year and ranked at fourth place among the 23 plant associations with respect to grazing by sheep.

During winter, which in the study area lasts 7 to 8 months, the emphasis of grazing was on dry grassland associations in all three altitudinal biogeoclimatic zones, even though those of the boreal zone were most heavily used. Almost 57% of all forage taken over the year came from the following three associations: Pentstemono (gormanii) - Artemisio (frigidae) - Agropyretum yukonensis: 36.1%, Agropyro (yukonensis) - Artemisietum frigidae - rupestris: 13.5%, and Calamagrostido (purpurascentis) - Arctostaphyletum uvae-ursi: 7.4%. The sub-alpine association, Oxytropo (viscidae) - Artemisio (hyperboreae - frigidae) - Caricetum filifoliae and the alpine association Oxytropo (viscidae) - Artemisio (hyperboreae) - Festuco (brachyphyllae) - Trisetetum spicati were grazed at a rate of 4.0% and 4.2% respectively (Table 20).

Sex - specific range use:

Throughout the discussions on range use over the annual cycle reference was made to the percentage of mixed bands observed, culminating during the rutting season, when practically all the bands observed consisted of nursery sheep as well as mature rams, and being lowest during the summer months when there was a more or less complete segregation of sexes.

Unfortunately our intensive study of range use was limited to Sheep Mountain, which includes only a fraction of the total summer range of this population (Figure 1). However, observations made during studies on phytosociology and sheep feeding behaviour, as well as during many survey flights which extended over the entire range of this population, indicate that particularly during the summer months certain portions of the area are exclusively used by either mature ram bands or nursery bands.

The entire drainage of Sheep Creek to its headwaters, the adjacent highlands to the north, referred to as 'summer range' on Figure 1, north to the headwaters of Congdon Creek have during the time of our study only been used by rams. On the other hand, the entire northeast slope of this range, including the drainage of Williscroft Creek north to the mouth of Congdon Creek have during the summer months been exclusively used by nursery bands. The two areas indicated on Figure 1 as 'heavily-used summer ranges' are primarily used by nursery bands (90% of all sheep observed), even though some mixing does take place at certain times.

On winter ranges, which are much smaller in extent than summer ranges, exclusive use by one sex is much more difficult to accomplish. Some areas, however, were exclusively used by one sex, and a number of others were primarily used by one sex. On the Williscroft Creek winter range only nursery bands were observed, except during the rutting season. On the other hand, the

winter range along Sheep Creek (Sections 1C, 1D, 1E) was exclusively utilized by rams. A number of small patches of grasslands at low elevations in Section 7D (Sheep Mountain east slope) was also only used by rams. The fact that these two sites were not used at all during the month of November, when rams are seeking nursery bands, support the claim of these sites being ram winter ranges.

The north slope of Sheep Mountain (Sections 4B, 5B, 6B) was during the summer months exclusively utilized by nursery bands. The heavily used winter range on Sheep Mountain's large south-east slope (Sections 4D, 5D, 6D) was up to 80% used by nursery bands, except during the rutting season. On the other hand, Sheep Mountain's west slope (Sections 2B, 2C, 2D) was up to 80% utilized by rams, except during the rutting season, while the east slope was up to 80% (Sections 7A, 7B, 7C) utilized by nursery sheep.

As already pointed out, sheep have specific areas where they venture to very low elevations. These areas have, either a very favourable, close association of wind-blown exposed patches of grassland with escape terrain (Figure 40), or they are the sites of mineral licks (Figure 15).

Rams descend to elevations as low as 2800 feet along Sheep Creek and use this area very heavily during late winter (Figure 40). They also descend to about 2900 feet at the bases of larger cliffs in Section 7D. Nursery bands and occasionally rams reach lowest elevations at the base of Sheep Mountain near the old cabin (Sections 5E and 6E). Here they occasionally come down to the Alaska Highway (+ 2600 feet). This area is the site of several mineral licks and offers some escape terrain in the form of steep road cuts. Perhaps escape terrain in this particular area may not be as important because of the traffic on the Alaska Highway and the tendency of wolves to avoid people.

The relationship of this sheep population to its winter range:

An inspection of Figure 38, showing the distribution of grazing over Sheep Mountain during 1970/71, and a comparison with the vegetation map (Part I of thesis) will reveal that sheep used almost all the available area, even though great differences were observed between sites in intensity of use.

Both intrinsic and extrinsic factors were found to influence the "strategy" of range use as the following summary will reveal.

The proximity of a feeding area to escape terrain is of great importance in determining the intensity of use. Almost all areas that are grazed heavily at low elevation (boreal zone) have escape terrain nearby (Figure 40). Exceptions are areas around mineral licks, or large open expanses on which the approach of predators can be noticed over a reasonable distance. The most heavily used sites were grasslands and scree slopes above treeline (Figure 31) at the bases of cliffs. Of great importance also are the locations of preferred bedding sites, which are often found along canyons or on elevated spots, allowing surveillance of the surroundings. Sheep return to such sites in the evenings and sometimes for the mid-day "siesta", and they feed while walking to those sites as well as when leaving them. As a result of this the vegetation around such sites has been greatly depleted and may even be lacking. Similar observations were made in the grazing behaviour of the European Ibex (Nievergelt, 1966).

Major shifts of grazing from one portion of the winter range to another could almost always be attributed to external stimuli. In addition to such factors as wind, temperature and snow, which have been dealt with, there were a number of occasions when predators and in a few instances also people were found responsible. It is therefore reasonable to say that the

Figure 40: Sheep Creek slopes - a heavily utilized winter range. Notice the close association of escape terrain and grassy slopes.

Figure 41: The large "saddle" on the west slope of Mt. Wallace (centre) and the north slope of Sheep Mountain (on the right) - a heavily used summer range of this population.

predators helped to distribute the grazing more evenly over the mountain. In a few cases it was noticed that the sheep "on their own" left an area where they had been grazing for four to six days previously.

In certain instances behavioural phenomena aid in the distribution of grazing pressure. During May pregnant ewes isolate themselves from the nursery bands and ascend into cliffs to give birth and remain there for a few days after with their new-born lamb. During this time considerable use is made of the sparse vegetation around such lambing areas.

During the rut sheep were occasionally found to feed in areas which they do not use except during this time.

Reference has been made to the exclusive use of certain areas by either ram or nursery bands. Since the ratio of members of nursery bands to members of ram bands is around 2:1, there is also a greater grazing pressure on areas occupied by nursery bands.

The question as to what constitutes good summer range was not investigated during this study. I observed, however, that at any season some areas are preferred over others and are more intensively used. The most favoured summer range of this population is shown in Figure 41. It is likely that the proximity to escape terrain is also important at this time of the year.

One of the original objectives of this investigation - to examine the basis for the high carrying capacity of this mountain - can largely be explained by the diversity and interspersion of vegetation types and escape terrain. Sheep Mountain has almost two square miles of winter range vegetation (dry grasslands) and about 90% of it is available to sheep because of proximity to escape terrain, or because it constitutes large, open areas.

If the intensity of use is expressed as sheep per square mile during

winter, Sheep Mountain is not different from many other good sheep ranges. Equally heavy utilized winter ranges have since been catalogued for other areas in Kluane Park and for other areas in the southern Yukon (Hoefs, 1973, 1974b, 1975). Some densities have also been published for other sheep ranges.

Murie (1944) estimated that there were between 5000 and 10000 Dall sheep in Mt. McKinley Park during the peak year of 1928, wintering on ranges of about 200 to 250 square miles in size. Densities were therefore between 25 and 50 sheep per square mile, and considerably higher if the winter ranges would not include cliffs, scree slopes and other sites which don't produce much forage.

Blood (1967), working on California bighorns in British Columbia, remarks: "The herd consisted of 250 to 300 sheep in 1962 and its maximum range was about 200 square miles. During winter the majority of the herd may be concentrated on less than 5 square miles of key winter range." The winter density was therefore 50 to 60 sheep per square mile.

Wishart (1958), studying Rocky Mountain bighorns in Alberta, states: "On the Sheep River 350 acres of grasslands associated with escape terrain are utilized by an average of 62 sheep each winter." This winter density was therefore 114 sheep per square mile.

Cowan (1947b) lists winter densities for Jasper Park as 30 to 40 wild ungulates per square mile.

Considerable information on this subject is contained in Stelfox (1974). He lists winter densities for the period of 1966 to 1973 in Jasper Park at 81 ungulates per square mile, and for Waterton Park at 37.5 ungulates per square mile.

In the latter two references "ungulates" are not only sheep, but also elk and mule deer, but sheep are the most numerous. For comparisons,

it was mentioned earlier that winter densities on Sheep Mountain averaged 17.4 sheep per square mile and were as high as 46.0 sheep per square mile on preferred ranges.

There is no doubt that winter ranges in southern Canada produce more forage and have therefore a higher carrying capacity. On the other hand, these areas are also subject to more competition by other herbivores compared to Sheep Mountain. It is therefore reasonable to say that the winter densities observed on Sheep Mountain are comparable to those of other good sheep winter ranges and are not "unusual".

It is difficult to discuss the concept of "carrying capacity" of the area, since our intensive research of range use was limited to one year and since all the criteria used to describe such indices as, for instance, "over-grazing" have been developed for "southern" ranges and may not necessarily apply here.

There is no doubt that certain portions of the winter range on Sheep Mountain are over-grazed, by whatever standards "over-grazing" may be defined, and there are other sites which could be used more than they are now. However, most of these sites do not have a very favourable location with respect to escape terrain.

Evidence has been presented to the effect that the maximum number of sheep has been between 150 and 200 adult animals for a great many years. Since they have not built up to higher numbers in spite of periods of intensive predator controls and of recent periods of complete protection from human persecution would indicate that 150 to 200 adult sheep is the carrying capacity of this winter range. To maintain this carrying capacity it is of utmost importance that the sheep engage in the annual vertical migration to alpine summer ranges. While sheep leave the winter range for only a

relatively short time (some nursery sheep are absent for only 2 months), they do so at the most critical period as far as the plant growth on the winter range is concerned. It allows the plants to complete their annual life cycle, to set seed, to store energy in the root system to be able to initiate new growth the following spring.

While this investigation was not a population study as such, since a number of parameters have not been looked into, our observations allow us to make some general comments. Evidence has been presented of this population maintaining itself at a relatively stable level for many years. This observation contradicts conclusions reached by Stelfox (1974), that sheep can not "regulate" their numbers, but build up to levels in excess of the carrying capacity of their range, and are therefore subject to periodic die-offs. As far as is known, these die-offs of bighorn populations are caused by malnutrition as a result of poor range conditions, with lungworm-pneumonia infestations being the ultimate cause of death.

Die-offs of this nature have so far not been observed in any Dall sheep populations. Alaska sheep, however, are subject to occasional declines as a result of severe winters. Neither of these phenomena have so far been found in Yukon.

The mechanisms keeping the Sheep Mountain population stable are at present not known, but some factors can be ruled out, and with respect to some others speculations are justified.

As already elaborated upon earlier, we have no evidence that diseases, parasites or winter weather have been of any importance to this population. Intensive predator controls in the early 1950's have certainly been a factor allowing a severely depleted population to recover more quickly. But once the optimum of 150 to 200 adult sheep was reached, predator persecution or

the lack of it appears to have had no further influence.

It appears that the population is kept stable, primarily through variations in the lamb crops, with emigration of young animals being perhaps a corollary factor in certain years.

Limited information suggests that the lamb crops are influenced by the nutritional status of the ewes during winter, which in turn is influenced by the forage production of the winter range the previous season. It is realized that this hypothesis contradicts findings made by Cowan (1947a) and Stelfox (1974), who documented that the natality rates of bighorn sheep did not decrease with deteriorating range conditions, on the other hand, Wishart (1958) concluded: "Malnutrition in pregnant females is synonymous with resorbtion, abortion, still-born and early mortality of the young".

Limited evidence also suggests that the annual forage production of the xerophytic vegetation on the winter range is largely determined by the amount of moisture available, and not by the length of the growing season with respect to favourable temperature.

If this hypothesis proves correct, it may - after a number of years of observations - be possible to predict the lamb crop from the precipitation data of the previous season if the population is maintained at carrying capacity levels.

Management recommendations:

It was one of the objectives of this study to come up with recommendations which would help the Game Branch in the conservation and management of this species. Out of the analyses of population dynamics data and related investigations on horn growth, came three issues with practical implications; the first one dealing with sheep censuses and classifications, the second dealing with horn growth characteristics and the third with optimizing of harvests.

Observations made during game surveys in other areas of the Kluane Game Sanctuary (Hoefs, 1973) and in areas of the south-central Yukon (Hoefs, 1974b) indicate that the Sheep Mountain population does not differ in productivity and horn growth characteristics from other populations in the southern Yukon and that management recommendations are therefore applicable to such populations.

a) Sheep Censuses and Classifications:

As pointed out by Nichols and Erickson (1969), it is not possible to obtain an accurate classification of all segments of a sheep population during any one count in one season. It was mentioned earlier that accurate determination of the number of lambs born in a population can only be made by being present on the lambing grounds continuously throughout the lambing period. Yearlings are best counted in late winter shortly before the new lambing period starts. Accurate ram to ewe ratios can only be established after repeated classified counts. However, extensive surveys are usually limited to one count per year for economic reasons.

Even though it is important to know the winter ranges of sheep populations, more accurate surveys — particularly aerial surveys — are

possible in summer when all sheep are above timberline and above the sub-alpine shrub zone. Such surveys should be done as late in summer as possible when the snow has melted but before new snow falls. In the southern Yukon, the most appropriate time is the second half of July and the first half of August.

Aerial surveys do not lend themselves to great detail in classification; however, when encountering nursery bands, it is always possible to separate lambs of the year from "adult" members of such bands (ewes, young rams, yearlings). In small bands it is often also possible to separate out the young (2 to 3 year old) rams. Members of ram bands should be separated into at least two groups: legal rams and younger animals. Under present Yukon legislation a legal sheep is defined as a ram whose horn curl circumscribes an angle of 270° or more.

To determine the age at which rams become legal, 13 sets of unbroomed horns were measured by methods described in Erickson (1970). It was found that most rams become legal during their sixth growing season (5 to 6 year age group), while some already reach that state at the end of their fifth growing season (4 to 5 age group). Since most hunting takes place in August and September, while the horn growing season is still in full swing, it is reasonable to say that few if any rams in their fifth growing season are legal during those months (Table 40b). Measurements of over 200 sheep skulls by the Yukon Game Branch in fall of 1973, support the data of Table 40b, as long as the skulls originated in the southern Yukon. In the north, for instance in the Ogilvie Mountains, it appears that it takes the rams one year longer to reach legal size. Table 40b shows that "degree curl" is an accurate method to classify rams up to the age of five years. From then on it becomes progressively less reliable

TABLE: 40a

Horn Statistics of Dall rams from the Kluane Game Sanctuary

| Collection No. | Years of complete increments | Cause of death + natural; - other | Time of death | Circumference at base (cm) | Annual increments in horn growth in cm. (centimeters) (Only complete increments are considered) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| C 35 | 13 | + | - | 31.8 | - | - | 14.0 | 13.0 | 9.8 | 8.0 | 5.2 | 4.5 | 3.8 | 1.7 | 1.2 | .6 | .5 |
| A 60 | 13 | + | - | 33.7 | - | - | 19.2 | 14.5 | 12.8 | 9.5 | 7.0 | 5.0 | 3.1 | 3.0 | 2.0 | 1.6 | 1.6 |
| C 47 | 12 | + | Winter /71/72 | 33.5 | - | 22.0 | 18.7 | 15.4 | 11.6 | 9.3 | 6.0 | 5.1 | 3.8 | 2.2 | 1.5 | 1.2 | |
| C 21 | 12 | + | - | 31.8 | - | 20.6 | 16.5 | 10.2 | 9.5 | 6.6 | 6.4 | 5.4 | 5.1 | 3.5 | 2.6 | 1.8 | |
| C 3 | 12 | + | - | 31.1 | - | - | 17.8 | 13.3 | 12.7 | 6.7 | 5.1 | 3.1 | 3.5 | 2.5 | 1.6 | - | |
| A 80 | 12 | + | Oct. '72 | 31.5 | - | - | 17.8 | 13.0 | 9.2 | 7.0 | 5.1 | 2.8 | 2.8 | 1.6 | 1.0 | 0.6 | |
| A 79 | 12 | + | Winter /72/73 | 33.7 | - | - | 21.6 | 14.0 | 11.5 | 7.6 | 4.7 | 2.5 | 1.9 | 1.6 | 2.8 | 1.9 | |
| A 83 | 12 | + | Winter /72/73 | 31.5 | - | - | 17.8 | 12.3 | 8.0 | 6.5 | 3.5 | 2.2 | 2.8 | 1.7 | 1.2 | - | |
| A 38 | 12 | + | - | 32.4 | - | - | 19.1 | 17.1 | 13.0 | 10.8 | 7.0 | 5.1 | 2.5 | 1.9 | 1.6 | 0.6 | |
| A 8 | 12 | + | Winter /69/70 | 34.3 | - | - | 18.1 | 14.0 | 12.4 | 10.2 | 6.4 | 5.4 | 4.1 | 2.8 | 1.3 | 1.0 | |
| A 37 | 11 | + | - | 33.0 | - | - | 18.1 | 13.7 | 8.9 | 7.3 | 4.4 | 3.1 | 2.2 | 1.6 | - | | |
| A 25 | 11 | + | - | 34.0 | - | - | 18.1 | 15.5 | 11.8 | 7.9 | 4.7 | 5.1 | 2.2 | 2.2 | - | | |
| A 13 | 11 | + | - | 33.0 | - | - | 19.1 | 14.9 | 13.3 | 11.2 | 8.6 | 6.7 | 4.4 | 2.5 | - | | |
| A 9 | 11 | + | - | 33.0 | - | - | 16.5 | 15.2 | 13.3 | 8.6 | 6.4 | 4.7 | 2.2 | 2.2 | 1.6 | | |
| A 4 | 11 | + | Feb. '70 | 35.6 | - | - | 23.5 | 16.5 | 10.8 | 7.6 | 3.1 | 2.2 | 2.2 | 1.9 | 1.6 | | |
| B 13 | 11 | + | - | 32.4 | - | - | 21.6 | 13.0 | 12.1 | 8.9 | 6.4 | 3.8 | 4.1 | 2.5 | - | | |
| B 6 | 11 | + | - | 30.8 | - | - | 19.1 | 12.7 | 10.8 | 7.6 | 6.1 | 5.1 | 4.4 | 2.5 | - | | |
| A 31 | 11 | - | Sept. '70 | 34.3 | - | - | 18.8 | 14.9 | 11.8 | 7.6 | 5.7 | 4.4 | 3.8 | 3.1 | - | | |
| A 46 | 11 | - | Feb. '71 | 34.0 | - | 21.3 | 18.1 | 12.7 | 9.8 | 6.7 | 5.4 | 4.7 | 3.5 | 2.2 | 1.0 | | |
| A 48 | 11 | - | March '71 | 31.8 | - | 23.9 | 18.1 | 13.3 | 10.2 | 5.7 | 5.1 | 4.4 | 4.1 | 3.1 | 2.2 | | |
| A 62 | 11 | - | June '71 | 35.6 | 10.2 | 26.4 | 19.3 | 15.8 | 9.5 | 7.0 | 3.8 | 3.5 | 1.9 | 2.6 | 1.6 | | |
| A 78 | 11 | + | Winter /72/73 | 31.8 | - | - | 17.8 | 13.7 | 8.6 | 7.0 | 4.4 | 2.5 | 2.5 | 3.5 | 2.5 | | |
| A 64 | 11 | + | Winter /70/71 | 34.0 | 7.6 | 25.5 | 19.0 | 12.7 | 9.5 | 6.3 | 4.5 | 4.2 | 2.8 | 2.8 | 1.9 | | |
| C 40 | 11 | + | - | 36.0 | - | 23.0 | 17.6 | 13.2 | 10.0 | 7.0 | 5.2 | 3.1 | 3.7 | 2.4 | 1.5 | | |
| C 38 | 11 | + | Winter /71/72 | 32.3 | - | 21.0 | 17.8 | 13.3 | 9.0 | 7.8 | 4.8 | 4.4 | 2.8 | 2.8 | 1.5 | | |
| C 25 | 11 | + | - | 32.1 | - | - | 16.2 | 11.2 | 11.2 | 8.6 | 8.6 | 6.1 | 4.1 | 3.5 | - | | |
| C 19 | 11 | + | - | 31.8 | - | - | 18.4 | 13.7 | 11.5 | 6.7 | 5.1 | 3.8 | 3.8 | 2.5 | 1.9 | | |
| A 10 | 10 | + | April '69 | 31.8 | - | - | 14.9 | 12.7 | 11.5 | 7.9 | 5.1 | 4.4 | 3.5 | - | | | |
| A 5 | 10 | - | Feb. '70 | 34.3 | - | - | 22.9 | 17.4 | 12.1 | 7.0 | 4.4 | 4.1 | 3.5 | 2.2 | | | |
| B 19 | 10 | + | - | 35.6 | - | 25.4 | 18.8 | 15.2 | 12.4 | 6.7 | 6.4 | 4.4 | 2.8 | - | | | |
| B 11 | 10 | + | - | 32.4 | - | - | 22.5 | 14.3 | 10.8 | 6.1 | 4.1 | 2.8 | 1.9 | - | | | |
| B 4 | 10 | + | - | 28.5 | - | - | 18.1 | 14.9 | 12.7 | 8.2 | 5.1 | 2.8 | 1.6 | - | | | |
| C 46 | 10 | + | Winter /71/72 | 30.0 | - | 20.0 | 16.8 | 14.5 | 13.0 | 5.0 | 3.2 | 3.4 | 3.4 | 4.8 | | | |
| A 30 | 10 | - | Sept. '70 | 33.6 | 8.6 | 21.9 | 17.8 | 10.2 | 6.7 | 5.1 | 4.7 | 3.8 | 2.2 | - | | | |
| A 57 | 10 | - | Oct. '70 | 33.7 | - | 25.4 | 20.0 | 14.3 | 11.8 | 7.6 | 5.7 | 3.1 | 2.8 | - | | | |
| A 75 | 10 | + | Nov. '72 | 30.8 | 5.7 | 21.3 | 17.4 | 15.2 | 9.8 | 10.2 | 6.7 | 6.4 | 5.1 | 3.8 | | | |
| A 70 | 10 | + | Fall '70 | 31.5 | - | 19.1 | 15.8 | 12.4 | 11.7 | 8.2 | 5.7 | 5.7 | 5.1 | - | | | |
| A 67 | 10 | + | Winter /70/71 | 35.9 | - | 21.9 | 15.5 | 13.7 | 11.4 | 8.9 | 7.3 | 5.4 | 3.7 | 2.5 | | | |
| A 65 | 10 | + | - | 30.5 | 7.6 | 22.8 | 17.1 | 13.0 | 12.8 | 7.1 | 5.3 | 4.8 | 2.8 | 2.2 | | | |
| A 42 | 10 | + | Nov. '70 | 31.8 | 7.3 | 22.5 | 15.2 | 14.0 | 10.5 | 8.9 | 7.6 | 6.7 | 4.1 | 3.5 | | | |
| C 39 | 10 | + | Winter /71/72 | 32.8 | - | 21.0 | 15.0 | 9.0 | 7.2 | 6.0 | 6.3 | 5.5 | 5.0 | 2.7 | | | |
| C 29 | 10 | + | - | 31.1 | - | - | 16.8 | 11.5 | 10.2 | 5.1 | 4.1 | 2.8 | 2.2 | 1.3 | | | |
| C 17 | 10 | + | - | 31.1 | - | - | 17.1 | 11.5 | 10.6 | 8.2 | 7.6 | 4.7 | 3.1 | 3.1 | | | |
| C 16 | 10 | + | - | - | - | 26.0 | 18.1 | 13.0 | 11.2 | 8.2 | 5.7 | 2.8 | 2.5 | 2.2 | | | |
| C 2 | 10 | + | - | 31.1 | - | - | 16.8 | 11.5 | 10.2 | 5.1 | 4.1 | 2.8 | 2.2 | - | | | |
| C 34 | 9 | + | - | 35.4 | - | - | 18.0 | 15.2 | 8.7 | 7.2 | 5.4 | 4.1 | - | | | | |
| A 23 | 9 | - | Fall '69 | 30.8 | - | - | 19.4 | 14.6 | 9.5 | 6.4 | 6.1 | 4.4 | 3.8 | | | | |
| A 22 | 9 | + | - | 32.4 | - | - | 19.1 | 13.7 | 11.5 | 8.9 | 7.6 | 5.7 | - | | | | |
| A 7 | 9 | + | Winter /69/70 | 32.1 | - | - | 19.7 | 14.3 | 10.2 | 5.7 | 4.7 | 3.5 | 2.2 | | | | |
| B 12 | 9 | + | - | 31.1 | - | 24.8 | 13.3 | 12.1 | 9.5 | 7.3 | 5.7 | 3.8 | 2.5 | | | | |
| B 10 | 9 | + | - | 30.5 | - | - | 15.5 | 16.5 | 18.1 | 12.4 | 8.6 | 6.1 | - | | | | |
| B 5 | 9 | + | - | 32.4 | - | - | 18.4 | 15.2 | 11.5 | 9.2 | 6.4 | 6.1 | - | | | | |
| A 29 | 9 | - | Sept. '70 | 35.9 | - | 26.0 | 16.2 | 14.6 | 11.2 | 9.5 | 6.1 | 3.8 | - | | | | |
| A 45 | 9 | + | Jan. '71 | 32.7 | - | 23.5 | 19.4 | 15.2 | 12.7 | 8.9 | 6.1 | 5.1 | 3.1 | | | | |
| A 76 | 9 | + | Winter /72/73 | 35.6 | - | 20.9 | 20.0 | 13.0 | 11.2 | 11.2 | 8.2 | 5.4 | 3.1 | | | | |
| A 77 | 9 | + | Winter /72/73 | 35.0 | - | 24.8 | 19.1 | 14.6 | 12.1 | 10.2 | 7.0 | 4.7 | 2.5 | | | | |
| A 81 | 9 | + | Winter /72/73 | 34.0 | - | - | 17.8 | 12.4 | 10.2 | 8.2 | 5.4 | 5.4 | 3.1 | | | | |
| A 69 | 9 | + | Fall '70 | 31.1 | - | 20.0 | 16.8 | 13.3 | 7.6 | 6.7 | 7.0 | 4.1 | - | | | | |
| A 68 | 9 | + | Winter /70/71 | 34.9 | - | 19.7 | 15.5 | 11.1 | 10.8 | 10.2 | 5.1 | 4.1 | 3.7 | | | | |
| A 66 | 9 | + | Winter /70/71 | 32.1 | - | - | 16.8 | 10.2 | 8.5 | 7.0 | 6.3 | 6.0 | 5.1 | | | | |
| A 54 | 9 | + | Winter /70/71 | 29.8 | 7.6 | 16.5 | 14.9 | 11.8 | 9.5 | 5.1 | 4.7 | 3.5 | 4.4 | | | | |
| C 48 | 9 | + | Winter /71/72 | 31.5 | - | - | 16.0 | 15.2 | 14.0 | 12.0 | 7.0 | 5.8 | 4.2 | | | | |
| A 1 | 8 | + | Winter /69/70 | 31.8 | 10.2 | 21.6 | 17.1 | 12.1 | 10.5 | 7.9 | 7.0 | 5.4 | | | | | |
| A 61 | 8 | - | June '71 | 34.9 | - | 17.5 | 19.4 | 15.3 | 13.0 | 8.3 | 6.7 | 5.4 | | | | | |
| A 82 | 8 | + | Winter /72/73 | 33.0 | - | 17.4 | 16.9 | 11.5 | 11.8 | 10.5 | 6.4 | 3.8 | | | | | |
| A 74 | 8 | + | - | 30.5 | - | - | 19.6 | 13.2 | 11.1 | 7.6 | 3.8 | 4.1 | | | | | |
| A 56 | 8 | + | April '71 | 31.5 | - | 17.1 | 14.0 | 12.7 | 11.8 | 8.9 | 7.6 | 6.7 | | | | | |
| A 53 | 8 | + | - | 35.6 | - | - | 17.1 | 11.5 | 12.1 | 9.8 | 8.2 | 6.4 | | | | | |
| C 26 | 8 | + | - | 26.4 | - | - | 11.5 | 10.2 | 11.5 | 8.6 | 3.8 | 2.5 | | | | | |
| C 20 | 8 | + | - | - | 6.1 | 18.7 | 19.4 | 14.9 | 8.6 | 8.6 | 4.7 | 3.2 | | | | | |
| C 15 | 8 | + | - | 33.6 | - | 16.2 | 19.1 | 16.2 | 13.5 | 9.2 | 6.5 | 3.8 | | | | | |
| C 11 | 8 | + | - | 29.5 | - | - | 11.5 | 10.5 | 7.0 | 4.7 | 5.4 | 3.5 | | | | | |
| C 36 | 7 | + | - | 29.7 | 7.5 | 20.3 | 15.3 | 11.2 | 6.8 | 5.5 | 3.8 | | | | | | |
| C 18 | 7 | + | - | 33.0 | - | 22.9 | 13.3 | 16.5 | 17.8 | 12.7 | 9.2 | | | | | | |
| C 4 | 7 | + | - | 32.4 | - | - | 20.3 | 16.2 | 8.6 | 7.0 | - | | | | | | |
| C 1 | 7 | + | - | 32.4 | - | - | 17.1 | 14.9 | 7.0 | 6.1 | 3.5 | | | | | | |
| A 6 | 7 | + | Winter 69/70 | 31.8 | - | - | 19.7 | 10.8 | 8.2 | 7.6 | 4.4 | | | | | | |
| B 3 | 7 | + | - | 27.6 | - | - | 16.5 | 9.5 | 2.8 | 1.6 | - | | | | | | |
| B 2 | 7 | + | - | 32.1 | - | - | 16.5 | 14.0 | 10.8 | 9.2 | - | | | | | | |
| C 13 | 6 | + | - | - | - | - | 11.2 | 6.1 | 6.4 | 6.1 | | | | | | | |
| C 6 | 6 | + | - | 30.8 | - | 27.0 | 22.5 | 13.7 | 8.2 | - | | | | | | | |
| B 1 | 6 | + | - | 33.6 | - | 23.1 | 20.3 | 15.8 | 10.8 | 8.6 | | | | | | | |
| A 63 | 5 | + | - | 31.1 | - | 15.9 | 18.1 | 16.5 | 11.1 | | | | | | | | |
| C 37 | 5 | + | - | 29.0 | - | - | 17.0 | 13.6 | - | | | | | | | | |
| C 7 | 5 | + | - | 26.4 | - | 24.8 | 15.8 | 12.7 | - | | | | | | | | |
| C 5 | 5 | + | - | 26.7 | 8.9 | 22.2 | 17.1 | 8.6 | - | | | | | | | | |
| A 26 | 4 | + | - | 27.0 | 8.9 | 25.4 | 21.3 | - | | | | | | | | | |
| A 21 | 4 | + | - | 21.6 | 8.6 | 20.3 | 16.2 | - | | | | | | | | | |
| B 15 | 4 | + | - | 25.1 | - | 17.8 | 15.5 | 9.2 | | | | | | | | | |
| A 47 | 3 | + | Feb. '71 | 22.9 | 6.4 | 16.8 | 17.4 | | | | | | | | | | |
| C 28 | 3 | + | - | 24.5 | - | 22.2 | 19.1 | | | | | | | | | | |
| B 16 | 3 | + | - | 24.8 | - | 18.8 | 19.4 | | | | | | | | | | |

TABLE: 40b

Horn statistics of Dall rams from the Kluane Game Sanctuary

Annual increments of horn growth expressed as "degree curl"

(a = increment for the year; b = total degree curl to that age)

| Collection Number | Age at death | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | 11 | | 12 | | 13 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | a | b | a | b | a | b | a | b | a | b | a | b | a | b | a | b | a | b | a | b | a | b | a | b | a | b |
| A 63 | 5 | 30 | 30 | 70 | 100 | 80 | 180 | 50 | 230 | 40 | 270 | | | | | | | | | | | | | | | | |
| A 53 | 8 | - | - | - | 70 | 60 | 130 | 50 | 180 | 50 | 230 | 40 | 270 | 35 | 305 | 25 | 330 | | | | | | | | | | |
| A 82 | 8 | - | - | - | - | - | 180 | - | - | - | 270 | - | - | - | - | - | 330 | | | | | | | | | | |
| A 61 | 9 | 30 | 30 | 80 | 110 | 80 | 190 | 50 | 240 | 40 | 280 | 30 | 310 | 25 | 335 | 20 | 355 | 10 | 365 | | | | | | | | |
| A 54 | 9 | 35 | 35 | 70 | 105 | 55 | 160 | 40 | 200 | 40 | 240 | 35 | 275 | 30 | 305 | 15 | 320 | 20 | 340 | | | | | | | | |
| A 45 | 9 | - | - | - | 100 | 80 | 180 | 60 | 240 | 45 | 285 | 30 | 315 | 25 | 340 | 20 | 360 | 20 | 380 | | | | | | | | |
| C 46 | 10 | - | - | - | 110 | 70 | 180 | 45 | 225 | 35 | 260 | 20 | 280 | 15 | 295 | 20 | 315 | 20 | 335 | 25 | 360 | | | | | | |
| A 65 | 10 | 25 | 25 | 90 | 115 | 65 | 180 | 60 | 240 | 40 | 280 | 30 | 310 | 25 | 335 | 20 | 355 | 15 | 370 | 10 | 380 | | | | | | |
| A 70 | 10 | - | - | - | 85 | 75 | 160 | 55 | 215 | 50 | 265 | 25 | 290 | 25 | 315 | 25 | 340 | 20 | 360 | 20 | 380 | | | | | | |
| A 57 | 10 | 25 | 25 | 85 | 110 | 70 | 180 | 50 | 230 | 40 | 270 | 25 | 295 | 15 | 310 | 10 | 320 | 10 | 330 | 5 | 335 | | | | | | |
| A 64 | 11 | 30 | 30 | 90 | 120 | 80 | 200 | 40 | 240 | 30 | 270 | 25 | 295 | 10 | 305 | 20 | 325 | 15 | 340 | 10 | 350 | 10 | 360 | | | | |
| A 46 | 11 | 20 | 20 | 70 | 90 | 90 | 180 | 45 | 225 | 25 | 250 | 20 | 270 | 20 | 290 | 20 | 310 | 15 | 325 | 15 | 340 | 10 | 350 | | | | |
| A 60 | 13 | - | - | - | 60 | 60 | 120 | 60 | 180 | 40 | 220 | 30 | 250 | 20 | 270 | 25 | 295 | 15 | 310 | 10 | 320 | 15 | 335 | 15 | 350 | 10 | 360 |
| | $\bar{X}$, | 28 | 28 | 79 | 98 | 80 | 171 | 50 | 220 | 40 | 260 | 28 | 287 | 22 | 310 | 20 | 330 | 16 | 345 | 14 | 352 | 12 | 348 | 15 | 350 | 10 | 360 |
| Range: upper | | 35 | 35 | 90 | 120 | 90 | 200 | 60 | 240 | 50 | 285 | 40 | 310 | 35 | 340 | 25 | 360 | 20 | 380 | 25 | 380 | 15 | 360 | - | - | - | - |
| lower | | 20 | 20 | 70 | 60 | 55 | 120 | 40 | 180 | 25 | 220 | 20 | 250 | 10 | 270 | 10 | 295 | 10 | 310 | 5 | 320 | 10 | 335 | - | - | - | - |

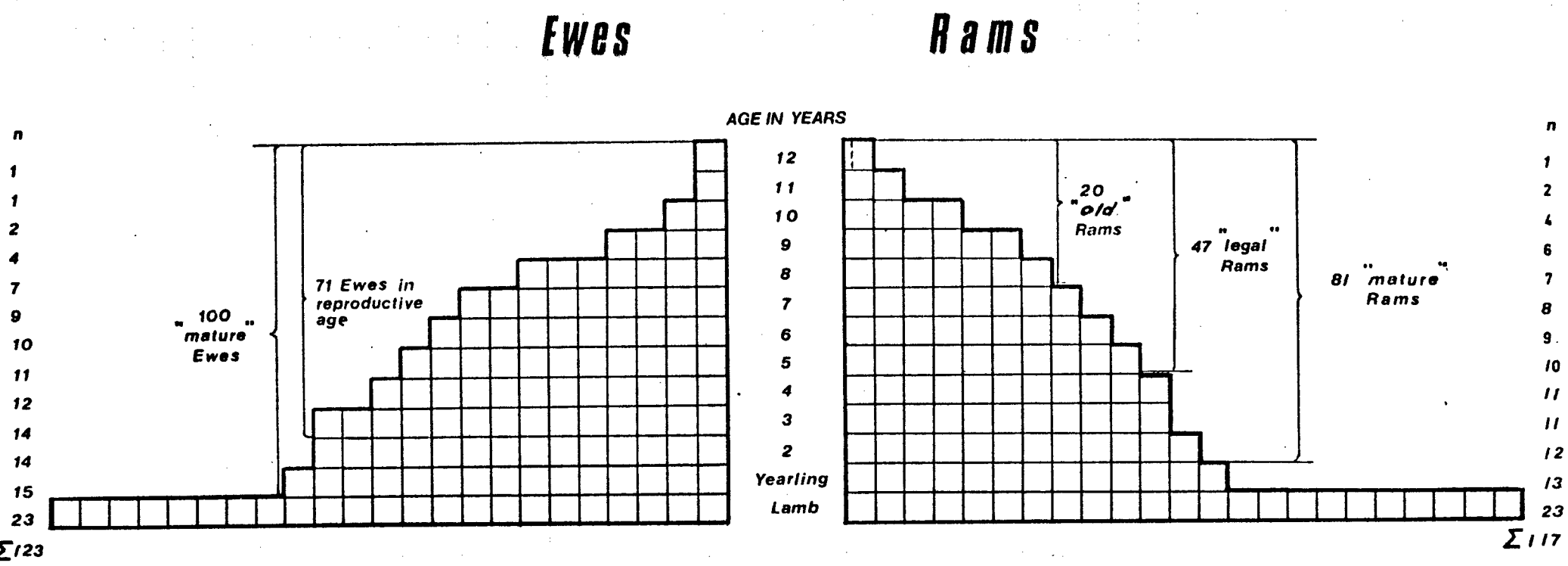
because of overlap between age classes and it becomes useless and often misleading in the old age classes (10 years and older). This method of classifying young rams and lumping those of six years and older was used in this study.

A model of an unhunted sheep population was developed as shown in Figure 42. It is based on statistics collected from the Sheep Mountain population and from the life table (Table 12). The model represents observed conditions as far as total numbers, sex ratios, lamb crop, and mortalities are concerned. The sex ratio of adult sheep was set at 94 rams to 100 ewes, 46 lambs are born, the maximum span of life is the 12 to 13 year age class. Some adjustments of the mortality rates of Table 12 could not be avoided to accommodate the desired total numbers (which are much less than those the life table was based on), the desired sex ratio, and the fact that we are dealing with only "whole" animals here. These adjustments resulted in a few distortions in the old age groups. For instance, the mortality in the 11 to 12 year age class is 86% of two animals, which would leave less than half an animal in the top 12 to 13 year age class. However, a whole animal is shown to indicate the maximum span of life. Errors introduced into the other age classes are much less severe and often function in a "compensatory" manner.

Few data were available for the female component of this model except for the total numbers, the numbers of lambs and yearlings, and the maximum span of life. The slightly unbalanced sex ratio was "created" by a 39% mortality rate in the first year of life, with two more rams dying than ewes. Age specific mortality rates were modified from Bradley and Baker (1967) to accommodate the longer life span. Whether or not the age structure of ewes is exactly as shown here is not important. We are only

Figure: 42

# STRUCTURE OF SHEEP POPULATION




*Explanation:*

*"mature" ram means males in the 2 to 3 year age group and older, since the great majority of them is found in ram bands.*
*"legal" ram means males whose horn curl circumscribes an angle of 270° or more.*
*"old" ram means males in the 8 to 9 year age group and older, since only this category contains trophy heads of 39 or 40 inches length.*

interested in this connection with the number of ewes in reproductive age (71) and the total number of "mature" ewes which is 100. The model represents the population structure in early June after all the lambs have been born. As far as mature rams are concerned it is also relevant to the forthcoming hunting season (August, September) since hardly any mortality occurs during the summer months (June, July).

There are 81 "mature" rams in this population, these are members of ram bands during the summer, except for a few 2 to 3 year olds. A total of 47 rams have completed their fifth growing season; they will be in their sixth growing season during the upcoming hunting period and will be "legal" rams. Out of these 47 "legal" rams not more than 20 can be described as "old " rams. For lack of better term "old " rams is here defined as rams in the 8 to 9 year age group and older. As will be discussed later, only this category contains trophy rams, whose horn length reaches 39 or 40 inches and more, and only this category should be subject to harvesting if "trophy hunting" is the objective.

Based on this population model the following ratios can be established which are useful in surveys and in calculating of expected trophy "yields". If 4 of the 2 to 3 year old rams (or about 1/3) are with nursery bands then there are 117 "nursery" sheep (ewes, yearlings, and four rams) in this population. Therefore the ratio of "mature" rams to "nursery" sheep is 66:100 in an unhunted population and can be as low as 26:100, if all legal rams have been removed. A ratio lower than this should not be encountered if hunting is the only "artificial" mortality factor. If it does occur it would indicate that the surveys missed ram bands, or that other important sex-specific mortality causes exist.

In an unhunted population the ratio of "legal" rams to "nursery"

sheep is about 40:100; while that of "old" rams to "nursery" sheep is as low as 17:100. Of the 20 "old" rams only about 8 (39%) are "trophies", giving a ratio of "trophy" rams to "nursery" sheep of 7:100.

b) Horn Growth Rates

Prevailing regulations, with very few exceptions, limit the hunting of mountain sheep to trophy rams, where trophy is defined in terms of characteristics of the horns, i.e. 3/4 or 7/8 curl. It is irrelevant whether or not this type of harvesting sheep populations is the most appropriate from the biological point of view; it has become deeply entrenched into the thinking of hunters, last not least because of its promotion by the Boone and Crocket Club.

During this study a total of over 100 sets of horns became available from which relevant statistics could be taken. Tables 40a and 41 list data on lengths of annual increments and circumferences at base for rams and ewes respectively. Figures 43 and 44 show correlations between the ages of rams and horn lengths and circumferences at base respectively. These figures give the means, the range of variation and the sample size for each age class.

Many investigators (Erickson, 1970; Simmons, 1968; Hemming, 1967; Geist, 1966; Nievergelt, 1966; Wishart, 1958; Scott 1951b) have collected horn growth statistics and related data. The observations presented here are therefore not new.

Considerable work on the growth of annual increments of horns of Dall sheep populations in Alaska has been done by Erickson (1970) and associates. Table 42 gives a summary of the mean values of annual increments in horn growth from various Alaskan populations as well as

TABLE: 41

HORN STATISTICS OF DALL EWES FROM THE KLUANE GAME SANCTUARY

| Collection Number | Years of Complete Increments | Circumference at Base (in cent.) | ANNUAL INCREMENTS IN HORN GROWTH ( IN CENTIMETRES) (Only complete increments are considered) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| D 21 | 13 | 12.0 | - | 8.4 | 6.2 | 1.5 | 1.7 | 1.2 | 1.4 | 1.4 | 0.8 | 0.7 | 0.3 | 0.2 | 0.3 |
| F 2 | 12 | 12.0 | 4.4 | 10.1 | 5.1 | 3.2 | 1.6 | 0.7 | 1.0 | 0.6 | 0.6 | 0.6 | 0.3 | 0.3 | |
| F 1 | 12 | 12.7 | - | - | 5.1 | 3.5 | 1.0 | 0.7 | 1.0 | 0.3 | 1.6 | 1.6 | 0.3 | 0.3 | |
| D 20 | 9 | 13.0 | 4.2 | 8.4 | 6.4 | 3.3 | 1.8 | 0.5 | 0.3 | 0.5 | 0.6 | | | | |
| D 19 | 9 | 13.0 | - | 9.8 | 6.4 | 2.5 | 0.6 | 0.3 | 0.6 | 0.3 | 0.3 | | | | |
| D 8 | 9 | 12.3 | 4.1 | 9.9 | 5.7 | 3.7 | 1.9 | 1.0 | 0.6 | 0.6 | 0.3 | | | | |
| D 1 | 8 | 13.0 | 5.4 | 12.3 | 2.9 | 3.5 | 2.5 | 2.2 | 1.6 | 1.3 | | | | | |
| D 6 | 6 | 12.7 | 7.3 | 11.1 | 4.1 | 2.9 | 2.9 | 2.5 | | | | | | | |
| D 3 | 6 | 12.7 | 3.2 | 12.0 | 6.0 | 4.1 | 3.2 | 2.5 | | | | | | | |
| D 2 | 6 | 13.0 | 5.1 | 9.5 | 6.0 | 4.4 | 2.2 | 2.2 | | | | | | | |
| D 7 | 5 | 12.0 | 4.7 | 10.4 | 7.3 | 1.9 | 2.5 | | | | | | | | |
| D 5 | 5 | 12.7 | 4.4 | 8.6 | 5.7 | 2.5 | 2.3 | | | | | | | | |
| D 4 | 1 | 7.0 | 6.0 | | | | | | | | | | | | |
| | | $\bar{X}$ | 4.9 | 10.0 | 5.6 | 3.1 | 2.0 | 1.4 | 0.9 | 0.7 | 0.7 | 1.0 | 0.3 | 0.3 | 0.3 |

Table: 42

Comparisons of annual increments in horn growth of Dall rams

| Age class | | | | | | | | | | | | | Area | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | |
| 3.8* | 15.0 | 14.8 | 12.6 | 10.4 | 8.9 | 7.2 | 6.2 | 4.6 | 3.6 | 2.8 | 1.9 | | Brooks Range, Alaska | Source |
| 3.9 | 16.4 | 16.3 | 14.3 | 11.9 | 9.6 | 7.6 | 6.0 | 4.4 | 3.3 | 2.8 | | | Alaska Range *** | |
| 4.1 | 18.5 | 16.4 | 14.0 | 11.6 | 9.2 | 6.9 | 5.1 | 3.7 | 2.7 | 2.2 | 1.4 | | Alaska Range **** | Erickson |
| 4.3 | 19.2 | 18.8 | 15.0 | 12.0 | 9.3 | 6.5 | 4.6 | 3.2 | 2.7 | | | | Wrangell Mts. " | (1970) |
| 3.9 | 16.7 | 17.7 | 13.9 | 11.1 | 8.5 | 7.2 | 5.4 | 4.1 | 3.8 | | | | Chulitna Area, " | |
| 3.6 | 18.0 | 18.2 | 14.5 | 11.9 | 9.3 | 7.1 | 5.2 | 4.2 | 3.1 | | | | Chugach Area " | |
| 5.1 | 19.9 | 18.8 | 14.6 | 11.5 | 7.7 | 6.2 | 4.9 | 3.4 | 2.4 | | | | Kenai Area " | |
| 7.9 | 21.5 | 17.7 | 13.2 | 10.6 | 7.9 | 5.7 | 4.4 | 3.3 | 2.6 | 1.7 | 1.2 | 1.0 | Sheep Mountain | Hoefs |
| | | | | | | | | | | | | | Kluane Area, Yukon | Present Stud |

* Numbers are mean values expressed in centimeters

** West of Mt. McKinley Park

*** East of Mt. McKinley Park

*FIGURE* : .43

*RELATION BETWEEN AGE OF RAMS AND HORN LENGTH*

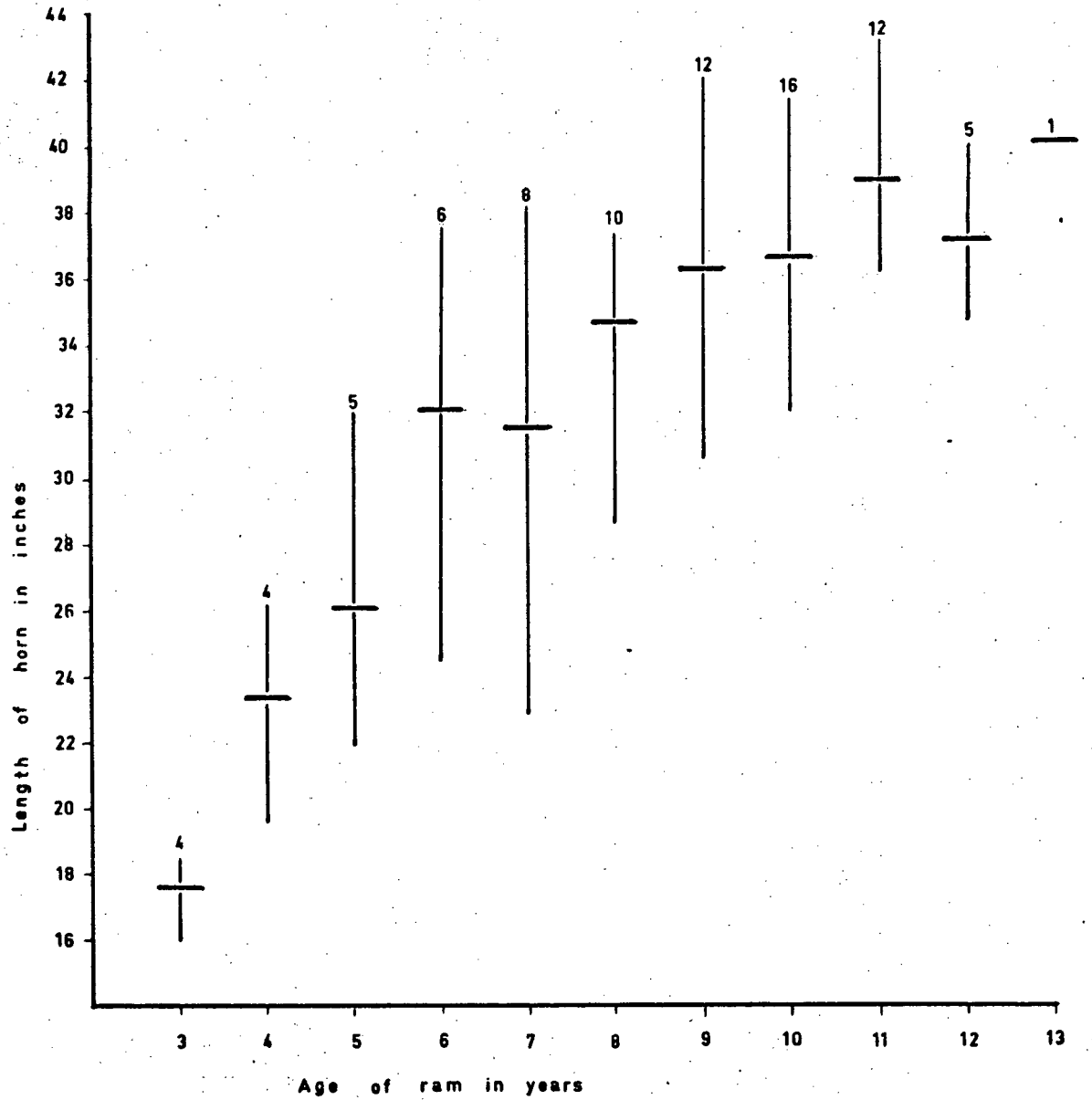
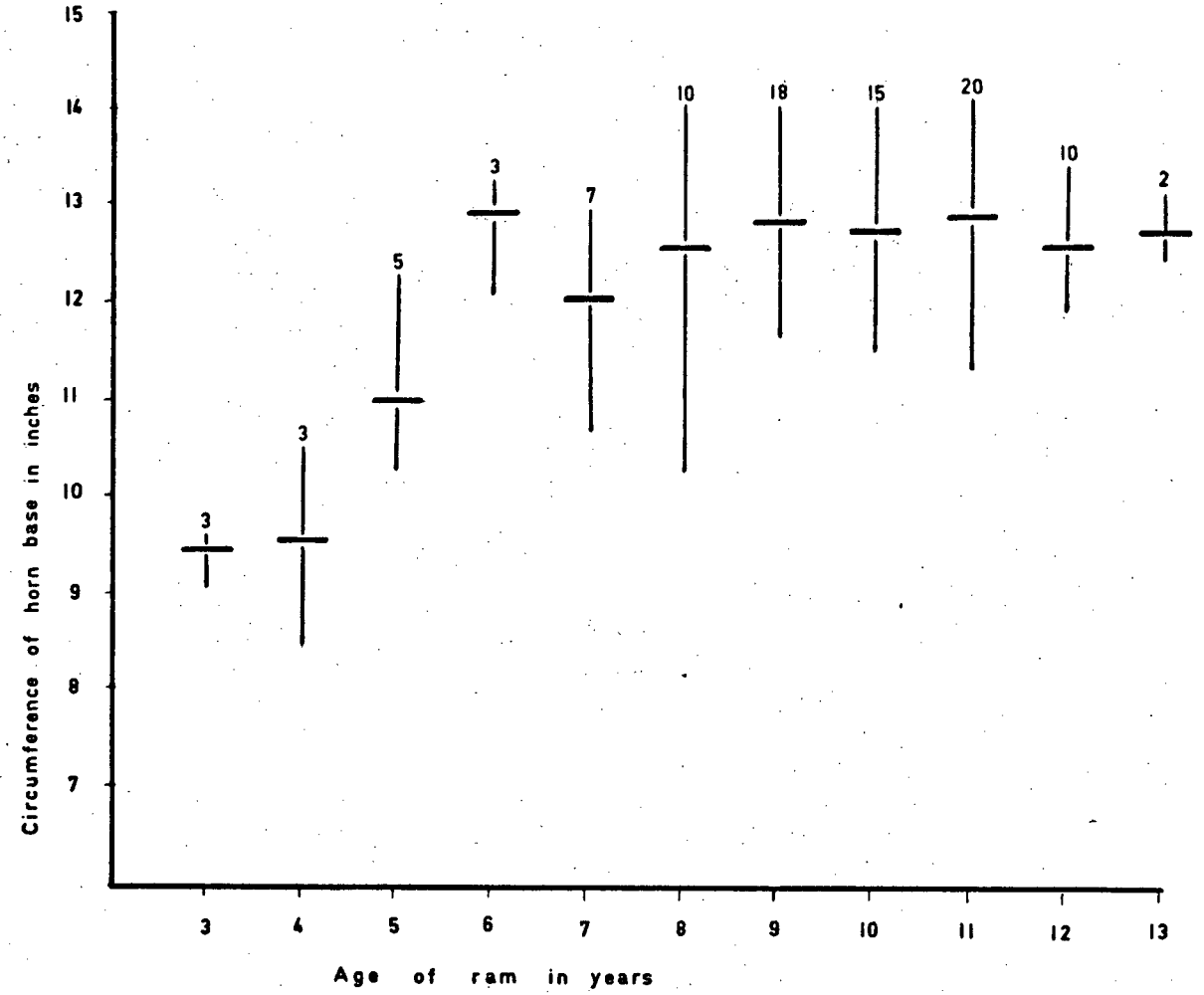


*FIGURE*: 44

*RELATION BETWEEN AGE OF RAMS AND HORN BASE*



those from the Sheep Mountain population.

As is apparent from Table 42, there is great variation in horn growth of Dall rams in various areas of Alaska, the fastest growth being observed in the Wrangell Mountains and on the Kenai Peninsula, the slowest growth in the Brooks Range — at least in the younger age groups where most growth takes place. Limited observations indicate that this relationship (latitudinal differences) also holds for the Yukon Territory. The longest horn growth per increment is found in the Kluane Game Sanctuary and in areas of south-central Yukon while the shortest annual increments were observed in the north, in the Ogilvie and British Mountains.

Comparisons in Table 42 indicate that the Sheep Mountain population is more similar in horn growth characteristics to the Wrangell Mountains populations than to those from other areas of Alaska. This is to be expected since the Wrangell Mountains are merely an extension of the St. Elias Range. Growth during the first and second years of life appears to be higher for Sheep Mountain rams than for rams of the Alaskan populations. I do not believe that this difference is significant for the first year's growth since I question the accuracy of the Alaskan data for the following reason. Erickson's (1970) horn statistics were obtained from hunter killed rams deposited in local taxidermy shops; they were not obtained from repeated measurements of live animals. His sample sizes are similar for the lamb's growth (first year increment) as for subsequent increments, indicating that most horns were measured to the tip, regardless of whether or not the tip (lamb's growth) was worn down or not. Investigations on captive rams over a five year period indicates that the first year's growth (lamb's growth) may be as high as 10 cm (4 inches), but by the time the ram is mature usually not more than 3 to 5 cm (1 to 2 inches) remain.

This is a very gradual wear and has nothing to do with "brooming", which usually is brought about during fights (Shackleton and Hutton, 1971). This gradual wear appears to be caused by using the horn tips to rub the hide and by supporting the head when lying down stretched out. Mishart (1958) reports similar observations for Bighorns. From these observations we know that very few of the horns of mature sheep have complete first year's increments. In Table 40a, less than 15% of the total number of rams had first year increments whose wear appeared to be insignificant and whose measurements were included. I am convinced that the differences observed between Alaskan rams and those of Sheep Mountain as far as their first year's horn growth is concerned are entirely due to these discrepancies in measurements.

Whether or not differences in measurements affected the second year's growth comparisons is not known. In our skull collection about 50% had incomplete second increments because of excessive wear or brooming. However, the differences observed between the second year's horn growth of Sheep Mountain rams and those of the most similar Alaskan ones from the Wrangell Mountains and the Kenai Peninsula are much smaller than the differences observed between Alaska populations and may therefore be real.

It is at present not possible to explain this faster growth rate of Sheep Mountain rams during the second year since not enough is known about the habitats (geology, forage, growing season) or population phenomena (expanding, stable) of the Alaskan rams. In addition, the Alaskan horn growth statistics are summaries from rams of entire mountain ranges and not characteristics of individual populations.

c) Optimizing of Harvests:

Of greater importance from the practical point of view than the annual increments are the total lengths of the horns and their "massiveness," which is usually expressed as circumference at base and at quarterly intervals, since these characteristics determine the trophy value of a ram. A study of Figures 43 and 44 reveals the following interesting relationship. Both, total length of horns as well as circumference at base show a high correlation with age up to about the eighth year. After this there is no further increase in the circumference at base and additional increases in horn lengths proceed at a very small rate. This relationship has already been described by Simmons (1968) and Wishart (1958). Simmons (1968) measured horn lengths of 159 Dall rams in the MacKenzie Mountains of the Northwest Territories. His curve, showing the correlation between horn length and age, levelled off at the 9 1/3 year of life. Further increases of horn lengths with age were insignificant. Wishart (1958) demonstrated that for Bighorn sheep this correlation becomes negligible after the eighth year of life, and as far as the correlation between age and circumference at base was concerned his curve reached the asymptote already after the fourth year of life.

These findings must be interpreted cautiously. It is known that the horns of a given ram continue to grow both in length and in circumference throughout the animal's life. The abovementioned correlations do not dispute this fact. However, great variations are found between rams in horn growth characteristics (Table 40a). The correlations discussed above (Figure 43 and 44, Simmons, 1968; Wishart, 1958) incorporate measurements of many rams. They demonstrate three facts: Firstly, the lengths of the annual increments become progressively smaller with age, as is obvious from

Table 40a and 42: secondly, the probability of brooming increases with age; and thirdly, rams with a faster growth rate per annual increment of horn die earlier than those with a slower growth rate. Both Geist (1966) and Nievergelt (1966) independently described the latter phenomenon and used it in connection with evaluating ungulate population quality.

With reference to the management of sheep, these findings are useful in computing optimum harvest figures. Earlier discussions of Figure 42 revealed that rams in their sixth growing season and older are "legal" rams, under existing legislation, while those in their ninth growing season and older are "old " rams. This statement must not be taken at face value, since there can be exceptional rams in the 6,7, and 8 year age groups, while there can be very poorly developed ones in the older age groups. But if a "trophy" is here arbitrarily defined as a set of horns whose lengths are at least 39 inches, then there are no trophies at all in the 6, 7, and 8 year age classes, while 39% of the horns in the 9 year age class and older are trophies. Preference is given to the use of 39 inches over 40 inches minimum length to quality as a "trophy" because 40 inch heads are not only very rare but also very "sporadic" in occurrence, which would make management for them very difficult. In our sample of 46 sets of horns in the 8 to 9 year age class and older, 20% had a length of 40 inches or better. Inspections of a much larger sample size by the Yukon Game Branch of hunter-killed trophies reveal that a percentage of as high as 20 is very optimistic (Table 44).

Since the circumference at base (Figure 44) does not change significantly after the 8 to 9 year age class I will restrict further discussion on optimizing the harvest of "trophy" rams to a consideration of horn lengths only. Average horn lengths appear to increase to the

oldest age classes, even though the annual rate becomes progressively smaller. However, the advantages gained from this trend from the point of view of harvesting trophy rams, is counteracted by a greatly accelerating natural mortality rate in the old age class.

Table 43 summarizes the relevant statistics necessary to compute optimum harvests. It is based on the assumption that the natural mortality patterns of a hunted population is the same as that of a protected population. We have so far no evidence to dispute this assumption. For comparative purposes, Table 44 is included here, which gives horn length statistics of Dall rams taken during the 1973 hunting season in the southern and south-western Yukon Territory. The following facts must be kept in mind when comparing this Table 44 to Table 43.

It is known that hunters select the "largest" rams out of a given band and it is also known that there is a tendency of rams of similar age groups to join up in bands (Geist, 1971), particularly on summer range when sheep are widely dispersed and when the hunting season is on. For this reason the average horn length per age group of these "selected" rams will be greater than the horn lengths of a more randomly selected and therefore more representative sample. This will not be the case anymore in the oldest age groups, since there are very few rams alive and little choosing is possible. These considerations are reflected in Tables 43 and 44.

However, Table 44 is useful for comparisons of certain aspects. It does support that very few rams are "legal" in their fifth growing season (4 to 5 year age class), that there is an increase of horn lengths with age, that the maximum life span is the 12 to 13 year age class, and that very few trophies are encountered in the legal age classes below the

Table: 43

Number of "Trophies"[1] in the legal age classes of rams.

| Age classes | 7 - 8[2] | 8 - 9 | 9 - 10 | 10 - 11 | 11 - 12 | 12 - 13 |
|---|---|---|---|---|---|---|
| Sample size | 10 | 12 | 16 | 12 | 5 | 1 |
| Mortality rate[3] | 14% | 24% | 39% | 56% | 86% | 100% |
| Numbers present[4] | 100 | 86 | 65 | 40 | 18 | 3 |
| Percent Trophies[5] | 0 | 33% | 38% | 42% | 20% | 100% |
| Number of Trophies | 0 | 28 | 25 | 17 | 4 | 3 |

1. "Trophy" is here defined as a horn length of 39 inches or more
2. The 7 to 8 year age class is used as a starting point since neither the 5 to 6 nor the 6 to 7 year age classes contain trophies, even though they are legal.
3. Based on Table
4. For ease of calculation 100 rams were assumed to be present.
5. Based on data for Figure 3.

Table: 44

Horn lengths of Dall rams taken in the southern and south-western Yukon Territory during the 1973 hunting season (Courtesy of Yukon Game Branch)

| Age Classes | 4 - 5 | 5 - 6 | 6 - 7 | 7 - 8 | 8 - 9 | 9 - 10 | 10 - 11 | 11 - 12 | 12 - 13 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ruby Range | 28.8* | 30.0<br>32.5<br>33.0<br>32.0 | 33.8<br>28.5<br>32.5<br>33.3<br>31.5<br>35.5<br>32.7<br>30.2<br>33.5 | 32.0<br>32.7<br>35.5 | 34.0<br>36.5<br>35.8<br>37.5 | 38.0<br>35.5<br>39.3<br>38.5<br>33.5 | 34.5<br>38.0<br>39.8<br>36.7 | 39.4<br>34.0 | | |
| Nisling Range | 32.0 | 28.5<br>32.0 | 34.5<br>36.5 | 32.5<br>40.0<br>36.2<br>34.2 | 35.5<br>35.5<br>35.5<br>34.5<br>37.0 | | 37.0<br>37.2<br>34.0<br>34.7 | 40.0<br>36.5<br>39.0<br>38.0 | | |
| Coast Range and Dezadesh Range | | 34.0 | | 35.4<br>38.5 | 38.3<br>36.7<br>40.5<br>32.0<br>37.2 | 33.7<br>39.0<br>42.0<br>41.2<br>33.0<br>36.8<br>36.2 | 39.2<br>36.7<br>40.2<br>36.0 | | 38.7 | |
| South Central Yukon ** | 31.2 | 30.7<br>30.2 | 32.0<br>27.2<br>33.2 | 34.5<br>36.7<br>33.7 | 33.5<br>33.5 | 36.7<br>33.7<br>33.2<br>36.5<br>31.0<br>37.2 | 36.5<br>40.0<br>34.7<br>39.7<br>34.2<br>39.2<br>42.0<br>38.0 | 40.7<br>40.5<br>36.5<br>35.5<br>36.0<br>39.0<br>36.5<br>43.2 | | |
| Southern Yukon (Exact location undetermined) | 27.5<br>33.7 | 29.5<br>33.5<br>30.2<br>30.0 | 36.0<br>31.0<br>34.5<br>39.7 | 36.5<br>35.0 | 30.7<br>33.7<br>38.8 | 32.5<br>37.5<br>36.0 | 34.8<br>36.5<br>34.8<br>40.2<br>41.2 | 41.0 | | |
| Sample size | 5 | 13 | 18 | 14 | 19 | 21 | 25 | 15 | 1 | Σ 131 |
| mean horn lengths | 30.8 | 31.3 | 32.5 | 35.2 | 35.6 | 36.3 | 37.4 | 38.4 | 38.7 | |
| Numbers > 39" | 0 | 0 | 1 | 1 | 1 | 4 | 9 | 8 | 0 | |
| % | 0% | 0% | 6% | 7% | 5% | 19% | 36% | 53% | 0% | |
| Numbers > 40" | 0 | 0 | 0 | 1 | 1 | 2 | 5 | 5 | 0 | |
| % | 0% | 0% | 0% | 7% | 5% | 10% | 20% | 33% | 0% | |
| Numbers > 41" | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 0 | |
| % | 0% | 0% | 0% | 0% | 0% | 10% | 8% | 13% | 0% | |
| Numbers > 42" | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | |
| % | 0% | 0% | 0% | 0% | 0% | 5% | 4% | 7% | 0% | |
| Numbers > 43" | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | |
| % | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 7% | 0% | |

* Length of longest horn in inches

** Mountain ranges bordered by the Alaska Highway in the North, Kusawa Lake - the west, The Yukon - B.C. border - the south, and the Carcross Highway - the east.

ninth year.

When working out optimum harvest figures the assumption is made that hunting pressure is so intense that the maximum number of rams should be available but at the same time the hunters should have a chance to bag a "trophy". No trophies were encountered below the 8 to 9 year age class in the writer's collection from the Kluane area (Table 43), and therefore, no hunting should be considered below that age group. Starting off with an assumed 100 rams in the 7 to 8 year age class (Table 43) of which none was a "trophy", natural mortality during winter has reduced the total number of rams present to 86, however, 28 of these (33%) have now become "trophies". If these rams continue to live to the 9 to 10 year age class, natural mortality will have reduced their number to 65 of which 25 (38%) are "trophies". To wait a further year would reduce the total number present to 40 because of the heavy natural mortality rate of 39% in this age class. Even though this age group has the highest percentage of "trophies" (42%), only 17 rams fall into this category because of the small total number of rams remaining.

Referring back to the population model (Figure 42) there are 7 rams in the 8 to 9 year age class which could be harvested annually. Of these, 33% or 2 animals can be expected to be "trophies", one may be a 40 inch ram. Converting this into a practical ratio, it can be said that 100 "nursery" sheep (bands of ewes, yearlings and about 1/3 of the 2 to 3 year old males) will produce 6 "old" rams annually, of which two will be "trophies". These 6 rams can be harvested every year on the basis of sustained yield, if they are taken in the 8 to 9 year age class.

If hunting pressure is less intense, as in inaccessible areas where only outfitters operate, preference may be given to rams that

"make the book" over a large total number harvested. Under such circumstances harvesting should be limited to the 10 to 11 or even 11 to 12 year age classes. As is obvious from Table 44, the chances of obtaining, 41, 42, 43 inch rams increases with age. However, because of greatly increasing natural mortalities in these age groups, the total number that can be taken annually on the basis of sustained yield becomes drastically reduced.

Inspection of Figure 42 reveals that there are only 4 rams in the 10 to 11 year age class, and only 2 in the 11 to 12 year age class. Therefore, 100 "nursery sheep" will only produce about 3 rams annually in the 10 to 11 year age class, one or two of these will be "trophies". However, the chances are increased that these trophies will "make the book".

Summary:

1. An ecological investigation was conducted on a population of Dall sheep from 1969 to 1973.

2. Population statistics on this herd are presented for this entire five year period, while intensive range use and forage selection studies were limited to one year (1970/71) period. To do this it was necessary to first analyse the vegetation of the area and to construct a vegetation map. Part I of this investigation deals with these vegetation aspects.

3. The study area -- or the range of this sheep population — is located near the centre of the newly proposed Kluane National Park. For practical purposes it is bordered by Kluane Lake in the east, Slims River in the south, Congdon Creek in the north, and Bullion Creek in the west. "Sheep Mountain", the most important winter range of this population, is located at the southern boundary of this population's range, and it is bordered by the Slims River in the south, Kluane Lake in the east, Sheep Creek in the west and the depression between Sheep Mountain and adjacent Mt. Wallace in the north.

   Population statistics were gathered over the entire range of this population, while intensive range use studies were limited to Sheep Mountain proper.

4. During the study period the numbers of adult sheep in this population, counted in late winter just prior to the arrival of the new lamb crop, has remained very stable around 200 animals.

5. The total "potential" range of this population is approximately 64 square miles, of which only about 43 square miles are used, giving a density on the year-round range of about 3.9 adult sheep per square mile. Winter densities (December to May) are considerably higher, and reach a maximum of 46 sheep per square mile on the most heavily used areas.

6. The sex ratio of this protected population was about equality at birth and averaged 93 ♂♂ to 100 ♀♀ among adults for the 5 year period.

7. Sheep reached sexual maturity at $2\frac{1}{2}$ years of age and continued to breed to maximum age. Collections of over 100 skulls indicated that the 12 to 13 year age class is the maximum life span in this population.

8. Natality rates varied between a maximum of 76 lambs per 100 ewes and a low of 51 lambs per 100 ewes, established at times of lambing, with no twinning being observed in this population.

9. Mortality during the first year of life averaged 33% with the heaviest loss during the first month of life (18%).

10. Mortality during the second year of life was estimated to be less than 10%.

11. Among adult sheep, man-inflicted mortality was the single most important cause of death, with predation being second in importance.

12. A life table for this population is presented, and comparisons are drawn

to other sheep herds.

13. The population statistics derived were used for such practical considerations as recommending appropriate times of sheep surveys, and classifications and designing quotas for various levels of harvests.

14. A historical review of this population showed that it was severely reduced first around the turn of this century because of mining activity and again during the construction of the Alaska Highway in the mid 1940's. The population survived from both these events and built up levels of 150 to 200 adult sheep, which appears to be the carrying capacity of this range.

15. The sheeps' response to a number of physical environmental variables was investigated. It was found that sheep fed whenever possible on areas with no snow or very shallow snow, that they were found at lowest elevations during the coldest spells in winter, and that they avoided exposure to wind chill indices as severe as IV and V.

16. This sheep population undertakes a seasonal vertical migration, which was found to be correlated with plant phenological changes as well as with temperature and snow conditions.

The winter (November to May) is spent primarily at low elevations, while vertical ascent takes place during June and descent during late August, September and October. Considerable differences were observed in this annual migration pattern between nursery bands and rams.

17. The length of the daily feeding periods of these sheep appears to be determined by the length of the photoperiod. On a daily basis there were two peak feeding periods, one in the early morning, and one just prior to sunset, when up to 90% of the population were actively engaged in grazing. These two activity peaks were separated by a fairly long midday resting period.

18. The range utilization patterns and the forage selected are discussed on a monthly basis over the annual cycle.

19. Over the annual cycle, the population utilized a total of 23 different habitat types (plant associations). They were most concentrated during winter, having access to only 12 associations during January and February, and they were most widely dispersed during mid summer, June to September, when up to 18 plant associations were used.

20. Over the annual cycle the population uses at least 110 different forage species. The lowest number being available in late winter (March: 35; April: 33) and the highest number in mid summer (August: 63), when theoretically all vegetation is accessible to sheep.

21. Of the different plant species utilized only a small fraction provided the bulk of the forage. During winter, e.g., not more than 5 or 6 species made up 75% of the diet, while 10 to 15 species were only used to a degree of 0.1% or less.

22. Of the 110 species utilized over the annual cycle as few as four made up

half (51.2%) of the annual forage (Carex filifolia: 15.8%, Artemisia frigida: 14.2%, Calamagrostis purpurascens: 13.2% and Salix glauca: 8.0%), and as few as 13 made up three-quarters (75.9%) of the annual diet.

23. The plant species used were divided into the following categories: a) "stable" forages, b) "preferred" forages, c) "neglected" forages, d) "emergency" forages and e) "avoided" species.

24. A division into broad forage classes revealed that sheep utilized grasses and grasslike vegetation on an annual basis to 46.3%, forbs 36.8%, browse 16.1% and lichens and mosses to only 0.8%. Considerable deviation from this annual average was observed during periods of vertical migration when fairly heavy use was made of the sub-alpine shrub zone (June: browse 44.6%, September: browse 36.9%).

25. Limited information suggests that neither predators, diseases, parasites nor severe winter weather have been important as "regulatory" mechanism in this population. It appears that the population level is kept stable primarily through variations in the lamb crops, and that these lamb crops are influenced by the forage production of the winter range.

Literature:

Allen, J.C. (1939): Ecology and management of Nelson's Bighorn or the Nevada Mountain ranges. Trans. N. Amer. Wildl. Conf. 4: 253-256.

Allred, L.G. & W.G. Bradley (1966): Comparative study of necrosis associated with teeth in desert bighorn sheep. Trans. Desert Bighorn Council. 10: 86-97.

Allred, L.G. & W.G. Bradley (1965): Necrosis and anomalies of the skull in desert bighorn sheep. Trans. Desert Bighorn Council. 9: 75-81.

Arnold, G.W. (1964): Factors within plant associations affecting the behaviour and performance of grazing animals. In: "Grazing in terrestial and marine environments." ed. D.7. Crisp; Oxford; Blackwell.

Auer, H.A. (1917): Camp fires in the Yukon. Stewart & Kidd Company, Cincinnati. 204 pp.

Banfield, A.W.F. (1953): Notes on the birds of Kluane Game Sanctuary, Yukon Territory. Canadian Field Naturalist 67: 177-179.

Banfield, A.W.F. (1960): Notes on the mammals of the Kluane Game Sanctuary, Yukon Territory. National Museum of Canada, Bulletin 172: 128-135.

Benjey, W. (1974): Seasonal heat balance of a broken spruce forest and clearing, Kluane Lake, Yukon Territory. Ph.D. dissertation, Dept. of Georgraphy, University of Michigan.

Benson, S.B. (1943): Occurrence of upper canines in mountain sheep. American Midland Nat., 30(3): 786 - 784.

Berwick, S.H. (1968): Observations on the decline of the Rock Creek, Montana, Population of Bighorn Sheep. University of Montana, unpubl. Master Thesis.

Blood, D.A. (1963): "Some aspects of behaviour of a bighorn herd." Can. Field Nat. 77 (2): 77-94.

Blood, D.A. (1967): Food habits of the Ashnola Bighorn Sheep Herd. Can. Field Nat. 81 (1): 23-29.

Bond, J. (1948): From out of the Yukon. Binfords & Mort Publishers, Portland, Oregon. 220 pp.

Bradley, W.G. & L.G. Allred (1966): A comparative study of dental anomalies in Desert Bighorn Sheep. Transactions of Desert Bighorn Council. 10: 78-85.

Bradley, W.G. & D.P. Baker (1967): Life tables for Nelson Bighorn Sheep on the Desert Game Range. Desert Bighorn Council Transactions. 11: 142-169.

Brooks, A.H. (1900): A Reconnaissance from Pyramid Harbor to Eagle City, Alaska, including a description of the Upper White and Tanana Rivers. U.S. Geological Survey, Annual Reports 21: 331-390.

Buechner, H.K. (1960): The bighorn sheep in the United States its past, present, and future. Wildl. Monog., No. 4.

Cameron, A.W. (1952): Notes on mammals of Yukon. National Museum of Canada Bull. 126: 176-184.

Chamrad, A.D. & T.W. Box (1964): A point frame for sampling rumen contents. J. Wildlife Mgmt. 28(3): 473-477.

Cherniavski, F.B. (1962): On the reproduction and growth of the sheep (Ovis nivicola Esch.) Zoologicheskii Zhurnal XII (10): 1556-1566. Translated by Canadian Wildlife Service.

Clarke, C.H.D. (1945): Biological reconnaissance of lands adjacent to the Alaska Hwy. in northern British Columbia and the Yukon Territory. Unpubl. report on file with Canadian Wildlife Service.

Couey, F. (1950): Rocky Mountain bighorn sheep of Montana. Montana Fish and Game Commission. Bulletin No.2. (90 pp.)

Cowan, I.McT. (1940): Distribution and variation in the native sheep of North America. American Midland Naturalist 24: 505-580.

Cowan, I. McT. (1947): "Range competition between Mule deer, bighorn sheep and elk in Jasper Park, Alberta." Trans. N. Amer. Wildl. Conf. 12: 223-227.

Cowan, I. McT. (1947b): The timber wolf in the Rocky Mountain National Parks of Canada. Can. J. Res. D. 25: 139-174.

Cowan, I. McT. (1950): Some vital statistics of Big Game on overstocked Ranges. Trans. N. Amer. Wildl. Conf. 15: 581-588.

Deevey, E.S. Jr. (1947): Life tables for natural populations of animals. The Quarterly Review of Biology, 22: 283-314.

Dixon, J.S. (1938): Birds and mammals of Mount McKinley National Park. U.S. Dept. of Interior, National Park Service, Fauna Series No. 3.

Eadie, J. (1970): Sheep production and pastural resources. In "Animal populations in relation to their food resources." ed. A. Watson; Oxford; Blackwell.

Edwards, R.Y. (1956): Snow depths and ungulate abundance in the mountains of western Canada. Journal of Wildlife Management 20 (2): 159 -168.

Edwards, R.Y. & R.W. Ritcey (1956): The migrations of a moose herd. J.Mammal 37: 486-494.

Egorov, O.V. (1967): Wild Ungulates of Yakutia. Israel Program for Scientific Translations, Jerusalem.

Erickson, J.A. (1970): Sheep Report. Alaska Dept. of Fish and Game. Project No. W-17 - 1 & 2. Unpublished Report.

Ericson, C. and K.A. Neiland (1973): Sheep disease Report. Alaska Dept. of Fish and Game. Project Program Reports W-17-4; W-17-5.

Folk, E.G. Jr.(1966): Introduction to environmental physiology. Lea & Febiger, Philadelphia.

Fuller, W.A. (1955): Report on a general reconnaissance of game conditions in southern Yukon. Unpublished Report on file with the Canadian Wildlife Service.

Fuschlberg, H. & W. Nerl (1969): Das Gamsbuch. F.C. Mayer, Verlag, Munchen 71; Germany.

Geist, V. (1966): Validity of Horn Segment Counts in Aging Bighorn Sheep. Journal of Wildlife Management. Vol. 30 (3): 634-635.

Geist, V. (1966b): The evolutionary significance of mountain sheep horns. Evolution 20: 558-566.

Geist, V. (1971): Mountain Sheep. A Study in Behaviour and Evolution. The University of Chicago Press.

Geist, V. (undated): On the significance of thermoclines to the biology of wintering Mountain Sheep. Manuscript, Environmental Science Centre, University of Calgary.

Gibbs, H.C. & W.A. Fuller (1959): Record of Wyominia tetoni Scott, 1941, from Ovis dalli in the Yukon Territory. Can. J. Zool. 37(5): 815.

Goble, F.C. & A. Murie (1942): A record of lungworms in Ovis dalli (Nelson). J. Mammal. 23(2): 220-221.

Gwynne, D.C. and J.M. Boyd (1970): Relationship between numbers of soay sheep and pastures at St. Kilda. In: Animal populations in relation to their food resources. ed. A. Watson, Oxford; Blackwell.

Hebert, D. (1972): Difference between Years and Nutrient Cycles. Northern Wild Sheep Council, Symposium Proceedings 1972: 15-22.

Hemming, J.E. (1969): Cemental deposition, tooth succession, and horn development as criteria of age in Dall sheep. The Journal of Wildlife Management. Vol. 33(3): 552-558.

Hoefs, M. (1969): Progress Report on Dall sheep ecology study on Sheep Mountain, Kluane Game Sanctuary, Yukon. Unpublished Report on file with U.B.C. Dept. of Zoology.

Hoefs, M. (1971): The Park in perpetual planning: The Kluane Park Reserve, Yukon. Can. Field. Nat. 85: 261-265.

Hoefs, M. (1973a): Ecological investigation in Kluane National Park, Yukon Territory. Unpublished report on file with the Canadian Wildlife Service.

Hoefs, M. (1973b): Birds of the Kluane Game Sanctuary, Yukon Territory, and adjacent areas. Can. Field. Nat. 87(4): 345-355.

Hoefs, M. (1974a): Food selection of Dall's sheep (Ovis dalli dalli Nelson). in Geist, V. & F. Walther (eds.) The behaviour of ungulates and its relation to management. Vol. 2: 759-786. International Union for conservation of Nature and Natural Resources.

Hoefs, M. (1974b): Game Surveys in south-central Yukon and an evaluation of the present degree of exploitation. Yukon Territorial Game Branch, Unpublished report.

Hoefs, M. (1974c): Abnormal dentition in dall sheep (Ovis dalli dalli Nelson). Can. Field. Nat. 88: 228-229.

Hoefs, M. (1975): Sheep surveys and evaluation of present harvests in southwestern Yukon. Unpublished report on file with the Yukon Game Branch, Whitehorse.

Hofmann, A. & B. Nievergelt (1972): Das jahreszeitliche Verteilungsmuster und der Äsungsdruck von Alpenstein bock, Gemse, Rothirsch und Reh in einem begrenzten Gebiet im Oberengadin. Zeitschrift fur Jagdwissenschaft. 18(4): 185-212.

Honess, R.F. & N.M. Frost (1942): A Wyoming bighorn sheep study. Wyoming Game & Fish Dept. Bull. #1; 127 pp.

Hopkins, A.D. (1920): The bioclimatic law. J. Wash. Acad. Sci. 10: 34-40.

Hornocker, M.G. (1970): An analysis of Mountain Lion predation upon Mule Deer and Elk in the Idaho primitive area. Wildlife Monograph No.21.

Hunter, R.F. (1954): Some notes on the behaviour of hill sheep. Brit. J. Animal Behav. 2: 75-78.

Jones, F. (1960): Sheep distribution and Abundance Surveys. Alaska Dept. of Fish and Game, Project No: W-6-R-1, Unpublished Report.

Jones, F. (1962): Sheep Distribution and Abundance Surveys. Alaska Dept. of Fish and Game, Project No: W-6-R-2, Unpublished Report.

Jones, F. (1963): Sheep Investigations. Alaska Dept. of Fish and Game, Project No: W-6-R-4, Unpublished Report.

Jones, F. (1963b): Sheep and Goat investigations. Alaska Department of Fish and Game, Project No.: W-6-R-3, Unpublished Report.

Jones, F. (1965): Sheep Report. Alaska Department of Fish and Game, Project No: W-6-R-5 & 6, Unpublished Report.

Karaer (1961): Reindeer fodder resources. In "Reinder Husbandry" ed. P.S. Zigunov. English Translation, U.S. Dept. of Commerce, Clearinghouse for Federal Scientific and Technical Information, Springfield, Va.

Kennedy, C.A. (1948): Golden eagle kills bighorn lamb. Journal of Mammalogy 29: 68-69.

Knaus, W. (1960): Das Gamswild. Verlag Paul Parey, Hamburg, Germany.

Knight, R. (1970): The Sun River Elk Herd. Wildlife Monograph No. 23: 1-66. A publication of the Wildlife Society.

Kurten, B. (1953): On the variation and population dynamics of fossil and recent mammal populations. Acta. Zool. Fennica 76: 1-122.

Leopold, A.S. & F.F. Darling (1953): Wildlife in Alaska. The Ronald Press Company New York.

Lincoln, B.J. (1972): Behaviour study of the Arctic Ground Squirrel. Icefield Ranges Research Project Scientific Results. Vol. 3: 245-253. Arctic Institute of North America.

Luckhurst, A.J. (1973): Stone Sheep and their habitat. University of British Columbia, Department of Plant Science, Unpublished Master of Science thesis.

Martin, D.J. (1964): Analysis of sheep diet utilizing plant epidermal fragments in faeces samples. In "Grazing in terrestrial and marine environments." ed. D.J. Crisp pp. 173-88; Oxford, Blackwell.

Martindale, T. (1913): Hunting in the Upper Yukon. Jacobs & Company Publishers, Philadelphia. 320 pp.

McGuire, J.A. (1921): In the Alaska-Yukon Gamelands. Cincinnati, Stewart Kidd Company, Publishers. 215 pp.

Meteorological Branch (D.O.T.) 1966: "Temperature." Instruction booklet on standards of temperature recording.

Mills, H.B. (1937): A preliminary study of the bighorn of Yellowstone National Park. J. of Mammalogy 18: 205-212.

Moser, C.A. (1962): The Bighorn Sheep of Colorado. Published by The Colorado Game and Fish Department. 49 pp.

Murie, A. (1941): Ecology of the coyote in Yellowstone. U.S. Dept. of Interior National Parks Service. Fauna Series No.4.

Murie, A. (1944): The Wolves of Mount McKinley. Fauna of the National Parks of the United States, Fauna Series No. 5.

Murie, A. (1946): Another look at Mt. McKinley Park Sheep. The living wilderness 1946.

Nasimovich, A.A. (undated): The Role of snow cover conditions in the Life of Ungulates in the U.S.S.R. Prepared for C.W.S. by Translation Service, Dept. of Indian Affairs and Northern Development.

Neiland, K.A. (1972): Sheep Disease Studies. Alaska Department of Fish and Game. Project NO: W-17-3 and 4, Unpublished Report.

Nichols, L. (1968): Dall Sheep Report. Alaska Dept. of Fish and Game, Project No: W-15-R-2 & 3, Unpublished Report.

Nichols, L. (1971): The Dall sheep and its management in Alaska. Transactions of North American Wild Sheep Conference 1: 2-8.

Nichols, L. (1972): Sheep Report. Unpublished Report on file with Alaska Department of Fish and Game. Project Progress Report W-17-3, 4 - 6.4R.

Nichols, L. & J.A. Erickson (1969): Sheep Report. Alaska Dept. of Fish and Game. Project No: W-15-R-3 and W-17-1 Unpublished Report.

Nichols, L. & W. Heimer (1972): Sheep Report. Alaska Dept. of Fish and Game. Project No: W-17- 3 & 4, Unpublished Report.

Nichols, L. & A. Smith (1971): Sheep Report. Alaska Department of Fish and Game. Project No: W-17 - 2 & 3. Unpublished Report.

Nievergelt, B. (1966): Der Alpensteinbock (Capra ibex L.) in seinem Lebensraum. "Mammalia depicta" Verlag Paul Parey. Hamburg, Germany.

Palmer, L.J. (1941): Dall sheep in the Mt. Hayes region. United States Department of the Interior Fish and Wildlife Service. Unpublished Report.

Pitzman, M. (1969): "Lamb survival." Alaska Dept. of Fish and Game Project No: W-15-R-3. Unpublished Report.

Pulling, A.V.S. (1945): Non-breeding in bighorn sheep. J. Wildlife Mgmt. 9 (2): 155-156.

Raesfeld, von F. (1964): Das Rotwild (5th edition) Verlag Paul Parey, Hamburg, Germany.

Raesfeld, von F. (1965): Das Rehwild (6th edition) Verlag Paul Parey, Hamburg, Germany.

Rausch, R.A. & F. Jones (1966): Sheep Report. Alaska Dept. of Fish and Game, Project No: W-6-R-6. Unpublished Report.

Scholander, P.F., V. Walters, R. Hock and L. Irving (1950): Body insulation of some arctic and tropical mammals and birds. Biol. Bull. 99: 225-236.

Schröder, W. (1971 ): Untersuchungen zur Ökologie des Gamswildes (Rupicapra rupicapra) in einem Vorkommen der Alpen (Part I). Zeitschrift für Jagdwissenschaft 17 (4): 197-235.

Scott, R.F. (1951 a): Mountain Sheep studies. U.S. Fish and Wildlife Service. Quart. Prog. Rept. Work Plan No. 9: 5(3): 11-21. Unpublished Report.

Scott, R.F. (1951 b): Mountain sheep studies for period April 1 to September 30. U.S. Fish and Wildlife Service. Quarterly Progress Report P-R Project 3-4-6, Work Plan (f), Alaska. 6(1): 64-95. Typewritten.

Scott, R.F. (1951c): Distribution and Abundance of Dall Sheep in Alaska. Second Alaska Science Conference, Mt. McKinley National Park. September 4-8 /1951.

Scott, R., E.F. Chatelain & W.A. Elkins (1950): The Status of the Dall Sheep and Caribou in Alaska. Transactions of the 15th North American Wildlife Conference: 597-611.

Shackleton, D.M. (1973): Population quality and Bighorn Sheep (Ovis canadensis canadensis Shaw). University of Calgary. Unpubl. Ph.D. Thesis.

Shackleton, D. & D.A. Hutton (1971): An analysis of the mechanism of brooming of mountain sheep horns. Zeitschrift fur Säugetierkunde. Bd. 36 (6): 342-350.

Sheldon, C. (1911): The Wilderness of the upper Yukon. Charles Scribner's Sons New York.

Sheldon, C. (1930): The wilderness of Denali: explorations of a hunter-naturalist in northern Alaska. New York and London. Charles Scribner's Sons.

Simmons, N.M. (1968): Non-resident big game hunting in game management zone 12, Mackenzie Mountains, N.W.T. Unpublished Report Canadian Wildlife Service, Edmonton.

Smith, D.R. (1954): The bighorn sheep in Idaho. Idaho Dept. Fish and Game. Wildlife Bulletin No. 1.

Spencer, C.C. (1943): Notes on the life history of Rocky Mountain Bighorn Sheep in the Tarryall Mountains of Colorado. Journal of Mammalogy 24: 1-11.

Stelfox, J.G. (1971): Bighorn Sheep in the Canadian Rockies: A History 1800 - 1970. Canadian Field Naturalist 85 (2): 101-122.

Stelfox, J.G. (1974): Range ecology of Bighorn Sheep in relation to self-regulation theories. A paper presented at the Northern Wild Sheep Council meeting in Great Falls, Montana, April 23-25/1974.

Stoddart, L.A. & A.D. Smith (1955): Range Management. McGraw-Hill Book Company, New York. 433 pp.

Taber, R.D. & R.F. Dasmann (1957): The dynamics of three natural populations of the deer Odocoileus hemionus columbianus. Ecology 30: 233-246.

Tribe, D.E. (1950): The behaviour of the grazing animal: A critical review of present knowledge. Brit. Grassl. Soc. J. 5: 209-24.

Wallace, R. (1884): The natural and artificial food of Scotch hill sheep. Trans. Highl. Agric. Soc. 16 (Series 4): 250.

Welles, R.E. and F.B. Welles (1961): The bighorn of Death Valley. Fauna of the National Parks of the United States. Fauna Series No.6.

Wishart, W.D. (1958): The Bighorn Sheep of the Sheep River Valley. University of Alberta. Unpubl. Master Thesis.

Woodgerd, W. (1964): Population Dynamics of Bighorn Sheep on Wildhorse Island. Journal of Wildlife Management Vol. 28 (2): 381-391.

Young, G.O. (1947): Alaskan-Yukon Tropies won and lost. Standard Publications Inc. Huntington, West Virginia. 273 pp.

# A P P E N D I X

*Table: 1* Numbers of Dall Sheep (excluding new born lambs) counted on Sheep Mountain "winter ranges"

**January**

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | | | 108 | | |
| 2 | | | 89 | | |
| 3 | | | | | |
| 4 | | | 84 | | |
| 5 | | | 90 | | |
| 6 | | | 92 | | |
| 7 | | | | | |
| 8 | | | 102 | | |
| 9 | | | 101 | | |
| 10 | | | 101 | | |
| 11 | | | 99 | | |
| 12 | | | 101 | | |
| 13 | | | 98 | | |
| 14 | | | 92 | | |
| 15 | | | | | |
| 16 | | | 100 | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | 94 | | |
| 20 | | | 96 | | |
| 21 | | | 101 | | |
| 22 | | | | | |
| 23 | | | 111 | | |
| 24 | | | 103 | | |
| 25 | | | 120 | | |
| 26 | | | | | |
| 27 | | | 117 | | |
| 28 | | | | | |
| 29 | | | | | |
| 30 | | | | | |
| 31 | | | 104 | | |

**February**

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | | | 76 | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | 99 | | |
| 5 | | | 75 | | |
| 6 | | | 85 | | |
| 7 | | | 78 | | |
| 8 | | | 96 | | |
| 9 | | | 114 | | |
| 10 | | | 116 | | |
| 11 | | | 99 | | |
| 12 | | | 90 | | |
| 13 | | | 98 | | |
| 14 | | | 116 | | |
| 15 | | | 155 | | |
| 16 | | | 141 | | |
| 17 | | | 113 | | |
| 18 | | | 118 | | |
| 19 | | | 112 | | |
| 20 | | | 136 | | |
| 21 | | | 138 | | |
| 22 | | | 116 | | |
| 23 | | | 130 | | |
| 24 | | | | | |
| 25 | | | | | |
| 26 | | | | | |
| 27 | | | | | |
| 28 | | | | | |
| 29 | | | | | |

**March**

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | | | 117 | | |
| 2 | | | 140 | | |
| 3 | | | 147 | | |
| 4 | | | 127 | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | 122 | | |
| 8 | | | 129 | | |
| 9 | | | 107 | | |
| 10 | | | 106 | | |
| 11 | | | 125 | | |
| 12 | | | 123 | | |
| 13 | | | 129 | | |
| 14 | | | 129 | | |
| 15 | | | 126 | | |
| 16 | | | 122 | | |
| 17 | | | 122 | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |
| 21 | | | | | |
| 22 | | | 146 | | |
| 23 | | | | | |
| 24 | | | 151 | | |
| 25 | | | | | |
| 26 | | | | | |
| 27 | | | | | |
| 28 | | | 153 | | |
| 29 | | | 147 | | |
| 30 | | | 146 | | |
| 31 | | | 150 | | |

**April**

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | | | 155 | | |
| 2 | | | 151 | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | 159 | | |
| 6 | | | | | |
| 7 | | | 164 | | |
| 8 | | | 151 | | |
| 9 | | | 164 | | |
| 10 | | | 149 | | |
| 11 | | 113 | | | |
| 12 | | | | | |
| 13 | | | 129 | | |
| 14 | | 117 | 88 | | |
| 15 | | | 129 | | |
| 16 | | | | | |
| 17 | | 119 | | | |
| 18 | | | 121 | | |
| 19 | | | 118 | | |
| 20 | | | | | 171 |
| 21 | | | 119 | | 156 |
| 22 | | | 118 | | |
| 23 | | 157 | 122 | | |
| 24 | | | | | |
| 25 | | 149 | | | |
| 26 | | | 85 | | |
| 27 | | 145 | | | |
| 28 | | | 93 | | |
| 29 | | 128 | | | |
| 30 | | | | | |

## May

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | | 139 | | | |
| 2 | | | 63 | | |
| 3 | | 129 | | | |
| 4 | | | 74 | | |
| 5 | | 142 | | 115 | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | 73 | 103 | |
| 9 | | 151 | 75 | | |
| 10 | | | | 86 | |
| 11 | | | | 104 | |
| 12 | | 98 | | 104 | |
| 13 | | | | | |
| 14 | | 103 | | | |
| 15 | | 103 | | 123 | |
| 16 | | | | 126 | |
| 17 | 61 | | 104 | 146 | |
| 18 | 90 | 131 | | 133 | |
| 19 | 51 | 120 | 82 | 139 | |
| 20 | | | 93 | 135 | |
| 21 | 75 | 126 | 88 | 123 | 136 |
| 22 | 81 | | | | |
| 23 | 60 | | | | |
| 24 | 31 | 132 | 100 | 148 | |
| 25 | 13 | | | 143 | |
| 26 | 56 | | 106 | 136 | |
| 27 | | 103 | 99 | 143 | |
| 28 | 29 | | 120 | 155 | 110 |
| 29 | 13 | 100 | 105 | 126 | 106 |
| 30 | 29 | | | 126 | |
| 31 | 35 | | | 130 | |

## June

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | 31 | | 98 | 109 | |
| 2 | 62 | 97 | 96 | | |
| 3 | 20 | 96 | | 100 | |
| 4 | 29 | | 96 | 81 | |
| 5 | 23 | | 75 | 79 | |
| 6 | 11 | | | 71 | |
| 7 | | 47 | 81 | 81 | |
| 8 | 15 | | 83 | 82 | |
| 9 | | 44 | 75 | 78 | |
| 10 | 1 | | 90 | 84 | |
| 11 | | 11 | 28 | 32 | |
| 12 | | 53 | | | |
| 13 | 3 | 45 | | | *24* |
| 14 | | 52 | 33 | 34 | *13* |
| 15 | | 10 | 37 | 17 | *11* |
| 16 | | 1 | | | |
| 17 | | 4 | 21 | 23 | |
| 18 | | | | 20 | |
| 19 | | 2 | 17 | 39 | |
| 20 | | 22 | 4 | 2 | |
| 21 | | 2 | | 4 | |
| 22 | | 6 | 7 | | |
| 23 | | 2 | 7 | | |
| 24 | | | 1 | 3 | |
| 25 | | | 1 | 8 | |
| 26 | | | | | |
| 27 | | | | | |
| 28 | | | | | |
| 29 | | | 1 | | |
| 30 | | | | | |

## July

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |
| 21 | | | | | |
| 22 | | | | | |
| 23 | | | | | |
| 24 | | | | | |
| 25 | | | | | |
| 26 | | | | | |
| 27 | | | | | |
| 28 | | | | | |
| 29 | | | | | |
| 30 | | | | | |
| 31 | | | | | |

## August

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | 6 | |
| 9 | | | | | |
| 10 | | | | | *55* |
| 11 | | | | 3 | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | 17 | 15 | | | |
| 15 | 37 | | | 32 | |
| 16 | | | | 44 | |
| 17 | | | 15 | | |
| 18 | | 22 | 35 | | |
| 19 | 8 | 39 | | | |
| 20 | 18 | | 32 | | |
| 21 | | | | | |
| 22 | | 34 | | | |
| 23 | 15 | | 7 | 98 | |
| 24 | 11 | 50 | | | |
| 25 | | 27 | | 63 | |
| 26 | | 72 | | 78 | |
| 27 | | 1 | 24 | 97 | |
| 28 | | 1 | | | |
| 29 | | | | 40 | |
| 30 | 11 | | 40 | 64 | |
| 31 | 9 | 42 | | 86 | |

## September

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | 31 | 45 | | 68 | |
| 2 | 42 | 45 | 30 | | |
| 3 | 90 | 57 | 34 | | |
| 4 | 94 | 47 | | 37 | |
| 5 | 59 | 42 | | | |
| 6 | 63 | 40 | | | |
| 7 | | 41 | | | |
| 8 | 111 | 75 | 82 | | |
| 9 | 68 | 95 | 73 | 100 | |
| 10 | 66 | 87 | 80 | 108 | |
| 11 | 114 | 49 | 91 | 110 | |
| 12 | | | 141 | 113 | |
| 13 | 72 | | 111 | 96 | |
| 14 | 85 | 55 | 104 | | |
| 15 | | 54 | 85 | | |
| 16 | | 78 | 142 | | |
| 17 | | | 119 | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | 85 | | | |
| 21 | | 76 | | | |
| 22 | | 102 | | | |
| 23 | | 86 | 137 | | |
| 24 | | 79 | 138 | | |
| 25 | | 94 | 139 | | |
| 26 | | 56 | 139 | | |
| 27 | | 63 | | | |
| 28 | | 74 | 81 | | |
| 29 | | 66 | 136 | | |
| 30 | | 48 | 139 | | |

## October

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | | 31 | 134 | 99 | |
| 2 | | | 120 | | |
| 3 | | | 136 | | |
| 4 | | 110 | | | |
| 5 | | 151 | | | |
| 6 | | 112 | 151 | | 133 |
| 7 | | | 121 | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | 93 | | | |
| 13 | | 81 | | | |
| 14 | | | | | |
| 15 | | 83 | | | |
| 16 | | 96 | | | |
| 17 | | 110 | | | |
| 18 | | 88 | | | |
| 19 | | 86 | | | |
| 20 | | 105 | | | |
| 21 | | 79 | | | |
| 22 | | 77 | | | |
| 23 | | 74 | | | |
| 24 | | 143 | | | |
| 25 | | 150 | | | |
| 26 | | 140 | | | |
| 27 | | 108 | | | |
| 28 | | 60 | | | |
| 29 | | 35 | 102 | | |
| 30 | | 45 | 78 | | |
| 31 | | 35 | | | |

## November

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | | 17 | | | |
| 2 | | 53 | | | |
| 3 | | 65 | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | 98 | | | |
| 9 | | 131 | | | |
| 10 | | | | | |
| 11 | | 88 | | | |
| 12 | | 70 | | | |
| 13 | | 105 | | | |
| 14 | | 111 | 99 | | |
| 15 | | 96 | | | |
| 16 | | 91 | | | |
| 17 | | | | | |
| 18 | | 74 | | | |
| 19 | | | | | |
| 20 | | | | | |
| 21 | | | | | |
| 22 | | 69 | | | |
| 23 | | 43 | | | |
| 24 | | 70 | | | |
| 25 | | | | | |
| 26 | | 73 | | | |
| 27 | | | | | |
| 28 | | | | | |
| 29 | | 111 | | | |
| 30 | | 98 | | | |

## December

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| 1 | | 105 | | | |
| 2 | | 111 | | | |
| 3 | | 101 | | | |
| 4 | | | | | |
| 5 | | 100 | | | |
| 6 | | | | | |
| 7 | | 102 | | | |
| 8 | | 97 | | | |
| 9 | | 95 | | | |
| 10 | | 101 | | | |
| 11 | | 94 | | | |
| 12 | | 94 | | | |
| 13 | | 102 | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |
| 17 | | 72 | | | |
| 18 | | 92 | | | |
| 19 | | 74 | | | |
| 20 | | 81 | | | |
| 21 | | 74 | | | |
| 22 | | 100 | | | |
| 23 | | 96 | | | |
| 24 | | | | | |
| 25 | | | | | |
| 26 | | | | | |
| 27 | | 83 | | | |
| 28 | | | | | |
| 29 | | | | | |
| 30 | | 88 | | | |
| 31 | | 114 | | | |

TABLE: 39)

Horn Data From the Kluane Game Sanctuary.

Sheep Mountain Population (Rams):

| Collection Number | Age at Death | Time of Death | Location of Kill | Owner |
|---|---|---|---|---|
| A 81 | 9 | April '73 | Sheep Mountain | Yukon Game Branch |
| A 75 | 9.5 | November '72 | Game Farm * | Niel Olson, Haines Junction |
| A 83 | 12 | Winter 71/72 | Sheep Creek | unknown |
| C 40 | 11 | unknown | Congdon Creek | Yukon Game Branch |
| C 42 | 8 | unknown | Sheep Mountain | |
| C 46 | 9.5 | November '71 | Sheep Mountain | Ken Summers, Vancouver |
| C 30 | 4 | unknown | Sheep Mountain | |
| C 29 | 10 | unknown | Congdon Creek | |
| C 20 | 8 | unknown | Sheep Mountain | |
| C 19 | 11 | unknown | Sheep Mountain | |
| C 14 | 10 | unknown | Congdon Creek | Dr. J. Theberge, U. of Waterloo |
| C 11 | 8 | unknown | Sheep Mountain | Joe Hubbart, U. of Wisconsin |
| C 7 | 4.5 | unknown | Sheep Creek | M. Hoefs, Whitehorse |
| C 6 | 5.5 | unknown | Sheep Creek | Yukon Game Branch |
| C 5 | 5 | unknown | Sheep Mountain | Yukon Game Branch |
| C 4 | 7 | unknown | Sheep Creek | Yukon Game Branch |
| C 3 | 12 | unknown | Congdon Creek | Yukon Game Branch |
| C 2 | 10 | unknown | Congdon Creek | Yukon Game Branch |
| C 49 | 3 | Winter 71/72 | Sheep Mountain | |

* Caught on Sheep Mountain, died in Yukon Game Farm.

| Collection Number | Age at death | Time of death | Location of kill | Owner |
|---|---|---|---|---|
| C 1 | 7 | unknown | Sheep Mountain | Rob Gordon, Vanc. |
| B 19 | 10 | unknown | Sheep Mountain | |
| B 18 | 10 | unknown | Sheep Mountain | |
| B 17 | 8 | unknown | Sheep Mountain | |
| B 16 | 3 | unknown | Sheep Mountain | Yukon Game Branch |
| B 15 | 4 | unknown | Sheep Mountain | Yukon Game Branch |
| B 6 | 11 | unknown | Sheep Creek | Yukon Game Branch |
| B 5 | 8.5 | unknown | Congdon Creek | Dan Stevens, Vanc. |
| B 4 | 10 | unknown | Sheep Creek | Yukon Game Branch |
| B 3 | 7 | unknown | Sheep Mountain | Yukon Game Branch |
| B 2 | 7 | unknown | Sheep Mountain | Rob Gordon, Vanc. |
| B 1 | 6 | unknown | Sheep Mountain | Yukon Game Branch |
| C 31 | 7 | unknown | Sheep Mountain | |
| C 32 | 7 | unknown | Sheep Mountain | |
| A 74 | 8 | unknown | Sheep Mountain | Yukon Game Branch |
| A 70 | 10 | unknown | Bullion Creek | Bill Richards, Guelph |
| A 69 | 9 | Winter 70/71 | Congdon Creek | Bill Richards, Guelph |
| A 64 | 11 | Winter 70/71 | Williscroft Creek | Niel Olson, Haines Junction |
| A 63 | 5 | unknown | Sheep Mountain | Niel Olson, Haines Junction |
| A 60 | 13 | unknown | Sheep Mountain | Dr. Stan Jones, Haines, Alaska |
| A 56 | 8 | April '71 | Sheep Mountain | Yukon Game Branch |
| A 47 | 3 | February '71 | Sheep Mountain | Yukon Game Branch |
| A 42 | 9.5 | November '70 | Sheep Mountain | Neil Olson, Haines Junction |

| Collection Number | Age at Death | Time of Death | Location of Kill | Owner |
|---|---|---|---|---|
| A 38 | 12 | unknown | Sheep Mountain | Yukon Game Branch |
| A 37 | 11 | unknown | Bullion Creek | Niel Olson, Haines Junction |
| A 26 | 4 | unknown | Sheep Mountain | Rob Gordon, Vancouver |
| A 25 | 11 | unknown | Sheep Mountain | Dave Mossop, Whitehorse |
| A 21 | 3.5 | unknown | Sheep Mountain | Rob Gordon, Vancouver |
| A 13 | 11 | unknown | Congdon Creek | Fred Lambert, Haines Junction |
| A 9 | 11 | unknown | Congdon Creek | Yukon Game Branch |
| A 8 | 12 | unknown | Sheep Mountain | Hubert Kurtz, Nanaimo |
| A 7 | 9 | Winter 69/70 | Sheep Mountain | Herb Wahl, Whitehorse |
| A 6 | 7 | unknown | Sheep Mountain | Rob Gordon, Vancouver |
| A. 5 | 10 | February '70 | Sheep Mountain | M. Hoefs, Whitehorse |
| A 4 | 11 | Winter 69/70 | Sheep Mountain | Yukon Game Branch |
| A 45 | 9.5 | Winter 70/71 | Sheep Mountain | Yukon Game Branch |
| Collections From Other Areas (Rams): | | | | |
| A 82 | 8 | Winter 72/73 | Kaskawulsh Terminus | Kluane Parks Branch |
| A 79 | 12 | Winter 72/73 | Duke River | Ron Chambers, Whitehorse |
| A 78 | 11 | Winter 72/73 | Duke River | Ron Chambers, Whitehorse |
| A 77 | 9 | Winter 72/73 | Duke River | Ron Chambers, Whitehorse |
| A 76 | 9 | Winter 72/73 | Duke River | Ron Chambers, Whitehorse |
| A 80 | 11.5 | October '72 | Jarvis River | Kluane Parks Branch |

| Collection Number | Age at death | Time of death | Location of Kill | Owner |
|---|---|---|---|---|
| C 49 | 9 | unknown | Ruby Range | Vic Hotte, Haines Junction |
| C 50 | 10 | unknown | Ruby Range | Vic Hotte, Haines Junction |
| C 51 | 11 | unknown | Ruby Range | Vic Hotte, Haines Junction |
| C 34 | 8.5 | unknown | Halfbreed Creek | unknown |
| C 35 | 13 | unknown | Halfbreed Creek | unknown |
| C 36 | 7 | unknown | Dickson Creek | unknown |
| C 37 | 4.5 | unknown | Dickson Creek | unknown |
| C 38 | 11 | Winter 71/72 | Nines Creek | Yukon Game Branch |
| C 39 | 9.5 | October '71 | Rock's Brook | Yukon Game Branch |
| C 41 | 10 | unknown | Vulcan Creek | |
| C 43 | 7 | unknown | Donjek Terminus | |
| C 44 | 12 | unknown | Donjek Terminus | |
| C 45 | 12 | Winter 71/72 | Donjek Terminus | |
| C 47 | 12 | Winter 71/72 | Kaskawulsh Terminus | Yukon Game Branch |
| C 48 | 9 | Winter 71/72 | Vulcan Creek | unknown |
| C 28 | 3 | unknown | Kaskawulsh Glacier | |
| C 27 | 11 | unknown | Vulcan Creek | |
| C 26 | 8 | unknown | Vulcan Creek | |
| C 25 | 11 | unknown | Kaskawulsh Terminus | Yukon Game Branch |
| C 24 | 11 | unknown | Kaskawulsh Terminus | Yukon Game Branch |
| C 23 | 5 | unknown | Vulcan Creek | |
| C 22 | 12 | unknown | Lynx Creek | |
| C 21 | 12 | unknown | Kaskawulsh Terminus | Bill Nickling, Arctic Institute |

| Collection Number | Age at death | Time of death | Location of kill | Owner |
|---|---|---|---|---|
| C 18 | 7 | unknown | Canada Creek | |
| C 17 | 10 | unknown | Canada Creek | |
| C 16 | 10 | unknown | Canada Creek | |
| C 15 | 7.5 | unknown | Canada Creek | Robin Houston, Arctic Institute |
| C 13 | 6 | unknown | Mines Creek | M. Hoefs, Whitehorse |
| C 12 | 6 | unknown | Vulcan Creek | Yukon Game Branch |
| C 10 | 11 | unknown | Donjek River | Yukon Game Branch |
| C 9 | 9 | unknown | Donjek River | Yukon Game Branch |
| C 8 | 9 | unknown | Donjek River | Yukon Game Branch |
| B 14 | 11 | unknown | Vulcan Creek | |
| B 13 | 11 | unknown | Vulcan Creek | |
| B 12 | 9 | unknown | Vulcan Creek | Yukon Game Branch |
| B 11 | 10 | unknown | Burwash Creek | Ron Chambers, Whitehorse |
| B 10 | 9 | unknown | Burwash Creek | Ron Chambers, Whitehorse |
| B 9 | 5.5 | unknown | Donjek Terminus | Yukon Game Branch |
| B 8 | 4.5 | unknown | Donjek River | Yukon Game Branch |
| B 7 | 12 | unknown | Donjek River | Yukon Game Branch |
| A 68 | 9 | Winter 70/71 | Vulcan Creek | Bill Richards, Guelph |
| A 67 | 10 | Winter 70/71 | Kaskawulsh Terminus | Don Armitage, Arctic Institute |
| A 66 | 9 | Winter 70/71 | Dickson Creek | Peter Radford, Destruction Bay |
| A 65 | 10 | unknown | Canada Creek | M. Hoefs, Whitehorse |
| A 54 | 9 | Winter 70/71 | Bock's Brook | Peter Radford, Destruction Bay |

| Collection Number | Age at Death | Time of Death | Location of Kill | Owner |
|---|---|---|---|---|
| A 53 | 8 | unknown | Kakawulsh Terminus | Jim O'Conell, Carmacks |
| A 22 | 9 | Winter 69/70 | Vulcan Creek | Yukon Game Branch |
| A 10 | 10 | April '69 | Duke River | Darryl Denusing, Burwash |
| A 1 | 8 | Winter 69/70 | Bock's Brook | Ken Williams, Vancouver |

Collection of Ewe Horns:

| | | | | |
|---|---|---|---|---|
| D 19 | 9 | unknown | Sheep Mountain | |
| D 20 | 9 | unknown | Bullion Creek | |
| D 21 | 13 | Winter 70/71 | Sheep Mountain | Yukon Game Branch |
| F 1 | 12 | unknown | Ruby Range | Yukon Game Branch |
| F 2 | 12 | Spring '70 | Williscroft Creek | Yukon Game Branch |
| D 12 | 8 | April '71 | Sheep Mountain | |
| D 9 | 13 | March '71 | Sheep Mountain | |

Summary for Rams

| Age of Ram | Numbers dying; based on horn collections |
|---|---|
| 0 - 1 | 0 |
| 1 - 2 | 0 |
| 2 - 3 | 4 |
| 3 - 4 | 4 |
| 4 - 5 | 6 |
| 5 - 6 | 5 |
| 6 - 7 | 10 |
| 7 - 8 | 11 |
| 8 - 9 | 17 |
| 9 - 10 | 21 |
| 10 - 11 | 18 |
| 11 - 12 | 12 |
| 12 - 13 | 2 |
| Sum | 110 |

LE3
B7
1976
A1
H63
v.2
set 1

This table published in Syesis vol. 8, 1975, Suppl. 1



Table LIII

# CONDENSED TABLE OF FLORISTIC STRUCTURE OF PLANT ASSOCIATIONS AND THEIR HIGHER UNITS

[expressed by the constancy classes (Roman numbers) and the average species significance]

| | | PUCCINELLIO - SALICORNIETALIA | | | | CARICETALIA AQUATILIS | | SALICETALIA PLANIFOLIAE | | DRYADETALIA DRUMMONDII | POPULETALIA BALSAMIFERAE | CALAMAGROSTIDO (PURPURASCENTIS) - ARCTOSTAPHYLETALIA UVAE-URSI | PICEETALIA GLAUCAE - MARIANAE | ARTEMISIO (FRIGIDAE) - AGROPYRETALIA YUKONENSIS | | | | BETULETALIA GLANDULOSAE | | ARTEMISIETALIA ALASKANAE | | DRYADETALIA INTEGRIFOLIAE | | OXYTROPO (VISCIDAE) - ARTEMISIO (HYPERBOREAE) - FESTUCO (BRACHYPHYLLAE) - TRISETETALIA SPICATI | | AGROPYRETALIA VIOLACEI | FESTUCETALIA ALTAICAE | SALICETALIA BARRATTIANAE | SALICETALIA POLARIS | | PETASITETALIA FRIGIDI | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Order | | 1 | | | | 2 | | 3 | | 4 | 5 | 6 | 7 | 8 | | | | 9 | | 10 | | 11 | | 12 | | 13 | 14 | 15 | 16 | | 17 | |
| Alliance | | 1 | | 2 | | 3 | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | | 11 | | 12 | 13 | 14 | 15 | 16 | | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Association | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| Number of plots | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 10 | 10 | 10 | 5 | 5 | 10 | 5 | 10 | 10 | 5 | 5 | 10 | 5 | 10 | 5 | 5 | 10 | 10 | 10 | 10 | 5 | 5 |
| CHARACTERISTIC SPECIES: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ORDER 1 & Alliance 1: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Aster yukonensis | III 0.6 | V 2.4 | V 4.6 | V 2.0 | IV 1.2 | I 0.6 | V 1.8 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Hordeum jubatum | . | V 2.0 | V 1.2 | I 0.4 | III 1.4 | I 0.2 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Puccinellia deschampsioides | IV 0.8 | V 5.0 | IV 1.0 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Taraxacum lacerum | V 3.0 | III 0.6 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Alliance 2: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Deschampsia caespitosa | . | I 0.2 | IV 1.0 | V 5.0 | IV 1.2 | I 0.4 | II 0.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Ranunculus cymbalaria | . | . | . | III 0.8 | III 0.6 | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| ORDER 2 & Alliance 3: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Calamagrostis neglecta | . | . | . | . | III 1.6 | III 0.6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Carex aquatilis | . | . | . | . | V 1.0 | V 6.8 | II 0.4 | V 5.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Triglochin palustre | . | . | . | . | V 2.4 | V 1.6 | III 0.6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Association 5: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Castilleja yukonis | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Lomatogonium rotatum | . | . | . | . | III 1.0 | . | III 0.6 | I 0.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Primula stricta | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| ORDER 3: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (B) Salix brachycarpa | . | . | . | . | II 0.4 | . | V 5.6 | II 1.2 | . | . | . | . | . | . | . | . | . | I 0.1 | I 0.1 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Salix planifolia | . | . | . | . | . | . | III 0.6 | V 6.6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (C) Carex hassei | . | . | . | . | . | . | II 0.4 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Equisetum palustre | . | . | . | . | . | . | IV 1.2 | III 2.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Juncus arcticus | . | . | . | I 0.2 | V 6.2 | . | V 6.2 | IV 1.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (D) Catoscopium nigritum | . | . | . | . | . | . | III 1.2 | III 0.8 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Cinclidium stygium | . | . | . | . | . | . | II 0.6 | II 0.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Alliance 4 & Association 7: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Carex microglochin | . | . | . | . | . | . | IV 0.8 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Carex parryana | . | . | . | . | I 0.2 | . | V 1.6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Pedicularis sudetica | . | . | . | . | I 0.2 | . | V 1.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Spiranthes romanzoffiana | . | . | . | . | . | . | III 0.6 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Alliance 5 & Association 8: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Eriophorum brachyantherum | . | . | . | . | . | . | . | II 0.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Juncus alpinus | . | . | . | . | . | . | . | I 0.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (D) Marchantia polymorpha | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Meesea uliginosa | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| ORDER 4, Alliance 6 & Association 9: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (B) Elaeagnus commutata | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (C) Crepis elegans | . | . | . | . | . | . | . | . | V 1.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Dryas drummondii | . | . | . | . | . | . | . | . | V 6.0 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Lupinus arcticus | . | . | . | . | . | . | . | . | III 0.6 | . | . | . | . | . | . | . | . | I 0.2 | I 0.1 | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . |
| Oxytropis campestris | . | . | . | . | . | . | . | . | III 0.8 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| ORDER 5, Alliance 7 & Association 10: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (A) Populus balsamifera | . | . | . | . | . | . | . | . | [II 0.6]* | V 6.8 | [I 0.2] | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Populus tremuloides | . | . | . | . | . | . | . | . | . | IV 4.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (B) Juniperus communis | . | . | . | . | . | . | . | . | . | V 5.4 | III 0.8 | II 0.5 | . | . | . | . | . | III 0.8 | II 0.5 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Rosa acicularis | . | . | . | . | . | . | . | . | . | V 3.2 | V 2.4 | I 0.2 | [I 0.2] | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Shepherdia canadensis | . | . | . | . | . | . | . | . | . | V 4.2 | IV 1.1 | I 0.2 | . | . | . | . | . | III 0.5 | III 0.5 | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . |
| Viburnum edule | . | . | . | . | . | . | . | . | . | III 2.6 | . | . | . | . | . | . | . | I 0.2 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (C) Epilobium angustifolium | . | . | . | . | . | . | . | . | . | IV 1.4 | . | . | . | . | . | . | . | II 0.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Juniperus horizontalis | . | . | . | . | . | . | . | . | . | V 2.6 | II 1.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| ORDER 6, Alliance 8 & Association 11: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Achillea lanulosa | . | . | . | . | . | . | . | . | . | . | IV 1.2 | . | . | . | . | . | . | II 0.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Anemone multifida | . | . | . | . | . | . | . | . | . | . | IV 1.2 | IV 0.7 | II 0.6 | . | . | . | II 0.4 | . | . | III 1.0 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Arctostaphylos uva-ursi | . | . | . | . | . | . | . | . | . | V 3.4 | V 7.0 | III 0.8 | . | . | . | . | . | V 2.9 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Astragalus williamsii | . | . | . | . | . | . | . | . | . | . | IV 2.6 | I 0.1 | . | . | . | I 0.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Bromus pumpellianus | . | . | . | . | . | . | . | . | . | . | III 1.2 | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Calamagrostis purpurascens | . | . | . | . | . | . | . | . | . | . | V 5.8 | . | III 1.1 | I 0.4 | . | V 1.8 | V 3.6 | . | I 0.1 | I 0.1 | V 1.2 | . | . | IV 1.4 | II 0.6 | . | . | . | . | . | . | . | . |
| Comandra umbellata | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | I 0.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Galium boreale | . | . | . | . | . | . | . | . | . | . | II 0.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Pulsatilla patens | . | . | . | . | . | . | . | . | . | . | V 2.2 | . | III 0.6 | . | . | I 0.2 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Smilacina stellata | . | . | . | . | . | . | . | . | . | I 0.4 | II 0.7 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Solidago decumbens | . | . | . | . | . | . | . | . | . | . | IV 1.0 | . | II 0.3 | . | . | I 0.2 | . | IV 0.7 | I 0.1 | . | III 0.6 | . | . | . | . | . | . | . | . | . | . | . | . |
| ORDER 7: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (A) Picea glauca | . | . | . | . | . | . | [I 0.2] | [I 0.2] | . | [II 0.4] | [I 0.1] | V 7.2 | . | . | . | . | . | [III 0.5] | [IV 0.7] | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (C) Carex concinna | . | . | . | . | . | . | . | . | . | . | . | IV 0.9 | . | . | . | . | . | I 0.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Geocaulon lividum | . | . | . | . | . | . | . | . | . | III 0.5 | . | III 1.8 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Linnaea borealis | . | . | . | . | . | . | . | . | . | II 0.4 | . | V 3.4 | . | . | . | . | . | V 1.7 | III 1.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Pyrola secunda | . | . | . | . | . | . | . | . | . | I 0.2 | . | IV 1.0 | . | . | . | . | . | II 0.4 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Alliance 9 & Association 12: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Cypripedium passerinum | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Hedysarum mackenzii | . | . | . | . | . | . | . | . | . | . | II 0.7 | III 0.7 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| (D) Abietinella abietina | . | . | . | . | . | . | . | . | . | . | . | V 4.6 | . | . | . | . | . | III 0.5 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Hypnum procerrimum | . | . | . | . | . | . | . | . | . | III 0.6 | . | V 5.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Peltigera canina | . | . | . | . | . | . | . | . | . | . | . | V 2.2 | . | . | . | . | . | IV 0.9 | III 0.5 | . | . | III 0.6 | I 0.2 | . | . | . | II 0.4 | IV 0.7 | IV 1.2 | II 0.3 | . | II 0.4 | |
| ORDER 8 & Alliance 10: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Agropyron yukonense | . | . | . | . | . | . | . | . | . | . | II 0.4 | . | V 4.4 | V 2.8 | I 0.4 | V 2.2 | I 0.4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Artemisia frigida | . | . | . | . | . | . | . | . | . | I 0.2 | III 0.9 | . | V 5.5 | V 5.6 | V 5.2 | V 3.3 | V 3.8 | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . |
| Aster alpinus | . | . | . | . | . | . | . | . | . | . | II 0.3 | . | III 0.6 | . | . | II 0.4 | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Carex filifolia | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | V 2.7 | II 0.6 | II 0.6 | III 2.7 | V 5.2 | V 2.9 | . | . | . | . | . | V 1.6 | I 0.2 | . | . | . | . | . | . | . | . |
| Erigeron caespitosus | . | . | . | . | . | . | . | . | . | . | III 0.6 | . | V 2.7 | I 0.2 | I 0.2 | IV 1.0 | V 1.0 | . | . | . | III 0.6 | . | . | . | . | . | . | . | . | . | . | . | . |
| Linum perenne | . | . | . | . | . | . | . | . | . | . | III 0.5 | . | IV 1.0 | I 0.2 | III 1.0 | II 0.3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| Pentstemon gormanii | . | . | . | . | . | . | . | . | . | . | II 0.4 | . | V 2.2 | III 0.6 | V 4.2 | IV 1.4 | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . |
| (D) Caloplaca cirrochroa | . | . | . | . | . | . | . | . | . | . | II 0.4 | . | IV 0.8 | I 0.2 | IV 1.0 | III 0.5 | V 1.0 | . | . | . | . | II 0.4 | II 0.4 | IV 0.7 | II 0.4 | . | . | . | . | . | . | . | . |
| Dermatocarpon hepaticum | . | . | . | . | . | . | . | . | . | . | II 0.5 | . | V 4.8 | I 0.6 | V 4.4 | III 0.6 | II 0.6 | . | . | . | . | V 1.4 | IV 0.8 | IV 1.4 | V 2.2 | . | . | . | III 0.7 | . | . | . | . |
| Hypnum vaucheri | . | . | . | . | . | . | . | . | . | . | II 0.6 | . | II 0.6 | I 0.2 | IV 1.2 | I 0.2 | IV 1.0 | . | . | . | . | . | . | III 0.5 | III 0.6 | . | . | . | . | . | . | . | . |
| Lecidea decipiens | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | IV 0.8 | I 0.2 | V 1.6 | I 0.2 | II 0.6 | . | . | . | . | I 0.2 | . | III 0.8 | III 0.8 | . | . | . | . | . | . | . | . |
| Lecidea rubiformis | . | . | . | . | . | . | . | . | . | . | III 0.6 | . | V 2.8 | I 0.2 | V 5.4 | III 0.6 | IV 0.8 | . | . | . | . | I 0.2 | . | IV 1.1 | . | . | . | . | . | . | . | . | . |

* Data in the brackets [ ] indicate the occurrence in lower layer (here in B) than indicated in front of the species name.

LE3
B7
1976
A1
H63
v.2
set 1

This table published in Syesis
vol. 8, 1975, Suppl. 1



Table LIII (Cont. I)

| | | |

LE3
B7
1976
A1
H63
V.2
Set 1

This table published in Syesis vol. 8, 1975, Suppl. 1



Table LIII (Cont. II)

| Order | 1 | | | | 2 | | 3 | | 4 | 5 | 6 | 7 | 8 | | | | | 9 | | 10 | | 11 | | 12 | | 13 | 14 | 15 | 16 | | 17 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alliance | 1 | | 2 | | 3 | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | | | 11 | | 12 | 13 | 14 | 15 | 16 | | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Association | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| Number of plots | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 10 | 10 | 10 | 5 | 5 | 10 | 5 | 10 | 10 | 5 | 5 | 10 | 5 | 10 | 5 | 5 | 10 | 10 | 10 | 10 | 5 | 5 |
| CHARACTERISTIC SPECIES: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ORDER 13, Alliance 17 & Association 26: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Agropyron violaceum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | . | IV 1.4 | I 0.2 | V 1.6 | . | . | . | . | II 0.4 | . |
| Astragalus nutzotinensis | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | III 0.6 | . | . | . | I 0.2 | . | . |
| Cerastium beeringianum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 | IV 0.8 | . | . | . | . | . | . |
| Crepis nana | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | I 0.2 | . | . | . | . | IV 1.0 | . | . | . | . | . | . |
| Erigeron purpuratus | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | V 1.6 | . | . | . | . | . | . |
| Melandrium apetalum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 0.5 | . | III 0.6 | . | . | . | . | . | . |
| Smelowskia borealis | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | IV 0.8 | . | . | . | . | . | . |
| Stellaria longipes | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | II 0.4 | V 1.4 | . | . | . | . | . | . |
| ORDER 14, Alliance 18 & Association 27: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Delphinium brachycentrum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.3 | . | . | . | . | . |
| Draba lanceolata | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | . | . | . |
| Erigeron eriocephalus | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | . | . | . |
| Festuca altaica | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | V 2.8 | V 2.0 | . | . | I 0.2 | . | . | . | . | V 7.9 | . | . | IV 1.1 | IV 0.8 | I 0.2 |
| Hedysarum alpinum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | V 2.1 | V 2.3 | . | . | IV 1.6 | . | . | . | . | V 3.0 | V 2.4 | . | II 0.6 | II 0.4 | . |
| Myosotis alpestris | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | I 0.1 | . | . | IV 1.2 | II 0.3 | II 0.4 | IV 1.0 | III 1.0 | I 0.2 |
| Oxytropis deflexa | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | IV 1.4 | . | . | . | . | V 1.4 | IV 1.2 | III 0.5 | III 0.7 | . | . |
| Polemonium boreale | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | I 0.2 | . | . | . | . |
| Solidago multiradiata | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | V 1.7 | V 1.1 | . | IV 0.7 | III 0.8 | . |
| Stellaria edwardsii | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 0.6 | . | . | . | . | . |
| ORDER 15, Alliance 19 & Association 28: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (B) Salix barrattiana | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | V 8.0 | . | . | . | . |
| Salix niphoclada | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.3 | . | . | . | . |
| (C) Gentiana prostrata | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | II 0.5 | IV 0.9 | I 0.2 | II 0.3 | . | . |
| Kobresia myosuroides | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | . | . | IV 1.3 | . | . | III 0.8 | . | IV 1.5 | V 3.9 | . | . | . | . |
| Stellaria laeta | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 0.5 | . | . | . | . |
| (D) Cetraria islandica | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | . | . |
| ORDER 16: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Anemone parviflora | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | V 2.0 | V 1.6 | . | . | III 0.7 | V 1.0 | II 0.3 | I 0.2 | . | V 2.1 | V 1.7 | V 1.7 | V 2.4 | V 2.2 | III 0.6 |
| Antennaria monocephala | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 0.5 | . | . | . | . | IV 0.8 | IV 0.8 | V 1.7 | IV 0.8 | I 0.2 | . |
| Draba hirta | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | . | . | . | . | II 0.3 | . | . | . |
| Erigeron humilis | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | V 1.1 | III 0.5 | V 1.5 | V 1.0 | V 1.2 | . |
| Equisetum variegatum | . | . | . | I 0.2 | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 | II 0.3 | . | II 0.4 |
| Gentiana propinqua | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | V 1.1 | IV 0.8 | . | I 0.2 | I 0.1 | . | I 0.2 | . | . | V 1.3 | V 1.1 | II 0.3 | V 1.4 | V 1.2 | I 0.2 |
| Lloydia serotina | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | I 0.2 | . | IV 2.0 | . | . | . | V 1.7 | IV 0.9 | . | . |
| Parnassia kotzebuei | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | V 1.0 | II 0.4 | IV 0.8 | V 1.7 | V 1.4 | I 0.2 |
| Salix polaris | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.3 | IV 1.6 | . | . | . | II 0.4 | . | V 8.1 | V 3.0 | III 0.5 | V 2.0 |
| Salix reticulata | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | V 4.2 | V 4.0 | . | . | V 3.4 | V 2.4 | . | . | . | V 5.4 | V 3.4 | IV 1.2 | V 8.1 | V 2.0 | V 4.8 |
| Saussurea viscida | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 0.8 | IV 0.8 | . | II 0.6 | . | III 0.7 | III 0.6 | IV 1.4 | IV 0.8 | I 0.2 | . |
| (D) Distichium capillaceum | . | . | . | . | . | . | . | . | . | . | V 1.1 | . | . | . | . | . | . | . | . | . | . | . | V 1.6 | . | . | . | III 0.7 | III 0.6 | V 2.2 | IV 0.9 | . | . |
| Solorina spongiosa | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | . | . | I 0.2 | . | . | I 0.1 | III 0.5 | II 0.3 | . | . |
| Alliance 20 & Association 29: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Arnica lessingii | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 | . | . | . |
| Papaver macounii | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | I 0.2 | . | . | I 0.1 | . | . | . |
| Ranunculus nivalis | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | . | . | . |
| Ranunculus pygmaeus | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | . | . | . |
| Senecio atropurpureus | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 0.5 | . | . | . |
| Taraxacum alaskanum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 0.6 | . | . | . |
| Alliance 21 & Association 30: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Minuartia biflora | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | I 0.2 | . |
| Senecio lugens | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | . | . | . | . | IV 0.8 | I 0.1 | . | . | . | . | I 0.2 | . | . | V 1.5 | V 1.3 | I 0.1 | V 1.7 | V 1.2 | V 1.4 |
| Valeriana capitata | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | I 0.2 | . | . | . | . | . | . | . | I 0.3 | II 0.4 | . | III 0.6 | II 0.8 | II 0.4 |
| (D) Tortula norvegica | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 | I 0.2 | . |
| ORDER 17: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Anemone richardsonii | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | I 0.1 | I 0.2 | I 0.2 |
| Artemisia arctica | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 0.7 | I 0.1 | . | . | . | . | . | . | . | V 3.2 | V 1.7 | V 1.9 | V 2.9 | V 4.0 | III 1.0 |
| Astragalus umbellatus | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | . | I 0.2 | I 0.2 |
| Carex podocarpa | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | . | III 1.0 | IV 0.8 |
| Draba praealta | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 | III 0.6 |
| Equisetum arvense | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 | III 0.7 | . | . | . | . | . | . | . | . | I 0.2 | . | II 0.5 | III 1.2 | V 2.4 |
| Petasites frigidus | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | III 0.6 | . | . | . | . | . | . | . | . | . | III 1.2 | IV 1.7 | IV 3.2 | V 4.8 |
| Poa alpina | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | . | I 0.1 | . | . | . | . | II 0.3 | I 0.2 | I 0.1 | II 0.7 | V 1.4 | III 0.6 |
| Polemonium acutiflorum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | II 0.4 | III 0.6 | V 1.8 |
| Polygonum viviparum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | I 0.1 | II 0.4 | . | . | . | IV 0.8 | III 0.5 | III 0.7 | IV 1.1 | V 1.2 | IV 0.8 |
| (D) Timmia austriaca | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 0.6 | . | . | . | II 0.3 | . | IV 1.1 | II 0.4 | III 0.6 | V 2.4 |
| Tomentypnum nitens | . | . | . | . | . | . | . | . | . | . | II 0.3 | . | . | . | . | . | . | . | . | . | . | . | III 0.6 | . | . | . | . | . | . | . | II 0.4 | V 1.4 |
| Alliance 22 & Association 31: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Achillea borealis | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | I 0.2 | IV 1.2 | . |
| Aconitum delphinifolium | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | IV 0.8 | . | . | . | . | . | . | . | . | . | . | . | . | IV 1.6 | . |
| Alopecurus alpinus | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . |
| Arnica alpina | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | I 0.1 | . | . | I 0.2 | . |
| Artemisia tilesii | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | V 6.0 | . |
| Aster sibiricus | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | II 0.4 | . | . | . | . | . | II 0.3 | . | . | . | IV 1.0 | . |
| Delphinium glaucum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 1.2 | . |
| Epilobium latifolium | . | . | . | . | . | . | . | . | . | . | V 1.2 | . | . | . | . | . | . | I 0.1 | II 0.3 | . | II 0.4 | I 0.3 | V 1.4 | . | . | . | . | I 0.1 | . | II 0.4 | V 4.2 | . |
| Hierochloe odorata | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . |
| Mertensia paniculata | . | . | . | . | . | . | . | . | . | I 0.4 | I 0.1 | III 0.5 | . | . | . | . | . | V 1.9 | V 1.3 | I 0.2 | . | I 0.1 | . | . | . | . | V 2.1 | V 2.1 | . | IV 0.9 | V 4.6 | . |
| Oxyria digyna | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.6 | . | . | . | I 0.1 | . | V 3.1 | III 1.4 | V 3.2 | . |
| Poa lanata | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | I 0.1 | I 0.1 | . | V 1.6 | V 2.2 | . |
| Poa paucispicula | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 | . |
| Potentilla diversifolia | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | I 0.2 | II 0.4 | . |
| Ranunculus sulphureus | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 | . |
| Sedum roseum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | . | . | I 0.1 | V 2.4 | . |
| (D) Philonotis tomentella | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 | . |
| Plagiomnium rostratum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | III 0.6 | . |
| Alliance 23 & Association 32: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (C) Cardamine purpurea | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | V 2.0 |
| Carex membranacea | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.5 | . | V 2.3 | V 1.6 | . | V 7.0 |
| Claytonia bostockii | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | V 1.6 |
| Claytonia sarmentosa | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | . | I 0.1 | I 0.1 | . | V 1.0 |
| Dodecatheon frigidum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.6 | . | I 0.1 | II 0.6 | . | IV 1.0 |
| Eriophorum angustifolium | . | . | . | . | . | III 0.8 | . | V 1.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | V 2.6 |
| Parrya nudicaulis | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 | I 0.2 | . | III 0.6 | . | I 0.2 | . | III 0.6 | I 0.1 | . | IV 1.2 |
| Pedicularis kanei | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | III 0.6 | . | II 0.4 | . | . | . | III 0.8 | . | . | V 1.0 |
| Saxifraga caespitosa | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 |
| Saxifraga davurica | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.3 | . | . | III 0.6 |
| Saxifraga hieracifolia | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.1 | . | . | . | I 0.4 | V 1.4 |
| Saxifraga hirculus | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | V 1.8 |
| (D) Cetraria richardsonii | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | . | . | . | . | . | . | . | II 0.4 |
| Dactylina arctica | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I 0.2 | . | . | III 0.7 | V 1.2 | . | III 0.6 | . | I 0.1 | . | . | . | . | IV 0.8 |
| Plagiomnium rugicum | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | II 0.4 |

HOEFS, M., COMAN, I., McT., and KRAJINA, V. J. (1975)
SYESIS, Vol. 8 (Suppl. 1)

# VEGETATION of SHEEP MOUNTAIN YUKON TERRITORY




## VEGETATION ASSOCIATIONS

### FOREST

12 Hypno ( procerrimi ) – Abietinello ( abietinae ) – Piceetum glaucae

10 Roso ( acicularis ) – Shepherdio ( canadensis ) – Populetum tremuloidis

### TALL SHRUB

7 Astero ( yukonensis ) – Junco ( arctici ) – Salicetum brachycarpae

8 Eriophoro ( angustifolii ) – Carico ( aquatilis ) – Salicetum planifoliae

18 Arctostaphylo ( rubrae-uvae-ursi ) – Festuco ( altaicae ) – Salicetum reticulatae – glaucae

19 Arctostaphylo ( rubrae ) – Cassiopo ( tetragonae ) – Salicetum reticulatae – lanatae – glaucae

### LOW SHRUB

11 Calamagrostido ( purpurascentis ) – Arctostaphyletum uvae-ursi

21 Artemisio ( hyperboreae – alaskanae ) – Salicetum myrtilli-foliae

28 Salicetum barrattianae

### GRASSLANDS

13 Pentstemono ( gormanii ) – Artemisio ( frigidae ) – Agropyretum yukonensis

14 Artemisio ( frigidae ) – Agropyro ( yukonensis ) – Eurotietum lanatae

15 Pentstemono ( gormanii ) – Artemisietum frigidae

16 Agropyro ( yukonensis ) – Artemisietum frigidae – rupestris

17 Oxytropo ( viscidae ) – Artemisio ( hyperboreae – frigidae ) – Caricetum fillfoliae

24 Oxytropo ( viscidae ) – Artemisio ( hyperboreae ) – Festuco ( brachyphyllae ) – Trisetetum spicati

25 Oxytropo ( huddelsonii ) – Salicetum dodgeanae

### SCREE SLOPES

26 Agropyretum violacei

IN ALPINE ELEVATION ONLY

20 Artemisietum alaskanae

### GRAVEL BEDS

9 Dryadetum drummondii

### ALPINE MEADOWS

22 Salico ( reticulatae ) – Sileno ( acaulis ) – Carico ( scirpoideae ) – Dryadetum integrifoliae

23 Salico ( reticulatae ) – Cassiopo ( tetragonae ) – Dryadetum integrifoliae

27 Artemisio ( arcticae ) – Salico ( reticulatae ) – Festucetum altaicae '

29 Saxifrago ( oppositifoliae ) – Oxyrio ( digynae ) – Salicetum polaris

30 Seneciono ( lugentis ) – Salicetum polaris – reticulatae

31 Oxyrio ( digynae ) – Artemisietum arcticae – tilesii

32 Saxifrago ( hirculi ) – Caricetum membranaceae

### FLOOD PLAINS

1 Puccinellio ( deschampsioidis ) – Taraxacetum laceri

2 Astero ( yukonensis ) – Hordeo ( jubati ) – Puccinellietum deschampsioidis

3 Hordeo ( jubati ) – Asteretum yukonensis

4 Astero ( yukonensis ) – Deschampsietum caespitosae

5 Triglochino ( palustris ) – Juncetum arctici

6 Triglochino ( palustris ) – Caricetum aquatilis

### LARGELY UNVEGETATED AREAS

Cliffs canyon walls

Boulder fields, slab rocks

NUMBERING OF SECTIONS **A1**

NUMBERING OF QUADRATS 27

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| A | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |

1 6

MILES 0 ¼ ½

KILOMETRES 0 ¼ ½ ¾

PHYSIOGRAPHIC BOUNDARIES: ridges, gullies, edges of cliffs, canyon walls, creeks, shores of ponds, rivers and lakes.

VEGETATION BOUNDARY : distinct narrow ecotones, little overlap between neighbouring associations.

VEGETATION BOUNDARY : diffuse, not distinct, considerable overlap between neighbouring associations.

6000 CONTOUR LINES WITH ELEVATIONS