ECOLOGICAL RESERVES COLLECTION
GOVERNMENT OF BRITISH COLUMBIA
VICTORIA, B.C.
V8V 1X4

UNIVERSITY OF VICTORIA

P.O. BOX 1700, VICTORIA, BRITISH COLUMBIA, CANADA V8W 2Y2
TELEPHONE (604) 721-7211, TELEX 049-7222

Department of Biology
721-7094

October 11, 1984

Ecological Reserves Unit
Ministry of Lands, Parks and Housing
1019 Wharf St.
Victoria, B.C.
V8V 1X5

To Whom it may Concern:

Enclosed you will find a copy of Robert Milko's M.Sc. thesis on the Vegetation and Foraging Ecology of the Vancouver Island Marmot. The thesis, a compilation of all relevant data, marks completion of the project supported by you. We trust this thesis will suffice as a final detailed report. The manuscript is presently being condensed to be submitted for publication to appropriate scientific journals; two papers are complete and a third will be forthcoming.

In particular, the section of Constraints of Vegetation in both the Results and Discussion of the thesis offer information with respect to habitat management. In addition we make the following recommendations:

1) According to recent Fish and Wildlife reports the marmot population appears to be doing well. If such be the case, before direct manipulation of either marmot populations or habitat is performed, we feel a comprehensive demographic study of stable colonies (along the Green Mtn.-Gemini Peak-Haley Lake ridge) should be undertaken. This might best be achieved by a graduate student of the Ph.D. level. Particular emphasis should be placed on dispersal patterns.

2) We strongly recommend the securing of habitat as an initial step towards conservation of the species. It appears that the Fish and Wildlife Branch in Nanaimo have established a liaison committee with interested groups and organizations whereby appropriate land designations are currently being discussed.

3) Careful assessment of possible reintroduction sites should be undertaken by a qualified plant ecologist. This study indicates that the <u>Anaphalis-Aster</u> community type is most preferred by the marmots, offering both abundant forage and burrowing potential.

4) Tall vegetation appears to affect habitat selection, and in particular, bracken fern (<u>Pteridium aquilinum</u>) is a problem. A review of the literature does not readily offer any easy or recommended techniques for fern management.

.../2

5) Reduction of marmot habitat by forest succession is the most probable reason for the low numbers. It may be possible to manage areas by careful selective logging techniques. This might best be done in the period from mid-October until the first snowfalls when marmots are predominantly in hibernation and the ground is frozen. We do not recommend such processes at any of the four studied sites until harvesting and log removal without disturbing the existing vegetation can be positively assured. Only then might application of these techniques be used at Gemini Peak. Manipulation at the other sites is not recommended.

6) Lupine (*Lupinus latifolius*) is both a prolific and preferred forage species. Enhancement of future reintroduction sites with this species may be of benefit.

7) Use of fertilizers may also be of interest in habitat enhancement, but again experimental studies on non-marmot-occupied subalpine meadows should be performed to determine the effects (both short and long term) on plant species composition and nutritional qualities.

8) Scientific co-operation and advice from the Canadian Wildlife Service during this study was most useful. Further interaction with the province of B.C. through Fish and Wildlife is strongly recommended. In particular, the 'quasi-political' problems related to the Vancouver Island marmot necessitate the involvement of a non-partisan, scientific organization in administering research, defining research goals and ensuring that political concerns do not interfere with scientific research once projects are underway.

We would like to take this opportunity to thank you for your support of this study and would be pleased to answer questions concerning this or subsequent studies.

Sincerely,

Marc Bell

M.A.M. Bell

Robert Milko

/bsw

VEGETATION AND FORAGING ECOLOGY
OF THE VANCOUVER ISLAND MARMOT
(*MARMOTA VANCOUVERENSIS*)

by

ROBERT JOSEPH MILKO

B.Sc. University of Waterloo, 1976
B.Sc. University of Ottawa, 1981

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in the Department

of

Biology

We accept this thesis as conforming
to the required standard

Dr. M.A.M. Bell

Dr. P.T. Gregory

Dr. M.C.R. Edgell

Dr. D. R. Flook

UNIVERSITY OF VICTORIA

July 1984

Supervisor: Professor Marcus A.M. Bell

ABSTRACT

The foraging ecology of the Vancouver Island Marmot (*Marmota vancouverensis*) was studied in the field to determine its degree of patch-type selection and diet breadth.

Vegetation analysis of the intensively studied Haley Lake site and two additional sites produced six community types in the summer. In addition, three vegetation types were classified from four sites in the spring, a period when early stages of plant development precluded recognition of plant community types derived from the late summer. These types provided a framework for analysis of patch type selection. Combining cover values of plant species from taxa which were difficult to identify did not affect the classification.

The six community types are: *Phlox*-moss, *Anaphalis-Aster*, *Ribes-Heuchera*, *Pteridium aquilinum*, *Senecio-Veratrum* and *Vaccinium-Carex*.

The Haley Lake site showed sharply delineated plant communities, while Bell Creek, the other floristically similar low elevation site, formed more of a vegetational continuum. Vegetation similarities allowed examination and comparison of marmot patch type selection at these two sites. Gemini Peak, the high elevation site, was floristically distinct and showed a more advanced stage of plant succession affecting its relatively homogeneous meadow vegetation.

The plant communities studied were compared with those described for other subalpine regions of the Pacific Northwest and explanations for the described vegetation patterns are proposed.

In the spring, patch-type selection was found with a low variability between sites. In the summer, the highest selection was for the *Anaphalis-Aster* community type, most notably at the site with the most distinct patch definition.

In the spring, four plant species accounted for 87.2% of the marmot's diet. Mean grazing of those four species was constant in all patch types independent of their mean availability, although examination of those species in individual sampling quadrats showed a variable response of use to availability.

Except *Phlox diffusa*, species availability was low. Incidence of use indicated the strongest selection for grasses. Diet composition shifted from graminoids at early phenological stages, to forbs, with a continuous summer preference for five plant species. Results indicated a strong conformity to herbivore diet selection models.

Patch type selection in spring or summer was not predictable by the relative abundance of the preferred forage species. Analyses suggested that the risk of predation in tall vegetation most strongly influenced patch type selection, although the benefits of greater food abundance appeared to balance the cost of risk. Distance from burrows and a high frequency of Golden Eagle presence are proposed as risk factors affecting patch type selection in the spring.

Plant succession and other aspects of the vegetation are discussed with respect to the possible contraints they may have on the marmot population.

Examiners: ________________________________

Dr. M.A.M. Bell

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Dr. P.T. Gregory

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Dr. M.C.R. Edgell

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Dr. D.R. Flook

TABLE OF CONTENTS

Page

CHAPTER ONE

Study Area

METHODS

Vegetation Analysis

RESULTS

DISCUSSION

CHAPTER TWO

METHODS

RESULTS

DISCUSSION

APPENDICES

LIST OF TABLES

LIST OF FIGURES

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I am greatly indebted to Jim Rogers and David Iannone for their companionship and assistance in the field. Thanks to Marc Bell and members of my committee who were helpful throughout and to members of Academic Consultants (UVIC). Thanks to Bob Gittins for help with multivariate analysis. M.A.M. Bell, P.T. Gregory, Warren Holmes and Hannah Carey helped improve this manuscript.

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CHAPTER ONE

SUBALPINE MEADOW VEGETATION OF VANCOUVER ISLAND MARMOT HABITAT

Robert J. Milko

CHAPTER ONE

ABSTRACT

The subalpine meadow vegetation at three sites in the south-central mountains of Vancouver Island was described to provide a framework for a study of the foraging ecology of *Marmota vancouverensis*.

Based on dominance, five plant community types were delimited by ordination and classification of the 51 samples of the Haley Lake site. The community types are *Phlox*-moss, *Anaphalis-Aster*, *Ribes-Heuchera*, *Pteridium aquilinum* and *Senecio-Veratrum*. Studies of two additional sites indicated the presence of a sixth community type, *Vaccinium-Carex*, prominent in areas of later snow melt.

Lumping of cover values of mosses, lichens, grasses, carices and *Vaccinium* spp. did not affect the classification. In the spring, when the early stages of plant development precluded recognition of most community types, three vegetation types based on dominance were derived. Community definition was sharply delineated at Haley Lake, but more continuous at the floristically similar, other low elevation site. Succession was more advanced at the floristically and compositionally different high elevation site.

Comparisons of the plant communities with those described for other subalpine regions of the Pacific Northwest indicated the strongest similarity to the vegetation of the Olympic Mountains, Washington.

INTRODUCTION

Phytosociological studies of subalpine zones have been conducted in much of the Pacific Northwest, including the Coast Range of British Columbia (Brink 1959, Archer 1963, Peterson 1964, Brooke 1966), the Olympic Mountains of Washington State (Kuramoto and Bliss 1970) and the North Cascades of Washington State and British Columbia (Douglas 1972, Douglas and Bliss 1977). The subalpine zone of Vancouver Island, although assigned to the biogeoclimatic unit of Maritime Parkland Mountain Hemlock Subzone (Klinka et al. 1979), has not received further description. Forb dominated subalpine meadows in the South Central mountains of Vancouver Island provide habitat for the little studied, rare and endangered Vancouver Island marmot, *Marmota vancouverensis* (Swarth 1911). Records indicate that the range of known populations has decreased in recent historic times, concomitant with a period of pronounced forest succession in the Pacific Northwest (Brink 1959, Kuramoto and Bliss 1970, Franklin et al. 1971).

An understanding of the vegetation patterns and processes of succession may help to elucidate whether some aspects of the vegetation are affecting the population of this species. More specifically, a classification of known marmot habitat would provide a practical framework on which to study the marmot's foraging ecology and degree of forage specialization.

This study was undertaken to 1) describe and classify the vegetation in habitats of selected marmot populations, 2) compare these community types with other types described for the Pacific Northwest and to 3) derive methods of classifying vegetation for marmot habitat which allow a) grouping of species which are difficult to identify and b) recognition of community types in early spring development. This study was undertaken as a necessary component of a wider study of the foraging ecology of *Marmota vancouverensis* (Milko 1984).

STUDY AREA

Site Descriptions

The subalpine meadows which provide habitat and foraging range for *M. vancouverensis* are located in the Maritime Parkland Mountain Hemlock Subzone (Klinka et al. 1979) in the south central mountains of Vancouver Island (Latitude 49°01' N. and Longitude 124°19' W.). The lush forb-grass meadows which characterize Haley Lake are rare and predominantly restricted to steep south facing slopes. Most of the low mountains (1,000 - 1,600 m) are dominated by forests of *Tsuga heterophylla* and *T. mertensiana*.

The major study site, Haley Lake, was chosen because it was the only site known to have supported a population of marmots for the last 50 years (Heard 1977). This site occupies 6 ha on a slightly bowl-shaped, continuously steep

(35^{o}) SSE-facing slope. Elevation ranges from 1050 to 1300 m. Vegetated cliffs at the top of the site are subtended by a well stabilized talus and boulder field. Alder (*Alnus sinuata*) dominates the central lower regions of the site above the lake, while the sides are dominated by coniferous forests. Bedrock outcroppings and shallow gulleys occur throughout the site and contribute to the heterogeneous nature of the vegetation.

The three other sites studied are interspersed among forests and clear cuts along the same 6 km, north-south oriented, Green Mountain-Gemini Peak ridge.

The Bell Creek site is a 4 ha subalpine meadow on an open, SW-facing, 35^{o} slope, ranging in elevation from 1200 to 1300 meters. Sparsely vegetated cliffs extend horizontally one third of the way into both ends of the site. Fewer bedrock outcroppings or gulleys are present, but more small rock piles and talus areas are scattered throughout the site than at Haley Lake. The colluvial soils also contain a higher abundance of large rocks than the other sites.

Gemini Peak is a S-facing, high elevation site (1500-1600 m) of lower angle and more undulating slope ($10\text{-}25^{o}$). This results in a higher snow accumulation and a slower melt rate because of an extended period with temperatures below freezing (interpolated from Peterson's 1964 data). The 3 ha site is heterogeneous, the meadow highly interspersed with conifers. A later stage of succession is evident at this site, indicated by the larger amounts of heather vegetation, *Vaccinium* spp. and tree seedlings invading the meadow areas. In addition, remnant meadow vegetation is prominent in the encroaching forests surrounding the site. The meadow vegetation itself is relatively homogeneous.

The fourth site, Green Mountain, situated at the upper reaches of a ski area, was studied only in the spring of 1982. It is a high elevation (1400-1500 m) mountain top, with sparsely vegetated cliffs located directly above and adjacent to the meadows, which range in aspect from WNW to SE. Spring vegetation is floristically similar to the other three sites.

Climate

The regional climate of these study sites is characterised by mild wet winters and cool drier summers. Movement of frontal systems from the Pacific Ocean and orographic processes result in generally heavy precipitation patterns (Brink 1959, Brooke 1965). Proximity to the Pacific Ocean moderates the temperatures, but the study sites' central locations in the island's southern mountains contribute to higher summer temperatures than are experienced on the coast. This effect is most evident in the common mid-July to mid-August drought which results from a stationary high pressure system off the west coast. This subzone has been assigned to the Koppen/Trewartha climate designation of colder Dfc (Klinka et al. 1979). Climate data of this subzone is presented in Table 1.1.

Elevation, affecting snow accumulation and duration of snow cover, are the major factors in determining an upper and lower subalpine zone (Peterson 1965). Topography also influences local accumulation patterns (Peterson 1964, this study). Based on the 450 m difference in elevation, the Gemini Peak and Green Mountain sites would have a 25% higher frequency of freezing temperatures from October 1 to June 1 compared to the Haley Lake and Bell Creek sites (interpolated from Peterson 1964). Observations indicate that snow accumulation at the higher sites is greater and snowmelt in spring is approximately one month later. The southerly aspect and steep slopes contribute to the rapid snow melt at the lower sites. Snowmelt occurred one month later in 1982 than in 1981. Snow accumulations exceeded 0.5 m at all study sites by mid-November from 1981 to 1983.

Geology

The mountains of Vancouver Island comprise a mid-Paleozoic and Jurassic volcanic-plutonic complex called the Sicker Group (Muller 1977). Various degrees of metamorphism has effected its mainly basic and silicic, and less abundant, clastic and carbonate rocks (Muller 1979).

The Green Mountain and Gemini Peak sites lie within the Nitinat Formation, which is composed of metabasaltic lavas, which have undergone varied and complex metamorphism (Muller 1979). The mafic rock types range from basalt to andesite, and contain high quantities of magnesium, iron and calcium and are low in silica, aluminum, sodium and potassium (Cazeau et al. 1976).

Bell Creek and Haley Lake occur in the Myra formation, ranging from basalt to rhyodacitic banded tuff to sediments and conglomerates, often associated with sulfides (Muller 1979). The generally more felsic rocks contain higher amounts of potassium, sodium, aluminium and silicon (Cazeau et al. 1976) than the Nitinat Formation of the higher elevation sites. Glacial overburden varies from completely absent on rock outcrops to deeper than one meter elsewhere.

METHODS

Field Methods

'Plant community' is defined as a homogeneous area that is limited so that there is no marked, progressive change toward a different kind of vegetation (Whittaker 1967) and 'community type' is an abstraction applied to a class of communities (Whittaker 1956, 1967) 'Stand' refers to a particular example of homogeneous vegetation within a community.

Preliminary observations of the vegetation at Haley Lake were made from June to August in 1981. I observed that homogeneous stands of vegetation occurred in discrete repeatable units based on dominant plant species (dominance measured as percent cover). Five tentative plant community types were established during this period and were preferentially sampled (Kuramoto and Bliss 1970, Moore et al. 1970, Mueller-Dombois and Ellenberg 1974, Gauch 1982) in late August of 1981 and 1982, when the vegetation was fully developed. Seven to nine stands of vegetation for each of the five tentative community types were sampled by means of releves meeting minimal area requirements (Cain 1938, Mueller-Dombois and Ellenberg 1974). Species lists with percent cover were recorded. In addition two variants of one previously recognized plant community type were observed and sampled with seven and three releves respectively. The only permanent seepage area was also sampled with one releve. A total of 51 samples were used to represent the 6 ha meadow vegetation in this 300 m elevational belt as suggested by Whittaker (1978). Based on this tentative classification, the site was mapped on air photographs. Each stand was ranked in the field with respect to an ecological moisture regime (Walmsley et al. 1980) which, in effect, is a subjective ranking of the stand's moisture status.

In 1982, two additional sites, Gemini Peak and Bell Creek, were sampled as follows. Homogeneous stands of vegetation in which marmots grazed were sampled by releves. The percent cover of each forb species and the combined percent covers for the taxonomic groups of carices, grasses, lichens, mosses and *Vaccinium* spp. were estimated and are referred to as 'lumped'. Fifty one and 46 stands, respectively, were sampled by releves at Bell Creek (from June 20 to September 10) and at Gemini Peak (July 12 to August 24) in 1982. The sampled stands were used in a study of the foraging ecology of *Marmota vancouverensis*, but facilitated examination of vegetation at these sites. Both sites were mapped in September 1983 after completing the vegetation analysis.

Reconnaissance of the four sites in spring indicated that the vegetation at such early stages of development only slightly resembled the plant community distinctions of the summer. Instead, three distinct vegetation types based on dominance were evident. Homogeneous stands of vegetation grazed by marmots were assigned to one of those vegetation types while in the field.

Each stand was sampled in spring by randomly placing quadrats (20 X 25 cm) along one or two transects which were oriented to maximize the homogeneity of the vegetation. Quadrats were placed at a frequency of 15% of the total number of placements possible along the transect. The percent cover of each species in each quadrat was estimated and the mean percent cover from all quadrats in a stand was used for the ordinations and classification analyses. A total of 199 quadrats were placed in the 29 stands, which produced 8 to 11 samples with mean cover values for each vegetation type. In addition,two stands which did not appear to be related to any of the vegetation types were sampled.

Community Analysis

Ordinations using detrended correspondence analysis (Hill 1979a, Hill and Gauch 1980) were used to visually display relationships among the 51 samples representing the tentative community types. The samples were also clustered with program FAUNA1 (Hagmeier 1983), a conserving unweighted pair-group arithmetic average (UPGMA) technique (Lance and Williams 1967, Sneath and Sokal 1973).

Clustering similarities among samples were calculated using the complement of the Bray and Curtis coefficient (Bray and Curtis 1957) as 1-C where C=2w/(a+b), w being the sum of the lesser abundances for those species common to both samples, and, a and b the summed abundances for all species in samples a and b respectively.

The same analyses were conducted after combining cover values for species of grasses, carices, lichens, mosses and *Vaccinium* spp. as separate groups. All further analyses were conducted with the combined cover values. The 29 spring samples with lumped species were similarly analyzed to examine their relationship with respect to the three predetermined vegetation types.

The Bell Creek and Gemini Peak samples were analyzed by ordinations with DECORANA to determine their beta-diversity (Hill and Gauch 1980). In addition, one exemplar representing each tentative community type and the more abundant variant was ordinated with all the samples from each site. This permitted determination of whether the unclassified samples fell within the variation of vegetation used to derive the classification.

The majority of samples of the Gemini Peak site were ordinated outside the position of the exemplars and were among themselves homogeneous (see Results). Eight samples were then selected randomly from the samples to be representative of this new community type. These were added to the original 51 samples and all 59 samples were ordinated and clustered. Discriminant analysis was used to examine the distinctness of the community types (Norris and Barkham 1970, Grigal and Goldstein 1971, Goldstein and Grigal 1972) based on the 59 samples. Discriminant analysis arranges the groups in discriminant space and maximizes the separation between groups relative to the variation within groups (Albrecht 1980, R. Gittins pers. comm.). Subprogram DISCRIMINANT of SPSS (Klecka 1975) was used in a 'step-wise' method with a generalized distance measure 'RAO' to assess the group distinctions as well as to determine discriminating variables of the groups.

In addition, the polythetic divisive classification method of TWINSPAN (Hill 1979b) was used to 1) assess its ability to classify the samples and 2) produce indicator species for the community types. "Cutoff levels" (cover values) for TWINSPAN were 'a priori' selected at 0, 2, 5, 10, 25, 50 and 75%. These values conformed with the cover classes observed in the field, which best defined the community type distinctions.

Vegetation Biomass and Effects of Marmot Grazing

At Haley Lake in mid-June of 1981, while still unfamiliar with the vegetation and its patterns, I identified paired plots in ten stands of vegetation which appeared homogenous. One by two meter exclosures (1 m high of 5 cm mesh fencing) were constructed in each stand. The other 1x2 m plot was left open to allow marmot grazing. At each sampling period (Table 1.2), standing aboveground vegetation was clipped to ground level in eight different, randomly selected 20x25 cm quadrats in the open and exclosed plots, respectively. Live vegetation was then dried and weighed.

Stands with the paired plots were sampled in August of 1982 and the community type they represented was identified by a computer program KEY1 SAS (Milko 1984). KEY1 SAS functions as a dichotomous key based on abundances of differentiating species for each community type . Differentiating species were derived from the original classification by use of TWINSPAN (Hill 1979b) and as discriminating variables in subprogram DISCRIMINANT of SPSS (Klecka 1975). Stringent multivariate assumptions precluded direct use of the allocation procedure of discriminant analysis (Green 1980, R. Gittins pers. comm.).

Nomenclature of vascular plant species followed that of Hitchcock and Cronquist (1973). Univariate statistics follows Sokal and Rohlf (1981). Significance is set at $P \leq 0.05$. Vouchers of all vascular plant species are retained in the British Columbia Provincial Museum, Victoria, B.C.

RESULTS

Descriptions of Plant Community Types

Six community types representing the subalpine meadows in which marmots foraged at the three sites are described below. Community types are named by the dominant and co-dominant plant species. Abbreviations are those used in the study of the foraging ecology of the Vancouver Island marmot (Milko 1984). Differentiating species are also identified (Table 1.2).

1) *Phlox*-moss (PHLOX): This type is restricted to cliffs and areas of bedrock outcroppings with shallow undeveloped soils. These xeric sites are often windswept in winter and the first areas to be snowfree in the spring. They are dominated by the cushion plant *Phlox diffusa* with

an average cover of (37%), and associated with high abundances of mosses (35%) and *Selaginells wallacei* (18%). Conspicuous, early flowering plants are *Saxifraga ferruginea* and *S. occidentalis*. The 8 sampled stands contain a total of 47 vascular plant species and clustered at a mean similarity of 60%.

2) *Ribes-Heuchera* (RIBES): This relatively rare community type occurs among moderate to large size boulders (30-200 cm) in stabilized talus deposits. Total cover of vascular plants (usually <70%) is the least of all the community types. The low shrub *Ribes lacustre* dominates (22%) and is commonly associated with moderately abundant *Heuchera micrantha* (8%) and abundant mosses (35%). *Vaccinium* spp. and *Sambucus racemosa*, occur with less regularity. The 7 stands include 50 vascular species and have a mean similarity of 64%.

3) *Anaphalis-Aster* (ANAST): This mesic community type has a disturbed variant, common to sites other than Haley Lake, and one grass variant of low abundance, found only at the Haley Lake site. Table 1.2 shows mean percent covers for the typical plant community samples and the disturbed variant samples combined. *Anaphalis margaritacea* (22%) and *Aster foliaceus* are co-dominants. *Lupinus latifolius* (9%) aids in distinguishing this plant community. The mean cover values of these three species are higher and lower in the typical type and the disturbed variant, respectively, by one

half of the cover values listed in Table 1.2. The well drained, fine soils are deep and developed, although the disturbed variant is distinguished by its less developed soil, containing higher amounts of large coarse fragments. Another distinguishing feature of the disturbed variant is its large amount of *Phlox diffusa* (7%), compared with the typical type samples (<1%).

The grass variant lacks *A. margaritacea* and retains the other key species at the same abundances as the typical *Anaphalis-Aster* community type. In addition a species unique to this variant, *Rubus ursinus*, has a 10% cover, concurrent with an increase in cover to 9% for each of the two grass species *Elymus glaucus* and *Bromus sitchensis*.

The 15 stands representing this community type and the disturbed variant contain 55 vascular species and have a mean similarity of 55%. The 8 stands representing the typical community type have a mean similarity of 68%. Addition of the grass variant to the typical stands and the disturbed variant stands (total: 18 stands) reduces the mean similarity to 38%, showing the lower similarity of the grass variant to the other samples. The disturbed and grass variants alone (7 and 3 stands) have mean similarities of 60% and 54% respectively.

4) *Pteridium aquilinum* (PTER): This community type is recognized after mid-July when the bracken fern fronds expand to a cover greater than 70%. Clones of bracken,

previously described as 'Pteridietum' (Nicholson and Paterson 1976), generally have a discontinuous distribution except at the lower elevations. Bracken is also found at the Bell Creek site with a lower cover value (40%).

Examination of Fig. 1.4 shows *P. aquilinum* sample positions between the *Anaphalis-Aster* and the *Senecio-Veratrum* community types. They appear closer in position, to the *Senecio-Veratrum* samples, with some of the samples clustering with this community type. However, based on indicator species (TWINSPAN Fig. 1.6), clusters show some mixture of samples with the *Anaphalis-Aster* community type. A reduced presence and cover of the main differentiating plant species (*S. triangularis* and *V. viride*) of the *Senecio-Veratrum* community in most *Pteridium* stands, and the presence of the dominant differentiating species (*A. margaritacea*) of the *Anaphalis-Aster* community in all stands, suggest that bracken fern invades the *Anaphalis-Aster* community type. Many low cover vascular plant species and bryophytes (Table 1.2) co-occur in both the *P. aquilinum* and the *Anaphalis-Aster* types. 53 vascular species are found in the 8 stands which themselves have a mean similarity of 75%.

5) *Senecio-Veratrum* (SENE): Although the co-dominant *Veratrum viride* has a higher mean cover (34%) than *Senecio triangularis* (20%) in the stands sampled, the reverse situation is just as common, particularly at the Bell Creek site. This community type occurs on moist areas, often in

shallow gullies, which may result in a two week delay of snow melt in the spring. Soils are fine grained and moist with a moderate humus layer development. In some stands the density of the co-dominants may restrict development of other plant species. Only 35 species were found in the 9 stands. Stands at Bell Creek, have a higher abundance of *Valeriana sitchensis* and are invaded by successional shrubs of *Vaccinium* spp. and, to a lesser extent, *Rhododendron albiflorum*. Mean similarity of the 9 sample stands is 56%.

6) *Vaccinium-Carex* (VACC): This plant community occurs predominantly at the less steep and higher elevation, Gemini Peak site. *Vaccinium membranaceam* (10% cover) and *V. alaskaense* (9% cover) are the most abundant shrubs invading meadows co-dominated by *Carex spectabilis* (14%) and *Lupinus latifolius* (14%). Other forbs are low in abundance and many forbs common to the other non-talus or bedrock plant communities are missing altogether. This community type occupies 95% of the area at Gemini Peak, succeeding to heath plant communities which surround the established and invading tree islands. Its closest similarity is to the *Anaphalis-Aster* community type, but whether the difference in species composition is a result of competition or other factors is not clear. This site and the stands of *Vaccinium-Carex* found at Bell Creek are snow free approximately one month later than the other plant community types.

The eight stands representing this community type contain 43 vascular species and have a mean similarity of only 44%. The analytic derivation of this community from Gemini Peak marmot grazing samples may account for the low similarity shown. The analysis, however, does distinguish this vegetation type from the other community types.

Seep: Only one stand representing a seepage area was observed at Haley Lake. *Aquilegia formosa* (18% cover) and the fern *Adiantum pedatum* (16% cover) differentiate this stand. Another seepage area at Bell Creek flowed over a rock outcrop and was dominated by mosses and *Parnassia* sp..

Descriptions of Spring Vegetation Types

The spring vegetation types described below are based on species dominance. All three vegetation types have low total percent cover.

1) *Juniperus communis* (JUVAC): This vegetation type is dominated by *Juniperis communis* (20% cover) with less abundant *Arctostaphylos uva-ursi* (5%) and *Vaccinium* spp. (3%). These areas are snow free early in spring due to vegetation height and the black-body effect of the shrubs facilitating snow melt. In addition, *J. communis* and *A. uva-ursi* are often associated with drier windswept ridges, or convex macrotopographic positions. This type is rare at Haley Lake where *J. communis* occurs with the *Phlox*-moss type of the summer. At Bell Creek this type is dominated by *J. com-*

munis, but is outside marmot foraging range in the summer and was not classified except as a spring type. At Gemini Peak this vegetation type is dominated by *Vaccinium* spp. and by all shrub types at the Green Mountain site. Mean similarity of the 8 representative stands is 51%.

2) Grasses (GRASS): These stands are dominated by graminoids: grass spp. (3.4%) and *Carex* spp. (1.1%). *Fragaria vesca* is the only other species of high abundance (1.6%). All other species each contribute less than 1% cover. Areas of this vegetation type appear snow free due to avalanches and convex mesotopographic positions. Later in the season they develop into *Anaphalis-Aster*, *Pteridium aquilinium*, *Senecio-veratrum* or *Vaccinium-Carex* community types. Mean similarity between the 11 stands is 51%.

3) *Phlox*-moss (PHLOX): This vegetation type is the spring stage of the summer *Phlox*-moss community type. Stands examined in the spring from all four sites have a lower mean cover of the dominant species: *P. diffusa* (23%), mosses (10%) and *S. wallacei* (5%). These differences result more from the variation between sites than from different sampling techniques. The mean similarity between the 8 stands is 44%.

Analytical Interpretations

Ordinations for the 51 samples using all individual species and lumped species are shown in Figures 1.1 and 1.2, respectively. The first two axes of Fig. 1.1 with all 117 species explain 69% of the variation of the first four axes. In Fig. 1.2, with 84 species, 82% of the variation between samples is explained by the first two axes. Beta-diversity has been reduced from 5.6 to 4.0 average standard deviations with lumped data. (A full turnover of species composition should occur in approximately four standard deviations.) Comparison of the two figures indicates roughly the same sample positions, the major difference being the locations of the three samples representing the less abundant variant. Derived groups from the clustering analysis (UPGMA) have not changed.

Ordination space partitioning (Gauch 1982), commonly recognized as subjective circling of visually perceived clusters of samples on ordination graphs, approximate the groupings of the tentative community types and their variants. Cluster analysis results are also similar to the tentative community types.

Ordination of the 46 summer samples from Gemini Peak with the six exemplars (Fig. 1.3), shows that the majority of the samples are not contained within the boundaries defined by the exemplars. They are amongst themselves relatively homogeneous. Mapping also indicated that 95% of the meadow vegetation does not conform to the community types derived from the Haley Lake site.

Ordinations of the Bell Creek site samples with the 6 exemplars (not illustrated) showed that greater than 95% of the 51 vegetation samples were located within the boundaries defined by the exemplars. Mapping of the site confirmed the similarity of the vegetation diversity to that of Haley Lake. Approximately 28% of the site area could not be classified since gradual changes between community types produced more of a vegetation continuum.

The eight samples from the cluster of 40 samples (located between 0 and 1.5 average standard deviations on the first axis of Fig. 1.3) that were randomly selected to represent the vegetation of Gemini Peak are shown ordinated and clustered with the 51 original samples (Fig. 1.4). The groupings are similar to those of Fig. 1.2, plus the new samples as a separate group, although the cluster analysis includes two samples with the *Phlox*-moss community type. These samples, representing homogeneous vegetation that differs from the other community types, are classified as a new community type (*Vacciniun-Carex*). The samples representing the grass variant are more dissociated from the *Anaphalis-Aster* community type. Ordination space partitioning would again implicate the divisions of the tentative community types. The seepage sample is distinct from the other groups in all analyses. Its closest group affinity, at a low level of similarity, is to the *Ribes-Heuchera* community type.

The first two axes of the discriminant analysis (Fig. 1.5) represents 70% of the variation and illustrates the distinctness of community types. All clusters have within-group distances (representing variation) less than between-group distances. The *Anaphalis-Aster* community type is shown represented by four randomly selected samples from both the typical community type samples and its disturbed variant. A previous analysis with all eight samples of the disturbed variant and the eight typical community type samples, represented as two separate 'discriminant functions' (Klecka 1975) showed the two groups could not be separated. Group centroids were superimposed and samples were intermingled.

The lack of distinction between the variants and the typical community type samples by all methods confirms that they are the same community type. The grass variant samples show their closest affinity to the *Anaphalis-Aster* type. The seepage sample's position may be a result of using only 32 species as discriminating variables. The distinctness of the seepage stand is better explained by the dominance and presence of species which were not found in the other community types nor contained in the list of discriminating variables.

Results of classification with TWINSPAN (Fig. 1.6), show most groupings of samples are similar to those derived by UPGMA clustering. A major difference is observed whereby the *Anaphalis-Aster* community type is divided into two groups on the first division. This approximates the distinction between the samples of the typical type and its disturbed variant, although inaccurately. All runs using variations of TWINSPAN's options produced the first divison through this community type. My 'a priori' cutoff levels (all other options not used) produced clusters most similar to those of UPGMA. This division has been shown to be questionable by the other methods of analyses. A later division in the analysis shows the grass variant was also distinguished. In summary, six distinct community types are found at these sites according to these methods.

Ordination and clustering of the 29 spring samples (Fig.1.7) indicate the distinction of the three vegetation types observed in the field. The cluster analysis results conform to the ordination groupings, which conform 100% to the perceived groups. The two samples which in the field were determined not to be representative of any of the three vegetation types, are the samples least associated with any group (Fig. 1.7). Sample Z, the furthest extension of the GRASS cluster, represents the *Ribes-Heuchera* community type at an early stage of development. It was free from snow in only one stand at the four sites and is not described as a spring type.

The transect represented by sample Y was located in a small snowmelt gulley in cliffs at Green Mountain. The 12 m long gulley was moist at the top and dry at the bottom and examination of the 10 quadrats shows the appearance and disappearance of plant species down the transect illustrating the moisture gradient. The sample is not homogeneous and fails to meet the definition of a plant community.

Vegetation Biomass and the Effects of Marmots

Of ten plots, five were in *Anaphalis-Aster*, two in *Senecio-Veratrum*, and one in *Phlox*-moss community type (Table 1.3). One paired plot was not identifiable and another was improperly paired (i.e. the exclosed vegetation plot in a ***Pteridium aquilinum*** community differed from the unexclosed plot in ***Anaphalis**-Aster*). Only biomass measurements are available on the latter pair. *Ribes-Heuchera* vegetation was sparse and its biomass was estimated lower than all other community types.

Reduction of biomass by marmots varied between community types, within stands in the *Anaphalis-Aster* community type, seasonally and annually. The maximum reduction between pairs was 51%. No significant impact was measured in the two stands of *Senecio-Veratrum* over the two year period (t-tests). Significant biomass reduction ($P \leq 0.05$) was measured on six occasions in the *Anaphalis-Aster* community type and on two occasions in the *Phlox*-moss community type. The *Anaphalis-Aster* type was shown to be the most selected for grazing by *Marmota vancouverensis*.

DISCUSSION

Community Pattern

Plant community patterns are most often explained by complex environmental factors and gradients. These parameters may be interpreted best from intensively collected environmental data; however, as in this study, inferences may be made from qualitative environmental data and observation (Kuramoto and Bliss 1970).

The first axis of the final ordination (Fig. 1.4) best explains the ecological series of plant community types (Whittaker 1978) along an environmental moisture gradient. This is inferred from the field rankings in an ecological moisture regime context. Both soil depth and the ability to retain moisture are important aspects of this moisture gradient.

The *Phlox*-moss community type, located in bedrock outcrops with coarse, shallow soils, are at the xeric end of the gradient. *Anaphalis*-*Aster* is more mesic, with moderately developed, deep and well drained soils. The disturbed variant, however, is submesic on disturbed soils, with a higher large coarse fragment content.

Evidence indicates that the *Pteridium aquilinum* community (bracken) occurs where bracken has invaded the *Anaphal-*

is-Aster community type. Page (1976) describes bracken's ecological requirement of good soil drainage and aeration. It is possible that the large accumulation of bracken litter and the increased humidity of a closed canopy has altered the ecological moisture status, creating a somewhat more hygric condition. This may account for the shift in species composition from the *Anaphalis-Aster* type to some species more commonly associated with the *Senecio-Veratrum* type. Total understory vegetation cover at the time of full frond development remains high, greater than 100% cover. Heavy competition by shading may have only limited effect due to the ephemeral nature of the open fronds. However, a significant reduction in spring cover of the dominant grass and carex species (65% reduction; t-test $P < 0.001$) has been recorded for grass vegetation types which later in the summer are dominated by *Pteridium aquilinum* (Milko 1984). This is most likely attributable to allelopathic secondary compounds released in the spring from dead frond litter (Gliessman 1976).

The *Senecio-Veratrum* stands occur at the hygric end of the moisture gradient, commonly in shallow gullies and concavities. The dominant species require much moisture and generally senesce after the summer drought.

The second axis of variation can likely be explained by humus content of the soils. *Ribes-Heuchera*, at one end of the gradient, occurs on talus with undeveloped soils. At the other end of the gradient, the *Vaccinium-Carex* community type of Gemini Peak is associated with both a later release from snow and with soils with much humus. This explanation conforms to Archer's (1963) proposed successional development from lush meadows to heath communities. The *Vaccinium-Carex* community would be an intermediate seral stage. The axis would represent changes in the organic matter content and stages of successional development from *Ribes-Heuchera*, through *Anaphalis-Aster* to *Vaccinium-Carex* communities.

In alpine and subalpine areas, mosaic patterns are often pronounced and are attributed to complex topography which results in variable snow accumulation, snow-melt times and a broad range of summer soil moisture regimes (Billings and Bliss 1959, Holway and Ward 1965, Canaday and Fonda 1974). These factors in the Pacific Northwest are prominent in the subalpine areas which support lush meadow community types: the Olympics (Kuramoto and Bliss 1970) and the west Cascades (Douglas 1972, Douglas and Bliss 1977). However, the Coastal Mountains of British Columbia rarely support the lush forb subalpine meadows characteristic of the Haley Lake and Bell Creek sites, and when found, little plant community distinction is present (Brink 1959, Archer 1963, Peterson 1964).

The snow melt patterns appear to play only a secondary role in the strong mosaic development at the Haley Lake site. In a year of heavy snowfall (1982), all community types were snowfree by mid-June. Rather, the variation in depth to bedrock creates the mosaic pattern.

At Bell Creek the bedrock depth is visibly less variable. Soils at that site are more uniform, more strongly colluvial and contain greater quantities of large coarse fragments than at Haley Lake. Plant community types are recognizable, but 28% of the site is ecotonal in nature, intermediate between the *Anaphalis-Aster*'s disturbed variant and the *Senecio-Veratrum* community type. This variant represents only 20% of the *Anaphalis-Aster* community type of Haley Lake, but accounts for 60% of this type at Bell Creek. In addition 4% of the area of this site is composed of the *Vaccinium-Carex* community in an area of late snow retention. The high abundance of *Vaccinium* spp. distinguishes this community type at Bell Creek, carices occurring in low abundances.

The Gemini Peak meadow vegetation is relatively homogeneous. Sporadic rock outcrops and adjacent cliffs contain small amounts of the *Phlox*-moss community type. It may be possible to follow a successional pattern of development from stands dominated by graminoids with forbs, to *Vaccinium* spp., to a final heath stage, succeeded by forest regeneration.

Meadow areas are overgrazed by marmots at this site, resulting in reduced plant vigor, and stands where bare earth represents 40% of the area. *Vaccinium* spp. often dominate these stands and may be favored, as they themselves are not grazed but have their competition reduced. *Lupinus latifolius*, the dominant forb and a preferred species of the marmots, develops later at this site due to delayed snow melt, a commonly observed phenomenon (Holway and Ward 1965, Canaday and Fonda 1974). In the Coast Range of British Columbia, plant community differences of heath and shrub types, can reflect topographic and soil differences (Brooke 1965, Brooke 1966). However, varying chemical compositions, with few consistencies between rock types were found (Brooke 1965).

The extent that soils and vegetation patterns may be affected by differences in bedrock type between sites in this study are undetermined. The deposits of glacial overburden could moderate differences between bedrock types. In addition, the geological differences are questionable due to the scale of map units and major discrepancies between references (Muller 1977 and 1979). On-site verification of rock types and a more detailed assessment of these questions are required.

Comparison of Plant Communities with Other Communities Described in the Pacific Northwest

Plant communities described here represent only forb dominated, subalpine meadows of marmot habitat at three closely located sites and should not be interpreted as a classification for all subalpine areas of Vancouver Island. Published descriptions and my personal observations indicate that the strongest similarity exists with ecologically equivalent plant communities of the Olympic Mountains, described by Kuramoto and Bliss (1970).

Phlox-moss Community Type:

This type closely approximates that of the Cushion Plant type of the Olympics, although bare ground is more abundant in the Olympic equivalent (Kuramoto and Bliss 1970). No equivalents have been described for the Cascades, but some species overlap is noticeable with the two rock outcrop associations, *Junipereto-Penstemonetum menzeisii* and *Silenetum acaulis* described by Archer (1963).

Anaphalis-Aster:

This type has variously described equivalents. Its strongest similarity is to the Mesic-grass type described for the Olympics (also extensively used by marmots) (Kuramoto and Bliss 1970), with an overlap into the Tall-sedge type and mesic variant of the Dry grass-forb type (Kuramoto and Bliss 1970). An *Anaphaleto-Lupinetum arctici* pioneer association, found on fragmented rocks and fell-fields, was described for Garibaldi Park, British Columbia (Archer 1963). The dominant species are similar, but the site descriptions of those stands and Archer's photographs show large quantities of boulders and little developed soil. That more closely approximates the Haley Lake disturbed variant, but at an earlier successional stage. Archer also described a moist alpine *Valerianetum sitchensis* association, found on well developed and well drained soils, which has some similarity to the *Anaphalis-Aster* community type. Brink (1959) mentions a "forb meadow" community in Garibaldi Park, but his species list indicates less distinction between communities than was made in Archer's study.

In the northwestern Cascades of Washington, no distinct ecological equivalents are described, but there is some overlap with the three community types described for colluvial slope habitats (Douglas 1972). Douglas and Bliss (1977) have also described two closely related *Lupinus latifolius* and *Festuca viridula* community types with apparent similarities to the *Anaphalis-Aster* type.

Pteridium aquilinum:

This type, described at Haley Lake and common at other subalpine meadow sites on Vancouver Island, appears unique in the Pacific Northwest. The presence of bracken fern has been recorded only in the *Rubus parviflorus-Epilobium Angustifolium* community of low elevation, subalpine meadows in the Cascades (Douglas 1972). There, *Pteridium* does not appear to play as prominent a role, sharing dominance on disturbed slopes with fireweed (*E. angustifolium*). Invasion of fern clones is common to disturbed habitats (Page 1976) and accurate historic records or dating of clones might allow determination of whether bracken's invasion into subalpine meadows on Vancouver Island is correlated with the intensive logging adjacent to and surrounding these areas.

Ribes-Heuchera:

This type also appears distinct. It has not been been described elsewhere as a community type in subalpine areas of the Pacific Northwest.

Senecio-Veratrum:

This type has widespread ecological equvalents. At Bell Creek, it most strongly resembles the moist *Saussaurea*-forb type of the Olympics but a similarity to the moist *Valeriana*-forb type is also apparent. The latter has larger boulder-size rocks and a greater cover of *Valeriana sitchensis* (Kuramoto and Bliss 1970). In the Cascades, this community type appears to be representative of two described types. They are the *Rubus parviflorus-Epilobium angustifolium* and the *Valeriana sitchensis-Veratrum viride* community types (Douglas 1972).

Vaccinium-Carex:

This type seems most representative of the dominant associations previously described for the Coastal Mountains of British Columbia. However, the abundances of forbs, the mixtures and dominance of graminoids, and the seral nature of this community, make direct comparison with described ecologically equivalent communities difficult.

Douglas (1972) has described a *Carex spectabilis* type for the western north Cascades in Washington which approximates the meadow characteristics. Dominant species are *C. spectabilis* and *L. latifolius*, but absence of shrubs implies an earlier stage of successional development. The separate shrub and heath community types described by Douglas (1972) are different from the *Vaccinium-Carex* type of Gemini Peak.

The vegetation at Gemini Peak is most similar to that described for Mt. Seymour (Peterson 1964), but at an earlier stage of succession. I have visited and confirmed these similarities. Peterson's (1964) *Vaccinium membranaceum-Rhododendron albiflorum* type contains "little or no *Rhododendron albiflorum*," and higher abundances of *V. membranaceum*, similar to my described *Vaccinium-Carex* type. More heath (*Phyllodoce-Cassiope*) and dwarf *Tsuga* associations and less forb meadows than at Gemini Peak, suggest Mt. Seymour's more advanced stage towards forested associations.

Meadow Origin and Maintenance

At Haley Lake and Bell Creek the lush forb-dominated meadows show little sign of succession except for the seral (Page 1976) *Pteridium aquilinum*. This is in contrast to Gemini Peak which has strong evidence of succession towards forested communities.

Stages of succession from meadow to forest- dominated communities are common in the Pacific Northwest (Brink 1959, Archer 1963, Peterson 1964, Franklin et al. 1971, Douglas 1972) and correlate with a period of pronounced conifer establishment, attributed to low snowfall from the early 1900's to 1940's (Brink 1959, Kuramoto and Bliss 1970, Franklin et al. 1971). Tree seedling establishment occurs predominantly in the heath communities rather than in the forb meadows. Brink (1959) suggested that forb meadows resist seedling establishment because of their xeric nature and higher pH, as well as because of spring snow creep on steep slopes (Brink 1964). Kuramoto and Bliss (1970) support the xeric condition hypothesis, which is related to high temperatures that result in a vapor pressure deficit on south and west facing slopes. A corollary to this (Douglas 1972) is that heaths have moderate early season temperatures more conducive to seedling establishment. Competition by dense graminoid mats (Franklin et al. 1971) has also been suggested as a deterrent to seedling establishment.

At the Haley Lake and Bell Creek site it appears that all of the processes described above occur. At Haley Lake, spring snow creep plays a major role in surficial disturbance. Freezing at night and thawing in the day produces a two inch ice layer below the snow which binds to the grounds' surface. Downslope movement causes slumping of soil and vegetation and is accentuated by localized spring avalanches.

At neither site is evidence of charred stumps or charcoal layers present. However, bleached snags occur on some lower portions of each site. A more systematic examination may indicate a history of fire, but it is probable, particularly on the longer and steeper Haley Lake slopes where snow creep is pronounced, that the sites have not been forested in the postglacial period. Such conditions have also been suggested for areas in the Cascades (Franklin et al. 1971).

In contrast, at Gemini Peak, *Abies lasiocarpa* demonstrates a broad spectrum of age classes. A distinct charcoal layer near the soil surface and remnant meadow vegetation in the surrounding forest suggest a recent fire history. Snow creep and avalanches are non-existent at this more gently sloping site.

Methodological and Analytical Questions

Results of analysis with TWINSPAN are not unexpected. Gauch and Whittaker (1981) have indicated that an agglomerative classification technique such as UPGMA could be more appropriate if there are natural clusters in the data, or if the classification is to be based on dominance. Both situations exist in these data.

The recognition of community types which were established in late summer based on dominance, was only partially possible in the spring. A classification based on incidence might be expected to be more appropriate for recognition in the spring. However, the 51 sampled stands of Haley Lake, analyzed by appropriate methods utilizing incidence, showed poorly established groupings. Further use of the classification for the foraging study dictated the importance of a classification based on dominance. This study demonstrates how the problem may be overcome for temporary practical purposes and illustrates the importance of sampling synchronization between years in a phytosociological study of a subalpine meadows.

North American plant ecologists frequently omit lichens and bryophytes from data collection and analyses (Gauch 1982). My analysis has indicated that in a heterogeneous subalpine situation, use of combined cover values of lichens, bryophytes and other species which are difficult to identify, produces the same analytical results as using individual species. Little extra effort is required to gather the data using this method. These groupings were shown to be discriminating variables by subprogram DISCRIMINANT, and 'mosses' was an important "indicator species" in the classification with TWINSPAN. The role of these plants in community definition may at times be important.

This taxonomic lumping, demonstrated for the foraging study of the Vancouver Island Marmot, will facilitate further research, or use of the classification as a management tool for a less experienced botanist. In particular, the lumped species are seldom foraged directly, except in the spring (Milko 1984) and more emphasis can therefore be placed on the important forb species. Forage preference in a grazing herbivore may be dependent on the relative abundance of a plant species (Westoby 1974, Ellis et al. 1976, Batzli 1983). Abundances of plant species are emphasized when using dominance and lumped species. Hence, dominance, particularly of forage species, could be important in discerning vegetational patterns. In this study, the classification based on dominance is shown to be somewhat successful in understanding marmot forage selection and constraints of vegetation on the marmot's population (Milko 1984).

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Table 1.1 Climate data[a] for the Maritime Parkland Mountain Hemlock Subzone of Vancouver Island which contains the study sites.

Climate Characteristics	Means and Standard Deviations
Mean Annual Precipitation	3358±1434 mm
Mean Precipitation of the Wettest Month	532±200 mm
Mean Precipitation of the Driest Month	76±46 mm
Number of Months With Mean Temperature >10°C	0.3±0.5
Number of Months With Mean Temperature <10°C	5.1±0.8
Maximum Snow Accumulation	370 cm

a. Data from Klinka et al. (1979).

Table 1.2 Mean percent cover of plant species in the six recognized community types[a] representing foraging habitat of *Marmota vancouverensis* at three sites on Vancouver Island.

Plant species	Plant Community Types[b]					
	SENE (7)[c]	PTER (9)	ANAST (15)	RIBES (7)	PHLOX (6)	VACC (26)
VASCULAR SPECIES						
≥ 1% MEAN COVER						
*VERATRUM VIRIDE**	34	9		-[d]		-
*SENECIO TRIANGULARIS**	20	1		3		-
CALAMAGROSTIS CANADENSIS	4	1		-		
*VIOLA GLABELLA**	5	-		-		-
TELLIMA GRANDIFLORA	1			-		
SAUSAUREA AMERICANA	7	-				
*LATHYRUS NEVADENSIS**	13	7	2	-		
*THALICTRUM OCCIDENTALE **	6	6	2	-		
*HERACLEUM LANATUM**	4	2	-			
BROMUS SITCHENSIS	2	11	2	-		-
VICIA AMERICANA	-	1	-			
*ACHLYS TRIPHYLLA**		3		3		
VALERIANA SITCHENSIS	1	2	-	1		1
*PTERIDIUM AQUILINUM**		86	2	7		
*ASARUM CAUDATUM**	-	2	-	3		
ASTER FOLIACEOUS	-	5	13	-	-	1
ELYMUS GLAUCUS	14	34	2	3	-	4
MELICA SUBULATA	4	3	2	-	-	-
*ANAPHALIS MARGARITACEA**	1	9	22	3	-	
*ACHILLEA MILLEFOLIUM**	-	4	11	1	4	2
FRAGARIA VESCA	-	6	15	1	6	8
*CIRSIUM EDULE**	-	1	6	-	-	1
*LUPINUS LATIFOLIUS**		1	9		-	14
CASTILLEJA MINIATA	-	-	1			-
CAREX HOODII	-	-	3	-	1	2
PHLEUM ALPINUM		-	3	-	-	-
POLYSTICHUM LONCHITIS			-	1		
*RIBES LACUSTRE**				22		
SAMBUCUS RACEMOSA				3		
RUBUS PARVIFLORUS				2		
DRYOPTERIS AUSTRIACA				1		
PENSTEMON SERRULATUS		-	1	1		-
*HEUCHERA MICRANTHA**		-	-	8	1	-
*CRYPTOGRAMMA CRISPA**		-	-	2	3	
SEDUM DIVERGENS		-	-	-	2	-
TRISETUM CANESCENS		-	-		-	2
*ERIGERON PEREGRINUS**		-	-			2

	SENE	*PTER*	*ANAST*	*RIBES*	*PHLOX*	*VACC*
*MONTIA PARVIFOLIA**	–	–	–	–	4	–
*SELAGINELLA WALLACEI**		–		–	18	
POTENTILLA GLANDULOSA					1	
*ERIOPHYLLUM LANATUM**	–	–	5		17	
*PHLOX DIFFUSA**			4	1	37	1
*JUNIPERIS COMMUNIS**			–		8	2
*PRUNELLA VULGARIS**			–		3	
DANTHONIA INTERMEDIA			–		5	
AGROSTIS SCABRA					2	–
CAREX SPECTABILIS	5	–	–			14
VACCINIUM MEMBRANACEUM			–	2		10
VACCINIUM ALASKAENSE		–		3		9
VACCINIUM CAESPITOSUM						3
*LUETKEA PECTINATA**						4
*ARNICA LATIFOLIA**						4
VASCULAR SPECIES						
<1% MEAN COVER						
STELLARIA CRISPA	–					
URTICA DIOICA	–					
GALLIUM TRIFIDUM	–			–		
CAREX DEWEYANA				–		
EPILOBIUM ANGUSTIFOLIUM				–		
ADIANTUM PEDATUM				–		
DICENTRA FORMOSA				–		
VACCINIUM OVALIFOLIUM				–		
SMILACINA STELLATA		–				
PYROLA SECUNDA		–				
STENANTHIUM OCCIDENTALE		–				
LACTUCA MURALIS		–				
RUBUS URSINUS		–	–			
BOTRYCHIUM MULTIFIDUM	–	–				–
ARABIS HIRSUTA	–		–			
POTENTILLA DRUMMONDII			–			
EPILOBIUM GLANDULOSUM	–	–	–	–		–
TRISETUM SPICATUM		–	–	–		
CAREX MERTENSIANA		–	–			–
POLYGONUM DOUGLASSII			–	–		
MITELLA TRIFIDA			–			–
LILIUM COLUMBIANUM	–	–	–			–
AGOSERIS AURANTIACA		–	–			–
CAREX PACHYSTACHYA		–	–	–		
PACHISTIMA MYRSINITES			–	–	–	
CAMPANULA ROTUNDIFOLIA	–	–	–	–	–	
ARENARIA MACROPHYLLA	–	–	–	–	–	
ERYTHRONIUM GRANDIFLORUM	–		–		–	
POA PRATENSIS		–	–	–	–	–
LUZULA MULTIFLORA		–	–		–	–
POLYGONUM MINIMUM				–	–	–
*CASTILLEJA HISPIDA**		–	–		–	
POA LEPTOCOMA			–		–	–

	SENE	*PTER*	*ANAST*	*RIBES*	*PHLOX*	*VACC*
CYSTOPTERIS FRAGILIS			-		-	
SILENE DOUGLASII			-		-	
SAXIFRAGA FERRUGINEA					-	
SAXIFRAGA OCCIDENTALIS					-	
DELPHINIUM MENZIESII					-	
HABENARIA HYPERBOREA					-	
PENSTEMON DAVIDSONII					-	
MIMULUS GUTTATUS					-	
LOMATIUM MARTINDALEI					-	
VERONICA WORMSKJOLDII					-	
MITELLA BREWERI					-	
VERONICA SERPYLLIFOLIA					-	-
ANTENNARIA NEGLECTA					-	-
ARCTOSTAPHYLOS UVA-URSI					-	-
CAREX ROSSII					-	-
FESTUCA OVINA						-
FESTUCA OCCIDENTALIS						-
ANTENNARIA ALPINA						-
PHYLLODOCE EMPETRIFORMIS						-
ABIES LASIOCARPA (SEEDLINGS)						-
LUZULA PARVIFLORA						-
HIERACIUM GRACILE						-
BRYOPHYTES						
PSEUDOLESKEA PATENS	-	-	1		2	
RHACOMITRIUM CANESCENS		-	-	4	21	
DRYPTODON PATENS		-	1	23	3	
PLAGIOMNIUM INSIGNE		-				
PORELLA ROELLIS		-	-			
BRACHYTHECIUM ASPERRIMUM		-	-			
TORTULA NORVEGICA		-	-			
DESMATODON LATIFOLIUS			-			
POLYTRICHUM PILIFERUM			1		9	
MOSSES						1
LICHENS						
CLADONIA sp.		-	-	-	-	
CETRARIA sp.		-	-	-	-	
CLADONIA ROBBINSII		-		-		
OPEGRAPHA sp.		-				
PELTIGERA sp.			-			
RHIZOCARPON GEOGRAPHICUM				-		
STEREOCAULON TOMENTOSUM					3	
CLADONIA GRACILIS					-	
THAMNOLIA sp.					-	

a All samples for community types are from the Haley Lake site except for *Vaccinium-Carex*: all samples are from the Gemini Peak site.

b SENE = *Senecio-Veratrum*, PTER = *Pteridium aquilinum*, *ANAST* = *Anaphalis-Aster*, RIBES = *Ribes-Heuchera*, PHLOX = *Phlox*-moss, VACC = *Vaccinium-Carex*.

c Numbers in parentheses are the number of stands sampled.

d '-' indicates mean cover less than 1% and a blank indicates not occurring in the samples representing the community type.

* Species used as discriminating variables in Discriminant Analysis; in addition species: Grasses, *Carex* spp. Lichen spp., *Vaccinium* spp., and Mosses were used.

Table 1.3 Mean dried biomass of live aboveground vascular plants (g/m^2) and their standard errors for 4 plant community types at the Haley Lake site.

Harvest Date*	Plant Community Type			
	Anaphalis-Aster	*Phlox-moss*	*Senecio-Veratrum*	*Pteridium aquilinum*
1981				
June 24	104±6	229±40	138±24	115±12
Aug 4	282±17	268±25	448±44	386±83
Sept 14	331±27	226±13	476±63	560±50
1982				
Aug 4	306±19	243±11	590±122	419±62
Sept 14	294±23	217±24	510±96	520±46
n	40	8	6	

* Harvest occurred over a 2-3 day period.

Figure 1.1 Results of detrended correspondence analysis (DCA) on unlumped data (117 species) from the Haley Lake site. Drawn lines represent clusters from UPGMA analysis. Like symbols represent samples of the tentative community types and the abundant variant as recognized in the field. The less abundant variant is shown by A, B and C and the seepage sample by D. The arrow indicates its closest group affinity. Axes units represent average standard deviations of species turnover (Hill and Gauch 1980). The percent of variance in the first 4 axes accounted for by axes 1 and 2 is presented.

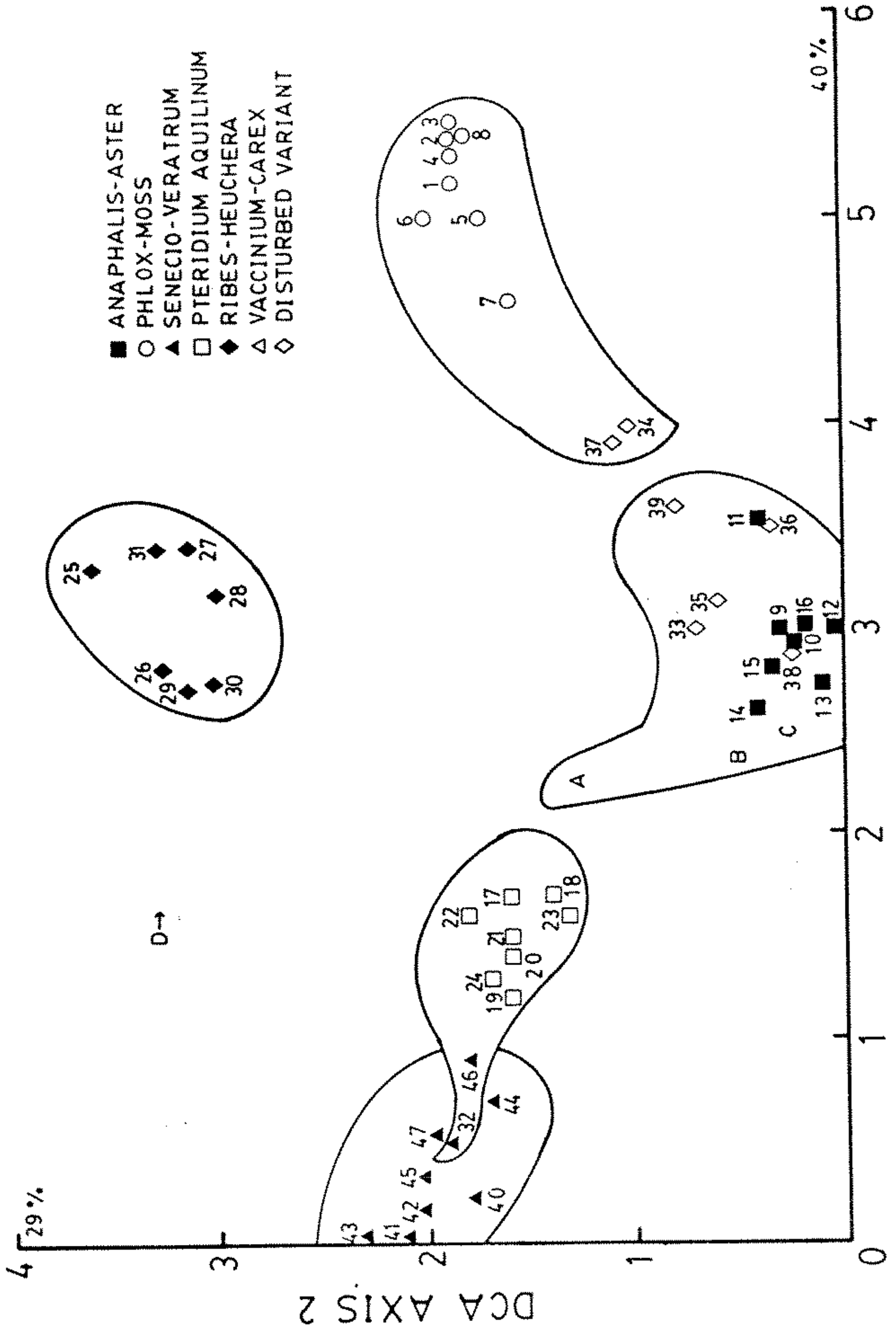

■ ANAPHALIS-ASTER
○ PHLOX-MOSS
▲ SENECIO-VERATRUM
□ PTERIDIUM AQUILINUM
◆ RIBES-HEUCHERA
△ VACCINIUM-CAREX
◇ DISTURBED VARIANT
DCA AXIS 1
DCA AXIS 2
40%
29%
0
1
2
3
4
5
6
A
B
C
D→

Figure 1.2 Results of DCA and UPGMA on lumped data with 84 species from the Haley Lake site. See Figure 1.1 for conventions.

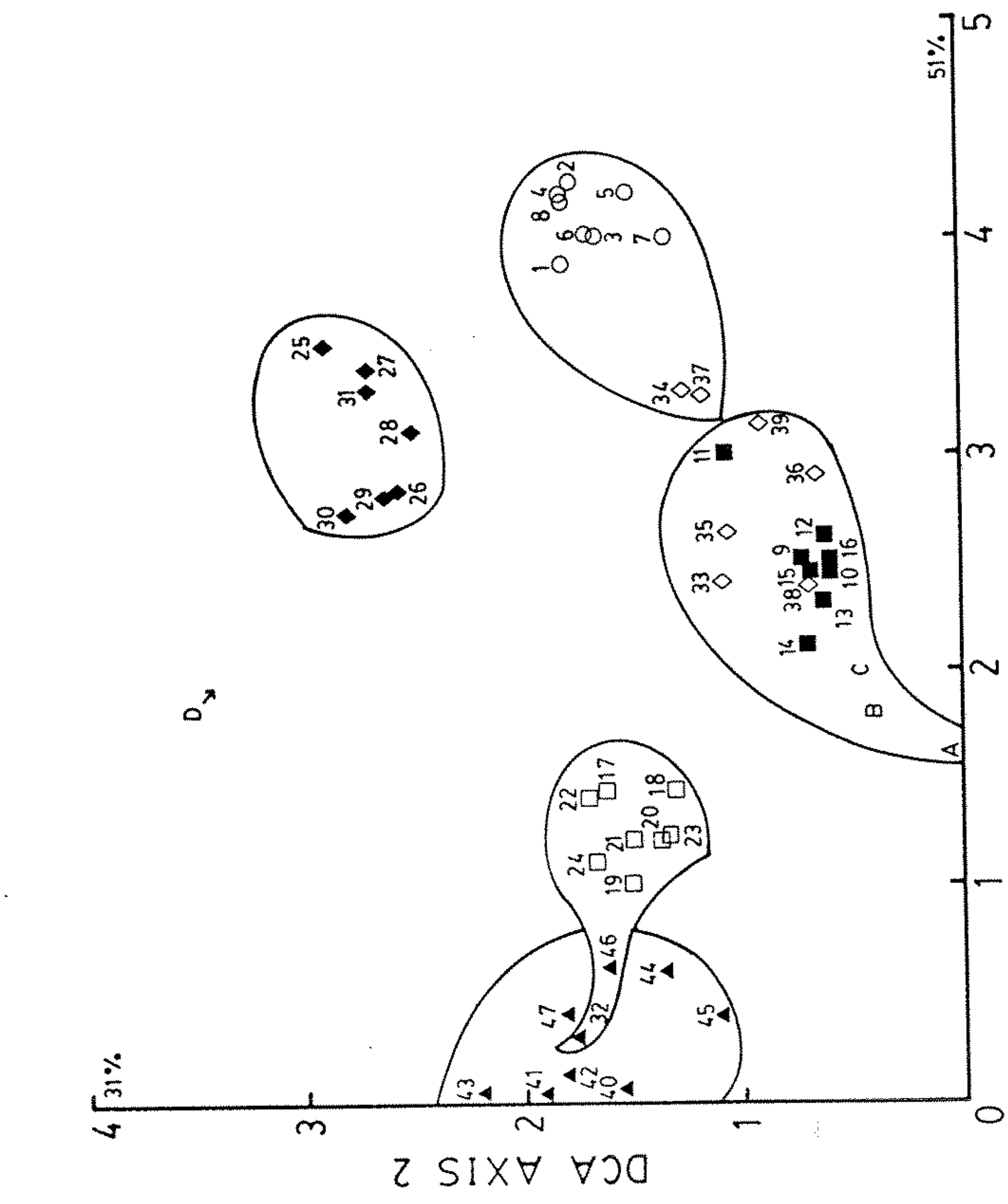

DCA AXIS 1
DCA AXIS 2
51%
31%
0
1
2
3
4
5
A
B
C
D
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47

Figure 1.3 DCA results on sumer vegetation samples foraged in by marmots at the Gemini Peak site. Numbered samples are exemplars of each 5 tentative community types and the abundant variant. 1 - *Phlox*-moss, 2 - *Anaphalis-Aster*, 3 - *A.-A.* variant, 4 - *Pteridium aquilinum*, 5 - *Ribes-Heuchera* and 6 - *Senecio-Veratrum*. Lumped species are used. See Figure 1.1 for conventions.

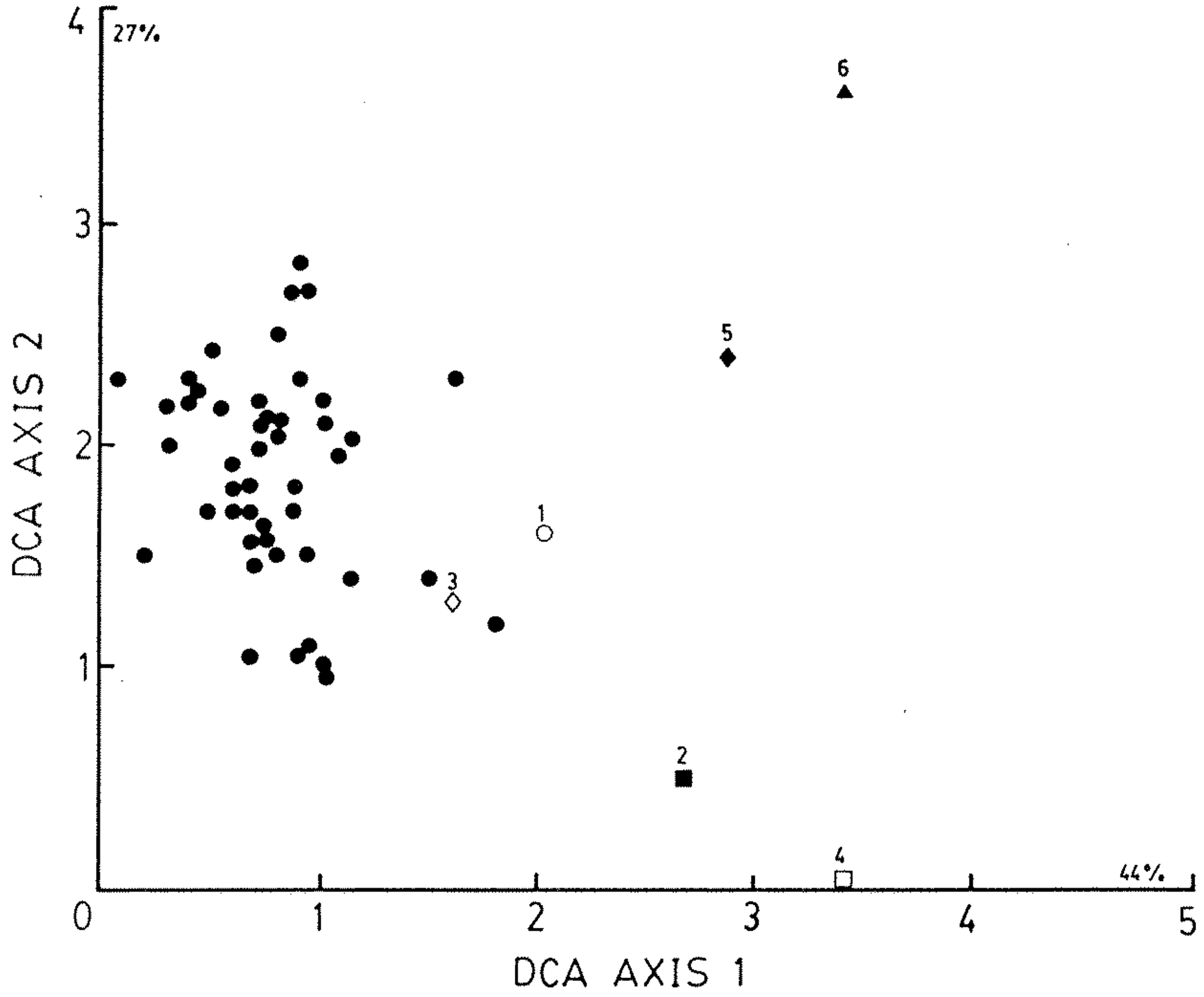

DCA AXIS 2
DCA AXIS 1
27%
44%
0
1
2
3
4
5
1
2
3
4
1
2
3
4
5
6

Figure 1.4 DCA and UPGMA results of the original 51 Haley Lake samples and 8 samples randomly selected to represent the vegetation at Gemini Peak. See Figure 1.1 for conventions. Lumped species are used.

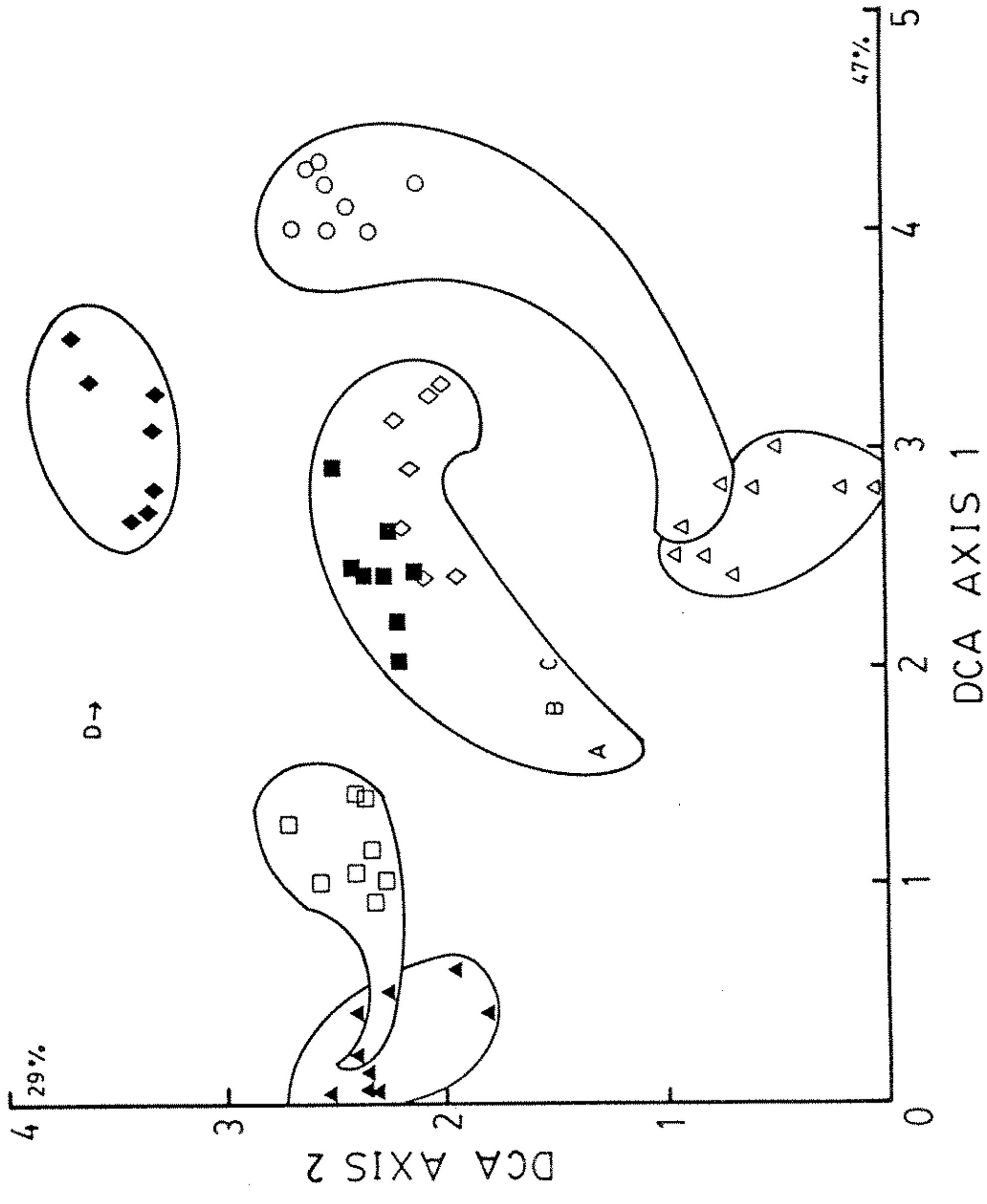

DCA AXIS 1
DCA AXIS 2
0
1
2
3
4
5
1
2
3
4
47%
29%
A
B
C
D→

Figure 1.5 Results of discriminant analysis on the samples of the 5 tentatively defined community types and the 8 samples representing the Gemini Peak vegetation. Group centroids are plotted. Four randomly selected samples from both the pure *Anaphalis-Aster* community type and the abundant variant represent this community type. The percent of total variance accounted for by axes 1 and 2 is presented. See Figure 1.1 for conventions. Lumped species are used.

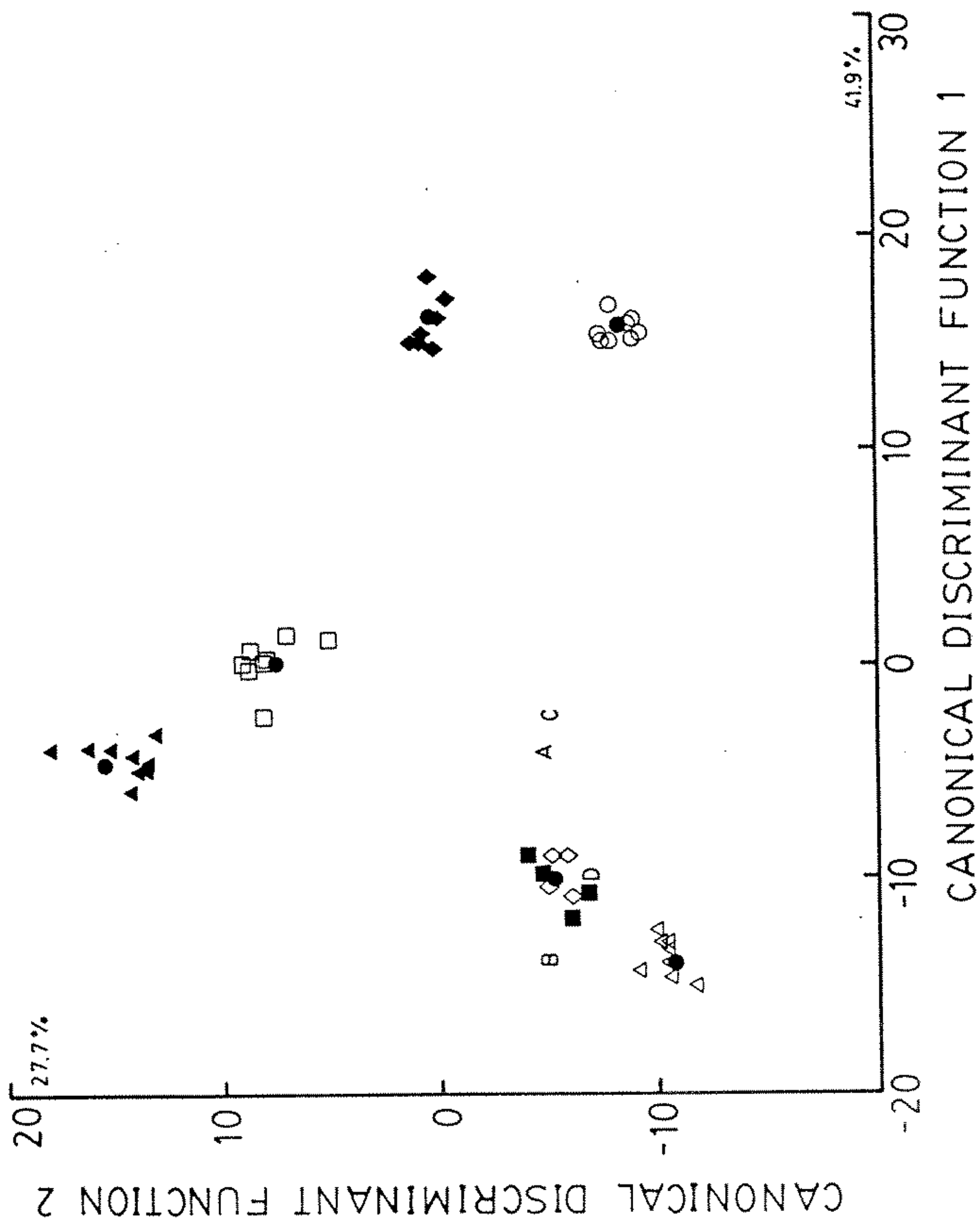

CANONICAL DISCRIMINANT FUNCTION 1
-20
-10
0
10
20
30
41.9%
CANONICAL DISCRIMINANT FUNCTION 2
20
10
0
-10
27.7%
A
B
C
D

Figure 1.6 Results of DCA and clusters derived from TWINSPAN on the 51 Haley Lake samples and the 8 samples from Gemini Peak. The dashed line indicatees a later division by TWINSPAN. See Figure 1.1 for conventions. Lumped species are used.

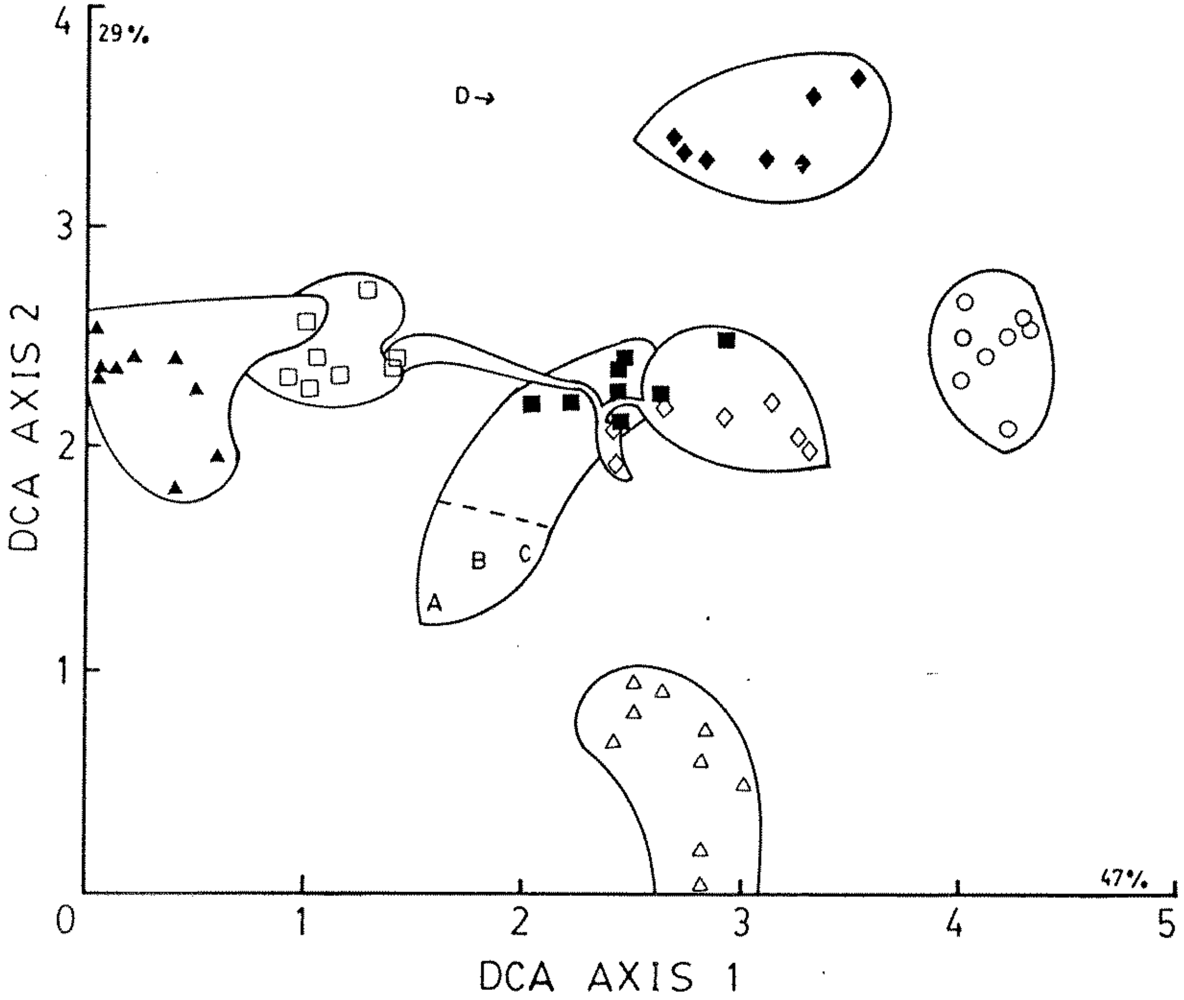
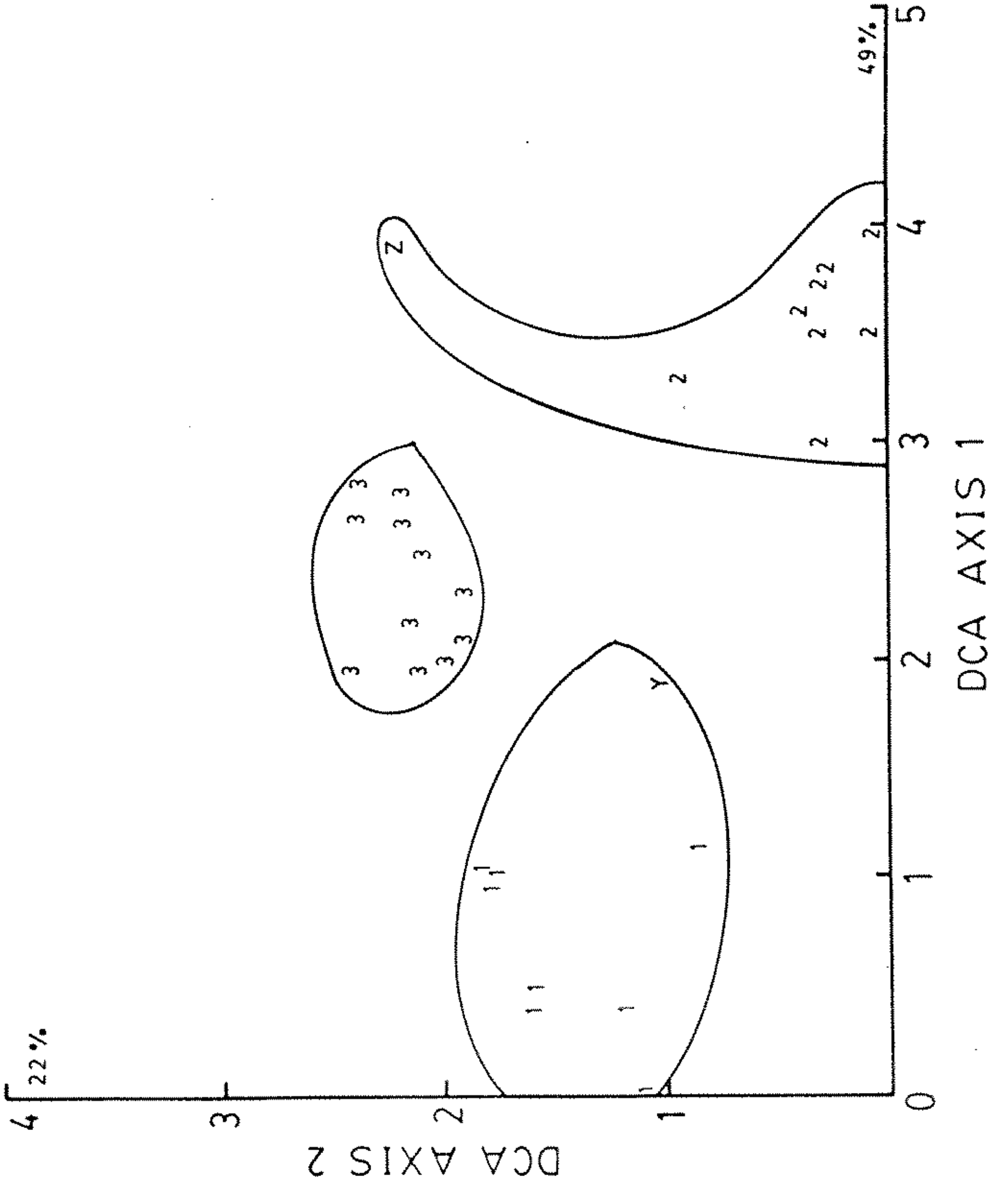

29%
4
3
2
1
0
DCA AXIS 2
D→
A
B
C
47%
1
2
3
4
5
DCA AXIS 1

Figure 1.7 Results of DCA and UPGMA on the 29 samples from the 4 spring sites. Drawn lines represent clusters from UPGMA analysis. Tentative vegetation type samples are: 1 - PHLOX, 2 - GRASS and 3 - JUVAC. Y and Z represent the gulley and *Ribes-Heuchera* samples. Lumped species are used.


DCA AXIS 1
49%
0
1
2
3
4
5
DCA AXIS 2
22%
1
2
3
4
Y
Z

CHAPTER TWO

FORAGING ECOLOGY OF THE VANCOUVER ISLAND MARMOT (*MARMOTA VANCOUVERENSIS*)

Robert Milko

CHAPTER TWO

ABSTRACT

The foraging ecology of the Vancouver Island marmot (*Marmota vancouverensis*) was studied to determine its degree of patch selection and diet breadth.

Significant selection of patch types in spring was found at 4 sites, with low between-site variability. Summer patch type selection was found at two sites, with a high between-site variability; the most consistent selection occurred at the site with the most distinct patches.

In the spring four plant species accounted for 87% of the diet. The mean percent that these species were grazed was constant in all patch types and independent of their different mean availabilities. A variable response of use relative to availability was found when individual samples were examined. Grasses were the most selected major diet species and grazed in 79% of the samples. Diet composition shifted from graminoids in the spring to forbs in the summer, when a continuous preference for five plant species was found.

Patch type selection by marmots was not correlated with either the abundance of preferred forage species in all seasons, or the total vegetation biomass in the summer. Within the preferred patch type a correlation between patch selection and vegetation biomass was found. Analysis indicates that a risk factor of tall vegetation most strongly influ-

enced patch type selection in the summer, but increased food abundances could balance the costs of risk.

A strong conformity to diet selection models for herbivores was found. Results were used to examine the implications of risk in patch selection and to assess constraints that the vegetation may place on *M. vancouverensis*.

INTRODUCTION

Diet selectivity and the abundance and distribution of available forage are important factors in understanding the foraging behavior and demography of a grazing herbivore. The diet habits of African ungulates, for example, have been related to their social structure and population parameters, the herbivore's size and degree of selective feeding affecting the size and mobility of herds (Jarman 1974). Population distribution and the regulation of herbivore population size have also been correlated with the quantity and quality of forage (White 1978, Haukoija 1980, Bryant 1981, Batzli 1983, Haukioja et. al. 1983, Laine and Henttonen 1983).

In a patchy environment the response of an herbivore is often dictated by the vegetation mosaic (Wiens 1976), and attempts have been made to predict the selection of patches based on the maximization of some currency, most commonly energy per unit time (Pyke et al. 1977). The diet of a medium sized herbivore is, however, probably not completely predictable by any single parameter such as energy. The role of toxic secondary plant compounds in producing a varied diet in herbivores has been emphasized (Freeland and Janzen 1974), as well as the importance of balancing nutritionally varied foods (Westoby 1974, 1978). Synthesis of these concepts (see Clark 1982) indicates that a selected set of plants, which can be detoxified and provide the balanced nutrients, should be retained in the diet through time and over a wide range of availabilities. Sampling of other plants should occur in order to assess changing chemical compositions of plants with phenological development.

I will call the selected set of plants which meets these requirements the 'optimal plant set'. If an optimal plant set is found, prediction of patch choice by a foraging herbivore may be possible based on the abundance of the optimal plant set in different patches (Royama 1970).

Alpine and subalpine species of the genus *Marmota* are medium sized herbivores which show varying degrees of diet selectivity (Barash 1973, Hansen 1975, Armitage 1979, Holmes 1979, Frase 1982, Carey 1984). Both the availability of hibernacula (Svendsen 1974) and the abundance of food for weight gain (Armitage and Downhower 1974, Armitage et al. 1976), appear necessary for winter survival. In addition, a limited abundance of spring forage can result in reduced litter sizes (Downhower and Armitage 1971) and a change in behavioral patterns and foraging range (Heard 1977, Johns and Armitage 1979).

Patch selection by foraging marmots has been examined in two studies which have used different definitions of patches. Hoary marmots (*Marmota caligata*) in Alaska were studied using patches defined by a grid system superimposed upon homogeneous vegetation (Holmes 1984a). Selection of patches was shown to be a response to both the abundance of preferred plants and predation risk. Predation risk was measured as the distance to home burrows and the availability of refuge burrows. In a study of foraging of yellow-bellied marmots (*M. flaviventris*), patches were defined by vegetation physiognomy and the distance to home burrows (Carey 1984). Again patch selection was attributed to the abundance of preferred plants and predation risk, although predation risk was related to the density and height of vegetation. In both studies the importance of a cost/benefit analysis (Covich 1976) is emphasized to help explain foraging patterns. A study of Olympic marmots (*M. Olympus*) showed a positive correlation of colony size with the number of plant communities (Wood 1973), and suggested that the distribution of plant communities may be affecting the marmots' foraging patterns.

In alpine and subalpine meadows plant community boundaries are often distinct (Billings and Bliss 1959, Douglas and Bliss 1977). A heterogeneous meadow would be composed of a mosaic of plant community types which would provide a framework for determining if selection or non-random use of patch types by foraging animals occurs.

This study examined the foraging patterns and diet selectivity of the Vancouver Island marmot (*M. vancouverensis*). It addressed five questions. 1) Does patch selection as defined by plant communities occur? 2) Does *M. vancouveren-*

sis show preference for individual plant species? 3) Does an 'optimal plant set' meeting the criteria of the herbivore diet models exist for *M. vancouverensis* and if so 4) can the relative abundances of the optimal plant set in the different plant community types predict patch selection by *M. vancouverensis*? 5) To what extent do various parameters of the vegetation affect the distribution of this species?

Study Animal

Marmota vancouverensis (Swarth 1911) is a hibernating ground squirrel endemic to the subalpine regions of south-central Vancouver Island, Canada. The population of the species is estimated to be in the range of 100-300 animals. Small groups of one or more colonies are separated by expanses of clearcuts and remnant forest and appear to be subject to large population fluctuations. Their social behavior most closely approximates that of *M. olympus* described by Barash (1973). A colony is composed of one or more social groups, each group consisting of one adult male and one adult female, and varying numbers of two-year-olds, yearlings and juveniles. Females breed biennially and young males disperse as two year olds (Heard 1977, Nagorsen 1984). For the purpose of this study, juveniles are defined as litter of the year, yearlings as those that have survived one winter, and adults as all other age classes. Hibernation lasts from mid-October (as evidenced by mud and rock hibernaculum plugs) to the first of May. Emergence at different localities is synchronous within a one week period.

Study Sites and Vegetation Classification

In 1981 and 1982 one site (Haley Lake, hereafter designated 'HL') was intensively studied; this is the only site known to have supported a population of marmots for fifty years (Heard 1977). In the spring of 1982, 11 adults and 5 yearlings were present. Two additional sites were studied in 1982 (Bell Creek 'BC' and Gemini Peak 'GP') and a fourth site (Green Mountain 'GM') was studied only in the spring of 1982. In the spring of 1982 these sites contained, 8 adults and 2 yearlings, 10 adults and 6 yearlings, and 8 adults and 3 yearlings, respectively. All sites offered the same selection of plant species and patch types in the spring and were therefore comparable. In the summer, the BC and HL sites were comparable, but the GP site was found to be floristically distinct. It was analyzed only with respect to plant species preference and site characteristics. At all sites in 1982, winter snow accumulation was high, resulting in spring snow-melt patterns one month later than in 1981. Mean litter size was observed to be less in 1982 (2.7±0.3 n=6) than in 1981 (4.6±0.5;n=5).

Six plant community types describe the vegetation of the three sites studied in the summer and three types describe the vegetation of the four sites studied in the spring (Milko 1984). Spring was defined as that period of time after emergence when a site still retained a 95% snow cover. Thus defined, spring ended as early as May 20, or as late as

June 20 depending on the site. Throughout the study 'patch' refers to a particular example of homogeneous vegetation within a plant community and 'patch type' is synonomous with plant community type. The combining of cover values for individual species of mosses, lichens, *Vaccinium* spp., carices and grasses did not affect the classification. The term 'species' is used to mean the combined cover values of these groupings of plants throughout the study and for individual plant species. Mean dry mass of live above-ground vascular plants and new growth of shrubs at the height of the growing season, weighted for varying abundances in different community types was 429 g/m^2 (this study and Milko 1984). Mean distance between hibernacula is 150 m.

METHODS

Determination of Patch Use by Marmots

Observations were made by two observers with 7-60 power binoculars and spotting scopes at distances of 50-300 meters. Exposed observation positions were used as the presence of a quiet observer did not affect the marmot's behavior (Heard 1977). Marmots were observed during peak foraging times, early morning (0700 to 0930 hours) and early evening (1730 to 2000 hours). Departure from this bimodal feeding regime occurs only in May and after August (Heard 1977). In order to reduce interference with this rare and endangered species, individual marmots were not captured or marked. Each site was sampled over a period of several days, changing study sites on a weekly rotating basis (Table 2.1). Scans (Altman 1974) were conducted from May 15 until July 20 in 1982 locating all grazing marmot postions in a particular patch of vegetation at each scan. Intervals between scans were adequate to permit traversing of all patch types by marmots and scans are assumed to be independent. Intervals were constant at each site but ranged from 10 to 25 minutes at different sites dependent on site size and observability differences. In later seasons in 1982, and in 1981, tall vegetation precluded accurate scan censuses and a single focus method was used. Individual marmots were then randomly chosen from all portions of the habitat and continuously followed, recording their foraging time in all homogeneous patches of vegetation. Marmot positions were located on photographs to assist in field sampling. A total of 200 observation hours were conducted in the two seasons.

At HL in 1981, at HL-1 in June of 1982, and at all sites in the spring of 1982, the patch type grazed by each marmot was subjectively classified and recorded at each scan. At other observation periods, the patches of vegetation grazed by marmots were sampled by recording the percent cover of each plant species in the grazed patch. These grazed areas of unknown patch identity were identified as one of the six patch types by use of a computer program KEY1 SAS (Milko 1984). KEY1 SAS functions as a dichotomous key based on abundances of differentiating species (Mueller-Dombois and Ellenberg 1974) for each community type. The program is conservative and allows for the designation of 'unidentified' if a sample was not easily identified as one of the six patch types. Unidentified patches of vegetation were predominantly ecotonal between two or more community types.

Observed and expected frequencies of use were calculated at each sampling period from the number of marmots foraging in different patch types and from the numbered expected in each patch type based on the random use and the relative availability of that patch type. Chi-square goodness of fit analysis was used to determine if use differed from that expected based on the number of foraging marmots when considering all patch types. The normal approximation to the binomial test ($|Z|$) was used to determine if use of individual patch types differed from that expected based on its availability, versus the use and availability of all other patch types combined.

With single focus observations, the time spent foraging in a patch type was calculated as a percentage of the total time spent foraging in all patch types and compared to the relative availabilities of that patch type. For these observations the ratio of use/availability is presented. Juvenile marmots forage mainly near natal burrows (Holmes 1979, Barash 1980, Carey 1983, this study) as do yearling *M. vancouverensis* in the spring. Consequently, data from these age classes at these times are excluded from the analysis.

Spring Plant Species Use

In the spring, 29 grazed patches of vegetation from the four sites were identified as one of the three patch types. Each patch was sampled by one or two transects oriented to maximize its vegetation homogeneity. 20 x 25 cm quadrats were randomly placed along the transect at a frequency of 15% of the total number of possible placements. Each patch type was represented by 8 to 11 transects, producing a total of 199 quadrats. In each quadrat I first estimated the percent cover each species represented in the quadrat (percent cover), then the percent that each species' cover had been grazed (percent grazed). Percentages were based on visual estimates (Terry and Chilingar 1955). The mean percent cover and the mean percent grazed, respectively, represents the availability and the preference for each plant species by marmots. Grazing was attributed solely to marmots as there was no sign of other herbivore scats or tracks.

An 'importance index' was calculated as the percent cover multipled by the percent grazed for each plant species in each quadrat. The relative percent each plant species was contained in the diet was determined by calculating the importance index of each species as a proportion of the total importance index for all plant species.

The Kruskal-Wallis test was used to determine if differences occurred in availability, preference and importance index among patch types for the species comprising a major portion of the spring diet. These were followed by multiple planned Mann-Whitney U-tests.

Microhistological analysis of scats was used to assist in determination of spring diets and to compare diets between sites. Four random samples (n = 25 scats/sample) were collected from the four sites and analyzed at the Composition Analysis Laboratory at Colorado State University.

To determine if forage preference was dependent on availability (Westoby 1974, Ellis et al. 1976, Batzli 1983), the percent grazed (representing preference) was plotted against the percent cover (availability) for the major species of the diet.

Summer Plant Species Use

In each sample of a foraged patch the intensity of grazing on each plant species was ranked from 0 to 3. A preference value was calculated which equally incorporates the incidence and intensity of grazing.

$$\text{Preference Value} = \frac{\text{\# sample patches sp.A was grazed}}{\text{\# sample patches sp.A was present}} \times \frac{\text{sum of ranks}}{\text{maximum sum of ranks}}$$

The 'sum of ranks' is the sum of the rank values of sp.A from all samples where sp.A was present, and the 'maximum sum of ranks' is the number of samples where sp.A was present, times 3 (the maximum rank value possible at each occurrence). The preference values for each species were then ranked, omitting species present in less than three patches (Loehle et al. 1982). When possible, direct observation with spotting scopes was made to compare ranking of individual plant species use. Ranking was measured as the percent of total grazing time the marmot grazed a species while in the patch. These preference rankings allowed determination of whether selection of an optimal plant set occurred.

Optimal Plant Set

The optimal plant set included the four species which ranked high in preference at all sampling periods in the summer, plus the single highest ranked species at each of the HL and BC sites,respectively, which were not included in those four.

I constructed a 'forage value' for each patch type at all sampling times. This consisted of the combined percent cover of all species in the optimal plant set from the grazed samples, or from the original classification samples in the late summer if a patch type was not grazed. Based on biomass measurements (see Vegetation Biomass and the Effects of Marmots), percent cover appears to be a reasonable relative measure of biomass of plant species of the optimal plant set, except in the case of *Phlox diffusa*. For *P. diffusa* percent cover would be an over-estimate of its biomass relative to the other plant species. *P. diffusa* plays a minor role in calculated forage values in all patch types except PHLOX.

In the spring, the unique and ephemeral nature of species foraged precluded the operational definition of an optimal plant set. However, a mean spring forage value for each patch type was calculated as the combined cover of the four species which comprised the major portion of the diet.

A correlation of use/availability ratio with forage value of the optimal plant set and the four major species of the spring diet was used to determine if patch type selection was predictable based on the relative abundances of food species.

Vegetation Biomass and the Effects of Marmots

At HL in June 1981, I identified 10, 1x2 m paired plots in homogeneous stands of vegetation, near, but at different distances from home burrows. One by two meter exclosures (1 m high of 5 cm mesh fencing) were constructed around one plot in each stand. The other 1x2 m plot was left open to allow marmot grazing. At each sampling period, standing aboveground vegetation was clipped to ground level in eight different, randomly selected 20x25 cm quadrats in the open and exclosed plots respectively. Live vegetation was then dried and weighed. Sampling was conducted after exclosure construction (June 24-26) 1981, and mid-summer (August 4-8) and late summer (September 13-14) in 1981 and 1982. Patches containing the paired plots were sampled by releves in August 1982 and identified by KEY1 SAS. In 1982, control exclosures of suspended mesh were constucted in one plot of ANAST and PHLOX to determine if ungulates may have reduced the vegetation biomass. Marmots were seen to graze freely under the control exclosures. Burrow and patch type locations were mapped at the BC and the HL sites.

Miscellaneous Measurements

In 1982, the incidence of Golden Eagle (*Aquila chrysaetes*) overhead flights and predation attempts and the incidence of marmot alarm calls (Noyes and Holmes 1979) were monitored as the frequency of an event per hour of observation time. Patch type names are abbreviations for plant community types described in Milko (1984).

Vascular plant nomenclature follows Hitchcock and Cronquist (1973). Univariate statistical tests follow Sokal and Rohlf (1981) and Zar (1974). Means are presented as (means ± standard errors). Statistical significance is assumed at $P \leq 0.05$.

Assumption

An assumption of this study is that adult marmots have access to all patch types in their habitat. Such access was suggested by my preliminary observations of foraging by *M. vancouverensis*, by the ability of other marmot species to forage long distances from their home burrows (Holmes 1979, Barash 1980, Carey 1984), and by the ability of hoary marmots to construct refuge burrows which allowed them to forage preferentially in patches of enhanced vegetation (Holmes 1979). Although social interactions may restrict marmot access to all portions of a site at some colonies (Heard 1977), the heterogeneous nature of the sites allows access to some patches of all patch types.

RESULTS

Patch Selection

Table 2.2 shows spring analyses on the selection of patch types. Pooled data of the four sites shows that overall selection of patch types occurred ($P < .001$). Patch type GRASS was preferred ($P < .001$), JUVAC avoided ($P < .001$) and PHLOX was used in proportion to its availability. Between site variation was minimal and patch selection occurred at all sites ($P < .001$) except at HL ($P < 0.1$). GRASS was preferred at all sites except HL, JUVAC was avoided at all sites and PHLOX was used in proportion to its availability at all sites.

Summer patterns of patch type selection are summarized in Fig. 2.1. During all observation periods in which scan sampling was used (HL-1, HL-2 and BC-1), chi-square analysis showed that significant selectivity occurred ($P < .001$) when considering all patch types. The use/availability ratios differ between sites and sampling periods although some trends are evident.

At the HL site, selection and avoidance of patch types was relatively constant through all sampling periods. At the BC site, greater variability in patch type selection was found. At HL in 1981 and 1982, the ANAST patch type was preferred and its use increased as the summer progressed. At the BC site use of ANAST remained relatively constant (use/availability ratio aproximately 1.0). RIBES and PTER patch types were consistently avoided at both sites and PHLOX was selected only at HL-2 in 1981 and avoided in late summer at both sites. The SENE patch type was selected only at BC, but not in the late summer (BC-3). VACC was selected at BC-1, but this patch type contributed only 4% of the available forage area.

Mean use/availability ratios, weighted for site and temporal differences of availability, are useful indicators of overall selection of patch types. The only patch type that was selected in all sampling periods at both sites was ANAST with a mean use/ availability ratio of 1.5.

Spring Plant Species Selection

Results of importance values indicate that four species accounted for 87.2% of all grazing; *Phlox diffusa* represented 42.2%, Grasses 30.3%, carices 10.6% and *Lupinus latifolius* 4.1%. The scat analysis showed the same four species accounting for 80.2% of the spring diet; *P. diffusa* 25.4%, grasses 20.5%, carices 21.8% and *L. latifolius* 12.3%. Thus the quadrat and scat analysis methods provide similar results with respect to the major component of the spring diet, but little agreement was found for the minor components.

The mean percent grazed of the four species above remained constant in all patch types (Fig. 2.2). However, the importance index was significantly different ($P \leq 0.05$) between different patch types for all species except for *Lupinus latifolius*. The importance index represents availability multiplied by use, and because there was no difference in use between patches for any given species, the importance index differences reflect differences in availabilities. These availabilities (percent cover) were also significantly different ($P < .001$) for all species except *Lupinus latifolius*.

Mean use (percent grazed) of the four species most important in the diet in spring remained constant regardless of their mean availabilities in the different patch types.

This indicates that patch type selection was not dependent on any one species, or a higher grazing intensity on that species in the patch type with the higher abundance would have been found (Charnov 1976).

No rank correlation between availability (mean percent cover) and preference (mean percent grazed) of the twenty species grazed (r=-0.135; P=0.57; n=20) was found. This indicates that selection of food plants is not based upon species' abundances, although the four major food species are the more abundant species.

Plots of use versus availabiity for all quadrats in which a species was found illustrates varied responses to availability (Fig. 2.3). *Phlox diffusa* was the only species with cover greater than 20%. Above 20% cover, availability did not effect selection. The other three species occurred only at low availabilities and were grazed at varying intensities.

The number of times a species was present in a quadrat and not grazed may reflect its not being detected by marmots, its being detected and not grazed, or both. Conversely a high proportion of use when present could reflect preference and the development of a search image for a particular species. *Lupinus latifolius* always occurred at less than 5% cover and was grazed only 38% of the time it was present. Grasses and carices, respectively, occurred in 88%

and 96% of the quadrats with a cover value less than 5%. Grasses were grazed in 79% of the quadrats and carices in 42%. *Phlox diffusa* was grazed in 56% of those quadrats where its availability was less than 5% cover, but only 31% of the quadrats in which it was found had a cover less than 5%. Based on this method of analysis grasses was the most selected species of the major components of the diet.

Two significant rank correlations were found between sites based on the abundances of the 22 plant species (not lumped species) found in the scats; one between HL and BC ($r=0.42$; $p=.05$; $n=22$) and the other between GM and GP ($r=0.72$; $P < .001$; $n=22$). These are pairs of low and high elevation sites respectively. These correlations represent similarities in diets which most likely represent similarities in forage species availabilities (Hansen et al. 1973, Hansen 1975).

It appears that although the spring diet reflects foraging on the more abundant species, overall diet selection is not dependent on availability. The selection of patch types, is also not dependent on the availability of any one species, although grasses are the most preferred.

Summer Plant Species Selection

A high degree of floristic similarity and marmot grazing preferences between the BC and HL sites was found in the summer. Rankings of species preference by direct observation conformed to the field rankings based on preference values and are shown in Table 2.3. *Lupinus latifolius*, *Thalictrum occidentale*, *Lathyrus nevadensis*, and *Castilleja* spp. (*C. miniata* and *C.hispida* were always grazed at the same preference ranking), were consistently among the nine most preferred species. If each sampling period and site is considered to be independent and if the probability that these four 'species' would occur in the top nine of all the species available for grazing at each sampling period is calculated, the probability of this being a random event is 8.6×10^{-15}. This indicates a high degree of selection. These five plant species, highly preferred and abundant throughout the summer, plus *Phlox diffusa* at HL and *Heracleum lanatum* at BC, were chosen as the optimal plant set.

Selectivity was also indicated by the absence of a significant rank correlation of use to availability ($r=0.22$; $P=0.15$; $n=44$). Of the 44 most abundant species, 32 had rare or no evidence of grazing.

Optimal Plant Set and Patch Type Selection

Forage values comprising the combined percent covers of the optimal plant set are presented in Table 2.4 with use/availability ratios for the different sites and sampling periods. Rank correlation of use/availability and forage values of all patch types, excluding and including ecotones, respectively, are not significant ($r=0.15$; $p=0.42$, $n=29$ and r=0.13; p=0.47; n=34), showing little relationship between patch type selection and the abundance of plants in the optimal plant set.

A response of the use/availability ratio to changes in forage values was demonstrated within some patch types. In patch type ANAST, as the forage value changed between sampling times, the use/availability ratio showed a parallel response at the HL and BC sites. RIBES patch type maintained a low forage value and low use/availability ratio at both sites. In contrast PTER had a high forage value but maintained a low use/availability ratio. PHLOX had a higher forage ratio and use/availability ratio at HL than at BC, but use dropped to zero in late summer at both sites, when vegetation in this xeric patch type was dry.

Equivalent use of ANAST, SENE, and PTER, based on forage values calculated from the classification samples (forage values = 17, 16 and 17 respectively), was expected but not found. I observed an avoidance of tall vegetation and an increased frequency of marmots in an alert, upright and nongrazing position when in tall vegetation. I hypothesized that this was a response to increased risk due to marmots inability to observe predators while in tall vegetation, in addition to their ease of detection because of the motion of the vegetation. The tall SENE patch type was used by marmots at BC-2, but the physiognomic and plant community distinctions are less pronounced at this site than at HL. In the late summer SENE patch types have shorter vegetation at BC (0.8 m) than at HL (1.0 m). In earlier seasons (BC-1 and HL-1), the vegetation height is low, approximating the maximum height in ANAST (<0.5 m).

Furthermore, the forage value of SENE was greater at BC than at HL, and *Heracleum lanatum* ,a highly preferred species at BC, had a significantly greater mean cover at BC (10.5 ± 3.0; n=8) than at HL (3.1 ± 0.8; n=10) in the SENE patch type (t-test; $.05 \geq P \geq .01$). Feeding trials with yellow-bellied marmots have also shown *H. lanatum* to be a preferred plant species (Armitage 1979). Its mean cover in foraged areas was also higher at BC-2 (11.2 ± 3.4; n=6) than at BC-1 (4.5 ± 0.9; n=8), while the total forage value remained constant. This could account for its greater use at BC-2. Selection of the SENE patch type at BC may thus be a response to a higher forage value and to the abundance of a preferred plant species.

In summary patch type selection was not predictable based on forage values of preferred forage species, and increased risk associated with tall vegetation appears to influence patch choice.

Burrow and Plant Biomass Influence On Patch Selection

Although patch use can be somewhat predicted by burrow availability (Carey 1984, Holmes 1984a), the number of burrows/unit area of forage patch type at HL showed no significant correlation with mean use/availability (r=0.5; P=0.38;

n=5). The most selected patch type, ANAST, did have the highest burrow/unit forage area ratio (1.7). Patch types SENE and PTER, with ratios of 0.4 and 1.4 respectively, were used by marmots only in the spring. The high burrow density in the little used PTER patches could have been dug in ANAST patches before they were invaded by bracken fern (Milko 1984) and might now be maintained by use in the spring. RIBES, with natural burrows in talus, has a high burrow per unit forage area of 1.5 and PHLOX, found on rock outcrops, has a low ratio of 0.3.

Exclosure results at HL indicated that reduction of vegetation biomass by marmot grazing can vary between patch types and within a patch type according to location, season and year. Mean reduction in biomass at any one paired plot ranged from 0% to 51%. Over a two year period, no significant reduction of biomass in two paired plots in patch type SENE was measured (t-test). Significant reduction was measured on six occasions in patch type ANAST, which had five paired plots in different locations and on two occasions in the one paired plot in PHLOX. No reduction of vegetation biomass by ungulates was measured. No patches of RIBES were examined because of their talus substrate. One pair of plots was unidentified by KEY1 SAS and one pair was placed half in PTER and half in ANAST.

Patch type selection appeared not to be a direct result of above ground vegetation biomass of all plant species.

Ranks of biomass for the different patch types and their rank preference based on the use/availability ratio, showed no correlation at any of the three sampling periods (Table 2.5). As biomass increased throughout the season the correlation with preference decreased. In addition, there was no rank correlation between percent reduction of vegetation biomass and the recognized risk factors (Holmes 1984a) of distance to the nearest home burrow or escape burrow when all paired plots are examined. The forage value of the optimal plant set, the hypothesized predictor of patch type selection, showed only a small non-significant, but positive rank correlation to percent biomass reduction when examined for the eight exclosed pairs at HL-3 (Table 2.5).

Examination of the five plots at HL-3 within the preferred patch type ANAST, indicated that the percent reduction of biomass was greater in patches with higher biomass (Table 2.6). ANAST had the median rank in vegetation biomass of the five patch types present at HL. The patches of higher biomass correlated with increased distance from home burrows, and to a lesser extent, escape burrows. The percent reduction of biomass also appeared higher the further the distance from burrows in the patches of higher biomass (positive non-significant rank correlations). Forage value again showed a low positive non-significant rank correlation to percent impact.

In contrast to the negative influence of biomass for patch type selection, within the preferred patch type, use of patches increased with vegetation biomass. These correlations also showed biomass reduction with proximity to burrows in this patch type, but whether this is a result of increased impact through time or due to edaphic factors would require long term exclosure experiments.

Spring Forage Values and Patch Type Prediction

In the spring there was no correlation between forage value and use/availability ratio considering all patch types and sites together ($r=-0.09$; $P=0.80$; $n=11$). The irregularity noted during the spring with respect to modified marmot behavior (Heard 1977), high risk (measured as snow cover requiring long travel distances (> 100 m) and travel time (> 60 sec) between refugia), and the rapidly changing locations of forage areas due to snow-melt patterns, could contribute to this lack of correlation. In addition, the mean number of golden eagle overhead flights and attacks per hour, was higher in the spring (0.42 ± 0.01) than in the late summer (0.18 ± 0.02) and may further increase the predation risk in the spring.

The consistently high use of patch type GRASS (Table 2.2) might, however, be explained by its forage value consisting of 75% grasses, the most selected species of the important forage plants. Furthermore, considering that *Phlox diffusa* occurred but was not selected at availabilities greater than 20% cover and that *P. diffusa* comprised greater than 95% of the forage value of the PHLOX patch type, the lack of selection of this patch type based on forage value is better explained.

The *Pteridium aquilinum* dominated patch type (PTER), which had been strongly avoided in summer, was a component of the spring GRASS patch type and could be identified by the presence of decaying fronds. Reanalysis of pooled data for all sites showed that the use/availability ratio of PTER (0.6) was lower than the use/availability ratio of GRASS (1.6) when areas of the PTER patch type were omitted. A comparison of the mean spring forage value showed a significant difference (t-test, $P < 0.001$) between GRASS (6.8 ± 0.7; n=41), and PTER (2.43 ± 0.4; n = 35). This concurred with the use/availabilty ratio differences. The only observable risk factor at this time, density of burrows, was equivalent for both the PTER and the ANAST components of the GRASS patch type. Marmot use in spring thus appeared to respond in part to differences of forage values.

Constraints of Vegetation on Marmots

At the GP site, five species which were consistently preferred at HL and BC were either absent (*T. occidentale*, *L nevadensis* and *Heracleum lanatum*) or rare (*C. hispida* and *C. miniata*). *Lupinus latifolius* was present and the most preferred species at all the sites. At MG-3 *L. latifolius* was grazed in all 26 foraged plots at an average intensity of 2.5 on the rank scale of 0 to 3 and was found to have a higher mean cover of 15% as compared to 10% at either the BC or HL site. Heavy grazing was evident in the spring at MG, resulting in reduced plant vigor and extensive patches of bare ground in 7 of the 18 plots sampled. GP also offered more of a selection of spring forage species throughout the summer, illustrated by the grazing of grasses and carices during all sampling periods (Table 2.3). These species were rarely grazed at the other sites later than the spring.

Range of vision at GP was reduced due to an abundance of large patches of shrubby *Vaccinium spp.*, stands of mature trees and forest regeneration in the meadow area. An increase in vigilance in yellow-bellied marmots, measured as the time looking up and not grazing, has been related to both tall vegetation and marmot-vocalized alarm calls (Carey 1983). Alarm calls of *M. vancouverensis*, calculated as the number of whistles/hour/marmot was significantly higher (t-test; $P < 0.001$) at this site (0.34 whistles/hr/marmot) than the other sites (0.06 ± .02 whistles/hr/marmot).

DISCUSSION

Patch Selection and Predictability

Patch type selection, defined by plant community types, occurs in *M. vancouverensis*, despite the suggested difficulties of defining patches in the field (Gill and Wolf 1977) or for the organism being studied (Wiens 1976).

Experiments have indicated that foraging can be concentrated in the most profitable patches (Harwood 1977, Smith and Sweatman 1974, Holmes 1979), as predicted by optimal foraging theory (MacArthur and Pianka 1966, Pyke et al. 1977) and Royama's (1970) profitability hypothesis. Strong distinctions between patches might also be necessary to invoke non-random foraging (Zach and Falls 1976) and the variance of the reward, as well as the mean value, may play a role in patch selection (Caraco et al. 1980).

At the HL site, patch types are more distinct than at the BC site and selection is more pronounced and less variable. Although patch selection was poorly predicted by forage value, *M. vancouverensis* demonstrated some preference for patches of higher food abundances. At HL, marmots avoided patch type RIBES, but selected patch type ANAST which had a higher forage value. The risk factors of burrow density and vegetation height were equivalent.

Avoidance of tall vegetation by other medium sized ground squirrels has been suggested as an anti-predator strategy (Carl 1971, Armitage 1982, Carey 1983). At HL, the avoidance of tall vegetation appears to be a more important factor than forage value in patch type selection. Patch type PTER, with the added risk factors of tall vegetation and a high percent cover, was avoided although its forage value and burrow density was the same as in the ANAST patch type.

Such differential patch selection, when patches differed only in predation risk, was shown for minnows (Fraser and Cerri 1982).

A major difference in selection of patch type SENE exists between the HL and the BC sites. At HL, this patch type, with tall vegetation, was avoided despite a forage value equivalent to that of ANAST. Although this could be attributable to a lower burrow density, SENE is still more highly selected at the BC site. At BC, the higher forage value of SENE, the reduced height difference between ANAST and SENE, plus the higher abundance of *Heracleum lanatum*, (a preferred forage species), could explain its selection. Such "balancing" of risk and benefit has been demonstrated for backswimmers (*Notonecta hoffmani*) (Sih 1980), but not for minnows (Cerri and Fraser 1983). The unpredictability of spring patch type selection from forage values again might best be explained as a modification of marmot behavior to decrease the risk of predation.

It therefore appears that although marmots can select patch types based on available forage (Holmes 1979, Carey 1983, this study) and reduce predation risk by constructing new burrows in preferred patches (Holmes 1979), for *M. vancouverensis*, the presence of refugia is not sufficient to overcome the risk associated with tall vegetation at a moderate forage value (benefit). However, as the benefit increases by further degrees (as shown by a higher forage value and the increased abundance of *H. lanatum*) it appears that the risk factor is balanced out. Experiments in which tall vegetation is removed in avoided patches and tall obscuring matter is placed in preferred patches could test this hypothesis. In addition, an experimental field situation, varying a quantifiable gradient of costs (risk factors) and benefits (eg. forage value of some kind), might define more clearly the processes involved.

Behavioural differences among individual marmots in different species can be pronounced (Svendsen and Armitage 1973, Svendsen 1974, Barash 1976, Holmes 1979, Carey 1983) and affect the sharing of forage range among kin (Johns and Armitage 1979, Frase 1982). The behavioral differences of individuals of *M. vancouverensis* observed in this study and by Heard (1977), could also play an important role in cost:benefit aspects of patch choice. Two individual adult marmots demonstrated distinct and consistent foraging behavior in SENE patches at BC. On most occasions this pair first sat on a large boulder and then entered and foraged in the patch type together. Such group foraging has been shown to reduce predation risk (Barash 1973, Carey 1983, Holmes 1984a). Variation in behavioral profiles could affect foraging abilities of individuals, and ontogenetic changes (Holmes 1979, Carey 1983, this study) could also play a role in the foraging behavior and success of marmots.

Diet Selection

That marmots select individual plant species is suggested by the lack of correlation between preference and availability. This is accentuated in the summer by the large number of plant species which are high in abundance but not grazed.

In the spring, the relatively high availability of graminoids appears to influence the diet composition of the marmots despite the stronger preference for a few forb species (Table 2.3). These forbs are too scarce to form a major part of the diet. In the summer, forb preferences are maintained, while graminoid preference and use decline despite an increase in their availability. Similar seasonal shifts in diet contribution of graminoids have been observed for yellow-bellied marmots, the extent being somewhat dependent on the availability of the preferred forb species (Frase 1982, Carey 1983).

Young graminoids might be selected because of the high protein content of the readily available and actively growing basal meristems (Mattson 1980). As grasses mature crude protein decreases (Frase 1982), and secondary cell wall deposition (Bidwell 1974) and structural or insoluble proteins increase (Mattson 1980). Preference for forbs over older monocots by herbivores might reflect the former's lower fiber (Carey 1983) and higher nutrient content (Batzli and Cole 1979), resulting in greater digestibility.

All portions of two plant species, *Lupinus latifolius* and *Lathyrus nevadensis* , are ingested in all seasons. They are both legumes (Fabaceae) which is a plant family preferred by many rodent species: *Citellus beechyi* (Fitch and Bently 1949), *Marmota caligata* (Hansen 1975), *Microtus ochrogaster* (Cole and Batzli 1979), *Spermophilous parryi* (Batzli and Sobaski 1980) and *Marmota flaviventris* (Frase 1982, Carey 1983). The high use of legumes is probably attributable to their high concentration of nitrogen (Mattson 1980).

Optimal Plant Set

The consistent preference of a selected set of plants in the diet of *M. vancouverensis* supports the concept of an optimal plant set. More than one plant species is used, as predicted in models which consider different nutritive qualities of plant species (Westoby 1974, Pulliam 1975), or where toxic secondary plant compounds might reinforce the need for a varied diet (Freeland and Janzen 1974). Westoby (1974) predicted a constant use of forage species at different availabilities and a sudden decrease in use when availability drops below a threshold value. These patterns are indicated for *M. vancouverensis* by the constant preference for species of the optimal plant set as their abundances vary with time, and by the diet in spring , when the optimal plant set species have low availability and are either not grazed or are less preferred. The role of high concentrations of plant toxins in the early phenological stages of forbs should also be examined as an explanation for their reduced preference in the spring.

Direct observation and examination of foraged plots of vegetation indicate that some plant species not normally in the diet are sampled. Some preferred species also contribute less to the diet because of their low availabilities or because of marmot preference for a particular portion of the plant (eg. *Lilium columbianum* and *Valeriana sitchensis* - flower, *Vaccinium* spp. - fruit, *Pteridium aquilinum* - fiddlehead)

Constraints of Vegetation

The avoidance of tall vegetation strongly reduces the available forage areas for *M. vancouverensis* and results in the highest biomass reductions in the patches that both support preferred forage plants and are free of tall vegetation. Because of marmot selection for particular plant species and parts thereof, my measured reductions of total vegetation biomass must underestimate the reduction of effective forage. Effective forage availability could be a limiting factor on the marmots' population. A smaller mean litter size in 1982 than in 1981, concurrent with a reduction of available spring forage area in 1982, is evidence of such a limitation.

Vegetation succession can play a role in animal population levels, by changing plant species composition which can result in a reduction of preferred plant species (Cole and Batzli 1979), by altering habitat structure (Nicholson and Paterson 1976), or both (Osborn and Allan 1949). Forest regeneration on Vancouver Island is presently altering marmot habitat by increasing the risk of predation because of the taller vegetation and by reducing the available forage areas.

In addition marmot use of patches of bracken fern (*Pteridium aquilinum*) was low in all seasons. This seral species (Page 1976) has elsewhere been shown to affect foraging patterns of grazing ungulates (Hunter 1962, Nicholson and Paterson 1976) and rabbits (Farrow 1917). The height and cover of bracken in the summer and the low forage value of bracken patches in the spring, are the likely causes of the low use of bracken patches (PTER). The reduction in plants is attributable to allelopathic secondary compounds from the dead frond litter released in the spring (Gliessman 1976).

It appears that the high biomass of meadow vegetation could be affecting the social organization of *M.vancouverensis*. Holmes (1984b) has attempted to explain the evolution of monogamy in Alaskan hoary marmots, and predict the breeding ratios of the genus *Marmota*. Abundant vegetation and a small mean distance between hibernacula (not mutually exclusive) should lead to a polygamous situation. Based on the vegetation biomass of the HL site, some degree of polygamy would be predicted for *M. vancouverensis*, contrary to what has been observed (Heard 1977). Although vegetation biomass of forage species may be a better predictor than total vegetation biomass (Holmes 1984b), available data have supported this prediction based on the total vegetation biomass. The second predictor, distance between hibernacula, more closely fits the observed monogamous situation. Since 1977 however, the population size has changed, including the number of reproductive females and further study of adult sex ratios is required.

The selection of forage patches in a patchy environment (Pianka 1978) and the selection of a narrow set of plant species from the wide choice possible (Roughgarden 1972) indicates some degree of specialization by *M. vancouverensis*. The Vancouver Island marmot also demonstrated the ability to alter its foraging patterns with varying availabilities of forage patches and food species at different sites and seasons. Although *M. vancouverensis* might then be considered a facultative specialist (Glasser 1982), as suggested by its use of a variable environment, its rare and endangered nature suggests its limits of adaptation may soon be reached.

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Table 2.1 Schedule for observations and vegetation sampling.

Site	Spring Sampling Dates (1982)
HL	May 15-20
GM	May 25-28
BC	June 2-5
GP	June 8-11

Site	Summer Sampling Periods (1982)		
	1	2	3
HL-	June 15-19	July 20-24	Aug 30-Sep 3
BC-	June 22-26	July 27-31	Sep 8-Sep 11
GP-		July 11-14	Aug 24-28

Site	Summer Sampling Periods (1981)		
	1	2	3
HL-		July 1-Aug 5	Aug 28-Sep 17

Table 2.2 Patch type selection in the spring by foraging marmots.

Site	Patch type	# of marmots Observed	# of marmots Expected	$\lvert Z \rvert$[a] probability	Observed/expected ratio	Chi-square[b] probability
Sites Pooled	PHLOX	58	57.3	ns	1.0	
	GRASS	156	109.2	P<0.001	1.5	P<0.001
	JUVAC	59	106.5	P<0.001	0.6	
HL	PHLOX	45	42.6	ns	1.1	
	GRASS	67	63.8	ns	1.0	ns
	JUVAC	0	5.6	P<0.05	0	
BC	PHLOX	5	4.3	ns	1.2	
	GRASS	36	17.2	P<0.001	1.8	P<0.001
	JUVAC	2	21.5	P<0.001	0.1	
GP	PHLOX	4	4	ns	1.0	
	GRASS	29	15.8	P<0.001	1.8	P<0.001
	JUVAC	46	59.3	P<0.001	0.8	
GM	PHLOX	4	7.8	ns	0.5	
	GRASS	24	11.7	P<0.001	2.0	P<0.001
	JUVAC	11	19.5	P<0.01	0.6	

a. The normal approximation to the binomial test.

b. Probability of chi-squared value for null hypothesis that use was proportional to availability based on the number of marmots observed foraging in each patch type.

Table 2.3. Plant species preference(a) rankings at different sites and sampling periods.

Plant species	HL-1 June 17	HL-2 July 22	HL-3 Sept 1	BC-1 June 23	BC-2 July 28	BC-3 Sept 9	GP-2 July 12	GP-3 Aug 24	Spring all sites
Pteridium aquilinum	1	(c)	-	8	-	9	**	**	**
Lilium columbianum	2	8.5	+	3	4	3			
Lupinus latifolius	3	2	1	2	3	1	2	1	7
Erythronium grandiflorum	4								10
Phlox diffusa	5	4	2.5	+	-		1	3	8
Thalictrum occidentale	6	5	5	4.5	6	4	**	**	+
Lathyrus nevadensis	7	3	8	6	5	7	**	**	-
Heracleum lanatum	8	8.5	+	4.5	2	2	**	**	+
Castilleja spp.	9	1	2.5	1	1	5.5			-
Arenaria macrophylla	10	+	-	+	-	-	-	-	+
Eriophyllum lanatum	+	-	9	-	-	-	**	**	-
Heuchera micrantha	+	+		-	+	8	-		9
Grasses	+	-	-	7	-	+	4	7	4
Campanula rotundifolia	+	6	7	-	-	+		5	-
Cirsium edule	+	7	+	-	-	+	6	+	3
Vacinnium spp.			4	-		10	-	+	+
Valeriana sitchensis	-	-	6	-	7	5.5	8.5	2	+
Erigeron peregrinus	+		-	-			8.5	10	1
Arnica latifolia				-	-	-	-	4	
Hieracium gracile							-	6	-
Achillea millefolium	-	-	-	-	+	-	10	8	+
Carex spp.	+	+	-	+	-	-	3	9	6
Luzula spp.							7	-	-
Penstemon serrulatus			-	-	-	-	-	-	5
Aster foliaceous			-	-			-	-	2
Veratrum viride	+	-	-	-	-	-	5		+
Others(b)									

(a) Defined in methods.
(b) Others represents 62 other species which were not grazed and which occurred in varying abundances (see Milko 1984).
(c) All blank spaces indicate less than 3 occurrences in samples.
- Not grazed in samples but abundant.
+ Grazed rarely but abundant.
** Absent from site.

Table 2.4 Forage value[a]/use-availability ratio for the different patch types at different sites and sampling periods.

Patch type	HL-1 1982	HL-2 1982	HL-3 1982	HL-3[b] 1981	BC-1 1982	BC-2 1982	BC-3 1982
ANAST	10/1.6	17/2.5	24/3.1	17/2.8	58/1.2	30/0.7	26/0.9
SENE	17/0.6	c/0	16/0	16/0.1	34/1.2	31/2.1	24/0.6
PTER		/0	16/0	17/0		/0	36/0.7
PHLOX	35/0.6	36/0.6	36/0	36/0.1	19/0.4	19/0	19/0
RIBES	0/0	0/0	2/0	0/0.02	3/0.8	4/0.4	/0
VACC					13/3.0	/0	/0
Ecotone	d/0.3	21/1.7	15/1.1		36/0.4	35/0.8	23/2.1

a Calculated as combined percent cover of the 'optimal plant set'- see methods.
b HL-3 forage value calculated from the classification samples used to define the patch type (see methods and Milko 1984).
c Forage values not calculated since no samples were grazed.
d No forage value calculated.

Table 2.5. Spearman rank correlations between vegetation biomass[a] and preference[b] for the 5 patch types at the HL site and between percent vegetation biomass reduction and variables known to influence patch choice[c] (predation risk factors and forage value[d]), measured for 8 exclosed vegetation plots[d].

	Sampling periods		
Patch Preference	June 24	August 4	September 14
Vegetation biomass	r = 0.20 p = 0.75	r = 0.10 p = 0.87	r = -0.30 p = 0.63

	Risk factors		
Influencing variables	Home burrow distance	Escape burrow distance	Forage Value
Percent reduction of vegetation biomass	r = -0.07 p = 0.87	r = 0.14 p = 0.74	r = 0.44 p = 0.27

a Mean dry mass calculated over two years, n = 8 to 48.
b Based on use/availability ratio, see Table 3.
c Variables approximating those in Holmes (1984a).
d See methods.

Table 2.6. Spearman rank correlations between vegetation biomass and preference[a] and burrow distances, and between percent reduction of vegetation biomass and influencing variables[b] (burrow distance and forage value[c]) for five replicates of the preferred patch type ANAST at the HL site.

Correlation variables	Percent biomass reduction	Home burrow distance	Escape burrow distance
Vegetation biomass	r = 0.90 p = 0.04*	r = 0.90 p = 0.04*	r = 0.80 p = 0.10

Influencing variables	Risk factors Home burrow distance	Risk factors Escape burrow distance	Forage Value
Percent biomass reduction	r = 0.80 p = 0.10	r = 0.60 p = 0.28	r = 0.41 p = 0.49

---

[a] Measured as the percent reduction of vegetation biomass.
[b] Variables approximating those in Holmes (1984a).
[c] See methods.
* Significant at $P \leq 0.05$.

Figure 2.1. Summer use/availability ratios of the 6 patch types and vegetation ecotones at different sampling periods for the two sites. Probabilities on patch types are from the normal approximation of the binomial test. Chi-square probalities are noted on sampling period abbreviations (HL-1, Hl-2 and BC-1). Probabilities are indicated as: ns means $P > 0.05$, a means $0.05 \geq P > 0.01$, b means $0.01 \geq P > 0.001$ and c means $P \leq 0.001$.

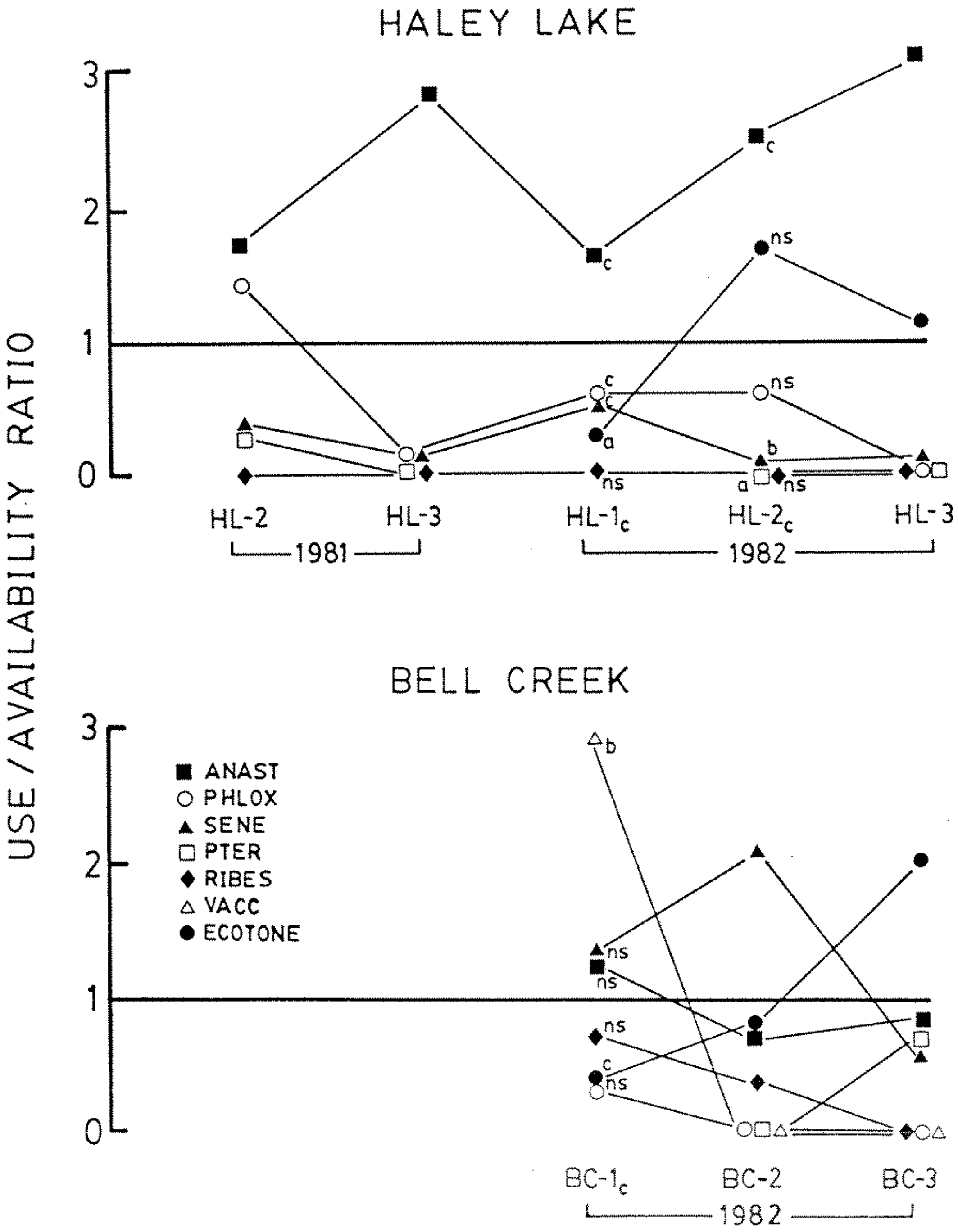

HALEY LAKE
USE / AVAILABILITY RATIO
3
2
1
0
c
ns
c
c
a
ns
b
a
ns
HL-2
HL-3
HL-1c
HL-2c
HL-3
1981
1982
BELL CREEK
3
2
1
0
■ ANAST
○ PHLOX
▲ SENE
□ PTER
◆ RIBES
△ VACC
● ECOTONE
b
ns
ns
ns
c
ns
BC-1c
BC-2
BC-3
1982

Figure 2.2. Mean importance index (left axis) and mean %-grazed (right axis) for the 4 species which provide 87.2% of the marmot's spring diet. Values are for each patch type from all sites combined. Non-significant differences (Mann-Whitney U-test) between patch types are shown by lines under bar graphs as in multiple range test convention. Sample sizes illustrated under bars are 1) the total number of quadrats, for Importance Index means and 2) the number of quadrats the species was present, for Grazing means. Experimentwise error rate for significance is $P \leq 0.017$.

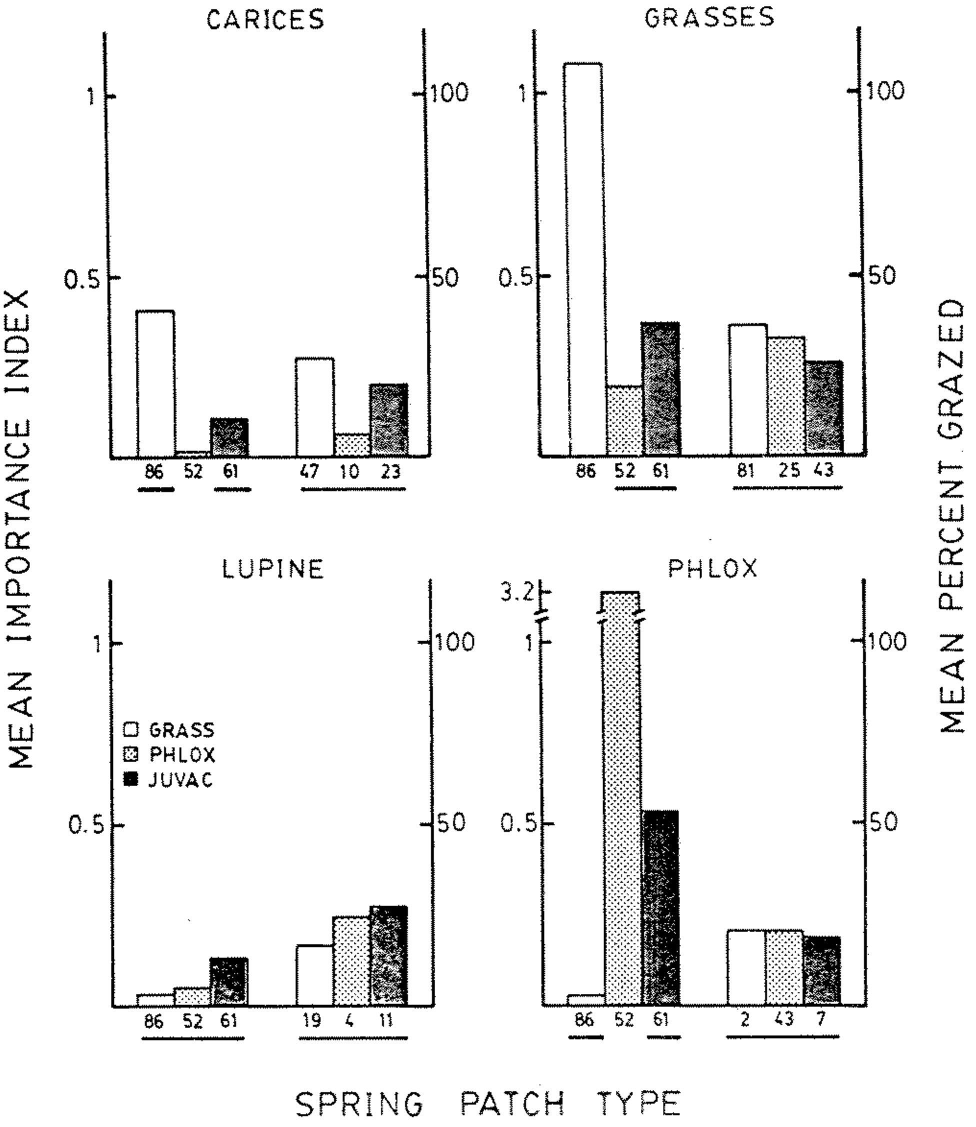
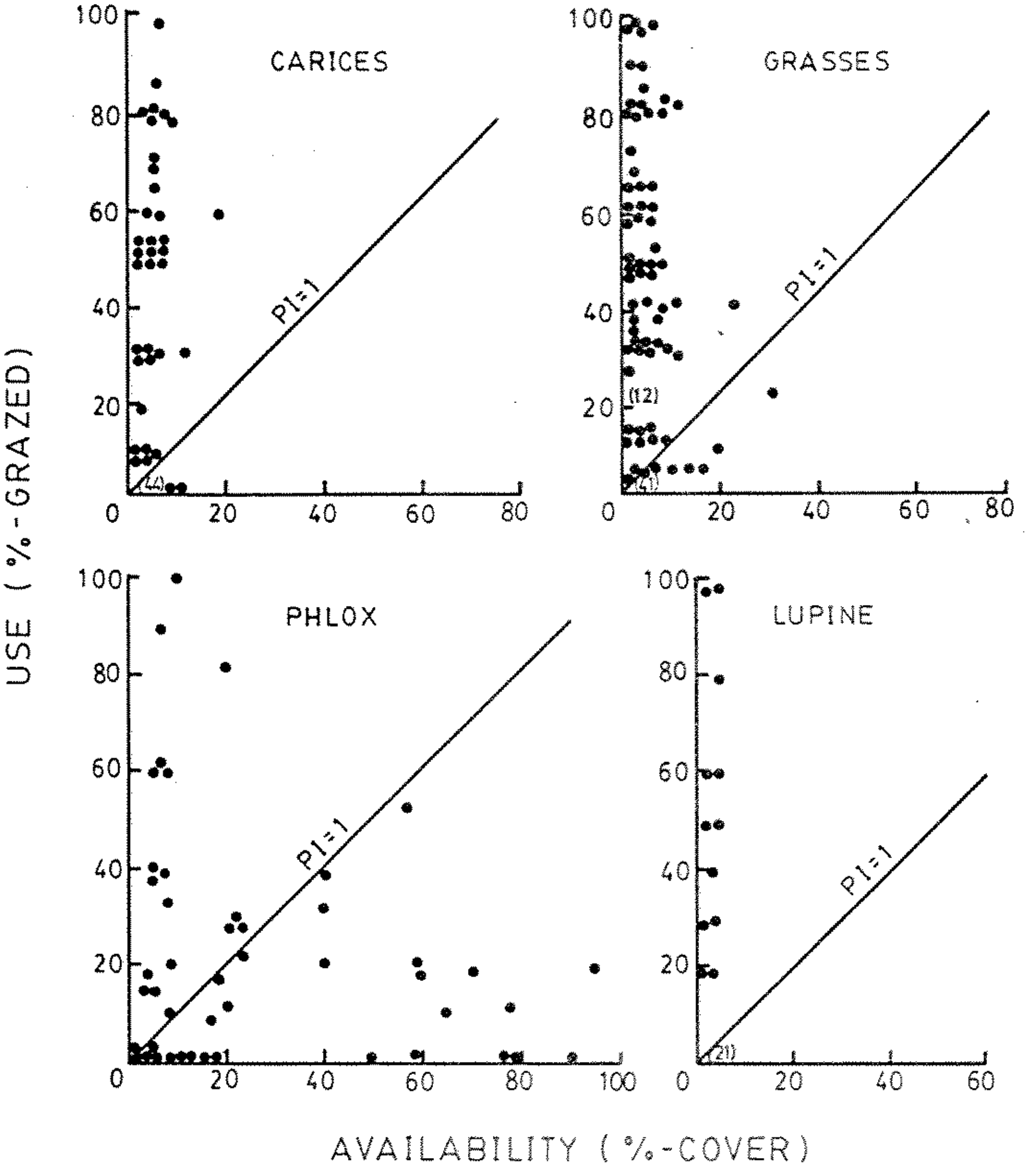

CARICES
GRASSES
LUPINE
PHLOX
MEAN IMPORTANCE INDEX
MEAN PERCENT GRAZED
1
0.5
100
50
3.2
86 52 61 47 10 23
86 52 61 81 25 43
86 52 61 19 4 11
86 52 61 2 43 7
□ GRASS
▨ PHLOX
■ JUVAC
SPRING PATCH TYPE

Figure 2.3. Plots of use (%-grazed) versus availability (%-cover) of the 4 species which provided 87.2% of the marmots spring diet. Measurements are from individual randomly placed 20x25 cm quadrats. Line PI=1 indicates a hypothetical linear relationship between use and availability. Numbers in parentheses eg.(12) represent incidences with the same value.


USE (%-GRAZED)
AVAILABILITY (%-COVER)
CARICES
100
80
60
40
20
0
20
40
60
80
PI=1
(4)
GRASSES
100
80
60
40
20
0
20
40
60
80
PI=1
(12)
(4)
PHLOX
100
80
60
40
20
0
20
40
60
80
100
PI=1
LUPINE
100
80
60
40
20
0
20
40
60
PI=1
(21)

APPENDIX 1

Computer Program KEY1 SAS written in Algorithm form: Reference to all species is percent cover. Sequential order MUST be followed.

Key: g.e. = greater than or equal to, l.t. = less than

To commence set identity of releve sample to "Unidentified".

1. If *Pteridium aquilinum* g.e. 70% then identity = "Pteridium".
2. If *Ribes lacustre* g.e. 10%, then identity = "Ribes-Heuchera".
3. If (*Senecio triangularis* + *Veratrum viride* + *Sausaurea americana*) g.e. 10% go to 3a, else go to 4.

    a. If (*S. triangularis* + *V. viride* + *S. americana*) g.e. 15% or
    If *S. triangularis* g.e. 12% or
    If *V. viride* g.e. 8% or
    If *S. americana* g.e. 8% or
    If (*S. triangularis* + *Heracleum lanatum*) g.e. 15% or
    If (*V. viride* + *H. lanatum*) g.e. 11% or
    If (*S. americana* + *H. lanatum*) g.e. 11%

    then identity = "Senecio-Veratrum"

4. If *Phlox diffusa* g.e. 25% or
   If *P. diffusa* g.e. 18 and (Mosses g.e. 13% or *Selaginella wallacei* g.e. 5%) then identity = "Phlox-moss".
5. If *Vaccinium* spp. g.e. 2% or *Luetkea pectinata* g.e. 1% or *Arnica latifolia* g.e. 3% then go to 5a, else go to 6.
   a. If *Anaphalis margaritacea* = 0% then identity = "Vaccinium-Carex" or
      If *Vaccinium* spp. g.e. 15% and *A. margaritacea* l.e. 4% then identity = "Vaccinium-Carex".
6. If *Viola glabella* g.e. 5% and (*S. triangularis* g.e. 5% or *V. viride* g.e. 5% or *S. americana* g.e. 5%) then identity = "Senecio-Veratrum".
7. If *A. margaritacea* g.e. 10% or *P. diffusa* g.e. 3% or *Eriophyllum lanatum* g.e. 4% go to 7a, else go to 8.
   a. If *A. margaritacea* g.e. 20% then identity = "Anaphalis-Aster" or
      If *P. diffusa* g.e. 5% or *Castilleja hispida* g.e. 1% or (*P. diffusa* g.e. 3% and *C. hispida* g.e. 0.5%) then identity = "Anaphalis-Aster (disturbed variant)" or
      If *A. margaritacea* g.e. 10% then identity = "Anaphalis-Aster" or
      If *P. diffusa* l.t. 3% and (*E. lanatum* + *A. margaritacea*) g.e. 10% and (*Lupinus latifolius* g.e. 8% or *Achillea millefolium* g.e. 10%) then identity = "Anaphalis-Aster".

8. If Grasses g.e. 6% and (*L. latifolius* g.e. 10% or *Aster foliaceous* g.e. 12%) then identity = "Anaphalis-Aster".

9. If *Carex* spp. g.e. 20% and *A. margaritacea* l.t. 4% then identity = "Vaccinium-Carex".

10. else identity remains "Unidentified".

APPENDIX 2

Census of marmot populations at study sites in spring (May 15 - June 11), mid-summer (July 12 - July 28) and late summer (August 24 - September 9) in 1982.

Site and Season	Marmot age class			
	Juveniles	Yearlings	Adults	Total
Haley Lake				
Spring	0	5	11	16
Mid-Summer	11-12	4	9	24-25
Late Summer	4-5	4	8	16-17
Bell Creek				
Spring	0	2	8	10
Mid-Summer	0	2	4	6
Late Summer	0	2	4	6
Gemini Peak				
Spring	0	6	10	16
Mid-Summer	0	6	6	12
Late Summer	0	5	5	10
Green Mountain				
Spring	0	3	8	11

---

a Juveniles are newborn of 1982, Yearlings those born in 1981 and Adults those older than yearlings.

APPENDIX 3

DATA FROM THE 51 RELEVES USED TO REPRESENT THE FIVE COMMUNITY TYPES AT THE HALEY LAKE SITE. NO LUMPING OF DATA HAS BEEN DONE.

NUMBERS 001 TO 051 ARE RELEVES.

RELEVES REPRESENTING TENTATIVELY DEFINED COMMUNITY TYPES ARE:

PHLOX-MOSS 001-007 AND 016
ANAPHALIS-ASTER 008-015
PTERIDIUM AQUILINUM 017-024
RIBES-HEUCHERA 025-031
DISTURBED VARIANT 033-039
SENECIO-VERATRUM 040-047 AND 032
SEEPAGE 048
GRASS VARIANT 049-051

VALUES ARE ESTIMATED PERCENT COVERS

```
001 ERIO LANA 025.0 PHLO DIFF 035.0 SELA WALL 015.0 ACHI MILL 003.0
001 FRAG VESC 010.0 DANT INTE 010.0 POA. PRAT 000.5 CARE HOOD 003.0
001 SAXI OCCI 000.5 PRUN VULG 001.0 HEUC MICR 000.5 RHAC CANE 055.0
001 POLY PILI 012.0 PSEU PATE 003.0 STER TOME 006.0 POTE GLAN 000.5
001 CRYP CRIS 001.0 ELYM GLAU 000.5 LUZU MULT 000.5 CLAD SP.. 000.5
001 MONT PARV 000.5 POLY MINI 000.5
002 JUNI COMM 015.0 ERIO LANA 025.0 PHLO DIFF 020.0 SELA WALL 034.0
002 RHAC CANE 030.0 POLY PILI 008.0 PSEU PATE 002.0 ACHI MILL 006.0
002 FRAG VESC 001.0 DANT INTE 004.0 POA. PRAT 000.5 AGRO SCAB 001.0
002 PHLE ALPI 000.5 MELI SUBU 000.5 LUZU MULT 001.0 SAXI OCCI 002.0
002 DELP MENZ 002.0 POTE GLAN 000.5 CRYP CRIS 003.0 PRUN VULG 004.0
002 MONT PARV 003.0 STER TOME 008.0 CLAD SP.. 000.5 TRIS CANE 000.5
003 JUNI COMM 004.0 ERIO LANA 015.0 PHLO DIFF 045.0 SELA WALL 040.0
003 RHAC CANE 020.0 POLY PILI 008.0 PSEU PATE 004.0 ACHI MILL 002.0
003 FRAG VESC 004.0 DANT INTE 015.0 AGRO SCAB 006.0 LUZU MULT 000.5
003 SAXI OCCI 001.0 POTE GLAN 003.0 CRYP CRIS 004.0 PRUN VULG 008.0
003 MONT PARV 006.0 STER TOME 001.0 CLAD SP.. 000.5 HEUC MICR 001.0
003 CLAD GRAC 002.0 SEDU DIVE 000.5 AREN MACR 000.5 LUPI LATI 002.0
003 CAST HISP 001.0 VERO WORM 000.5 CAMP ROTU 000.5 MIMU GUTT 000.5
003 LOMA MART 000.5
004 JUNI COMM 006.0 ERIO LANA 008.0 PHLO DIFF 035.0 SELA WALL 025.0
004 RHAC CANE 020.0 POLY PILI 015.0 PSEU PATE 003.0 ACHI MILL 003.0
004 FRAG VESC 006.0 DANT INTE 003.0 LUZU MULT 000.5 DELP MENZ 000.5
004 CRYP CRIS 004.0 PRUN VULG 004.0 MONT PARV 006.0 STER TOME 006.0
004 CLAD SP.. 001.0 ELYM GLAU 000.5 HEUC MICR 001.0 CARE HOOD 002.0
004 AREN MACR 000.5 CAST HISP 000.5 VERO WORM 000.5 CAMP ROTU 000.5
004 LOMA MART 003.0 ERYT GRAN 000.5 ANTE NEGL 000.5 HABE HYPE 000.5
005 JUNI COMM 025.0 ERIO LANA 015.0 PHLO DIFF 053.0 RHAC CANE 006.0
005 POLY PILI 008.0 PSEU PATE 002.0 ACHI MILL 003.0 FRAG VESC 004.0
005 POA. LEPT 000.5 AGRO SCAB 002.0 PHLE ALPI 002.0 LUZU MULT 001.0
005 SAXI OCCI 000.5 POTE GLAN 002.0 CRYP CRIS 000.5 PRUN VULG 004.0
005 MONT PARV 004.0 STER TOME 000.5 CLAD SP.. 000.5 HEUC MICR 001.0
005 CARE HOOD 001.0 SEDU DIVE 009.0 AREN MACR 001.0 LUPI LATI 002.0
005 CAST HISP 000.5 CAMP ROTU 000.5 LOMA MART 000.5 CETR SP.. 001.0
005 ANAP MARG 002.0 CYST FRAG 000.5 CIRS EDUL 000.5 DRYP PATE 006.0
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006 JUNI COMM 002.0 ERIO LANA 003.0 PHLO DIFF 030.0 SELA WALL 008.0
006 RHAC CANE 014.0 POLY PILI 009.0 ACHI MILL 003.0 FRAG VESC 007.0
006 DANT INTE 006.0 POA. LEPT 000.5 AGRO SCAB 001.0 PHLE ALPI 000.5
006 MELI SUBU 000.5 LUZU MULT 000.5 SAXI OCCI 001.0 CRYP CRIS 003.0
006 PRUN VULG 001.0 MONT PARV 002.0 CLAD SP.. 000.5 TRIS CANE 000.5
006 HEUC MICR 003.0 AREN MACR 000.5 CAMP ROTU 000.5 DRYP PATE 006.0
006 MITE BREW 001.0 ANTE NEGL 002.0 SAXI FERR 000.5 HABE HYPE 000.5
007 JUNI COMM 002.0 ERIO LANA 030.0 PHLO DIFF 040.0 SELA WALL 001.0
007 RHAC CANE 004.0 POLY PILI 003.0 PSEU PATE 001.0 ACHI MILL 007.0
007 FRAG VESC 007.0 POA. PRAT 001.0 AGRO SCAB 001.0 PHLE ALPI 001.0
007 POTE GLAN 003.0 CRYP CRIS 003.0 MONT PARV 004.0 CLAD SP.. 000.5
007 HEUC MICR 002.0 CARE HOOD 001.0 SEDU DIVE 003.0 AREN MACR 000.5
007 CAST HISP 004.0 CAMP ROTU 001.0 DRYP PATE 008.0 PACH MYRS 003.0
007 SILE DOUG 006.0 ASTE FOLI 001.0 CETR SP.. 000.5 PENS DAVI 000.5
008 LUPI LATI 008.0 ACHI MILL 020.0 CIRS EDUL 003.0 ERIO LANA 018.0
008 ANAP MARG 040.0 ASTE FOLI 018.0 FRAG VESC 018.0 PHLE ALPI 008.0
008 THAL OCCI 006.0 AREN MACR 000.5 MELI SUBU 006.0 CARE PACH 000.5
008 CAMP ROTU 000.5 LATH NEVA 006.0 ELYM GLAU 002.0 CAST MINI 003.0
008 AGOS AURA 000.5 CARE HOOD 002.0 LILI COLU 001.0 BROM SITC 002.0
008 PORE ROEL 000.5 DRYP PATE 003.0 CETR SP.. 000.5 SEDU DIVE 000.5
008 ARAB HIRS 000.5 CLAD SP.. 000.5 RHAC CANE 000.5
009 LUPI LATI 009.0 ACHI MILL 020.0 CIRS EDUL 006.0 ERIO LANA 002.0
009 ANAP MARG 030.0 ASTE FOLI 023.0 FRAG VESC 018.0 PHLE ALPI 004.0
009 THAL OCCI 001.0 AREN MACR 001.0 MELI SUBU 001.0 CAMP ROTU 001.0
009 LATH NEVA 002.0 ELYM GLAU 007.0 AGOS AURA 000.5 BROM SITC 001.0
009 DRYP PATE 004.0 POLY DOUG 000.5 ARAB HIRS 000.5 RHAC CANE 000.5
009 CLAD SP.. 000.5
010 LUPI LATI 012.0 ACHI MILL 010.0 CIRS EDUL 000.5 ERIO LANA 012.0
010 ANAP MARG 035.0 ASTE FOLI 007.0 FRAG VESC 015.0 PHLE ALPI 003.0
010 AREN MACR 000.5 MELI SUBU 000.5 CAMP ROTU 000.5 LATH NEVA 002.0
010 CAST MINI 000.5 AGOS AURA 000.5 CARE HOOD 000.5 LILI COLU 000.5
010 ELYM GLAU 001.0 BROM SITC 000.5 DRYP PATE 004.0 CETR SP.. 000.5
010 MONT PARV 000.5 ERIG PERE 003.0 VERO SERP 000.5 CRYP CRIS 001.0
010 TRIS CANE 000.5 POLY PILI 020.0 PHLO DIFF 002.0 RHAC CANE 001.0
010 CLAD SP.. 000.5 BRAC ASPE 001.0
011 LUPI LATI 030.0 ACHI MILL 020.0 CIRS EDUL 004.0 ANAP MARG 036.0
011 ERIO LANA 002.0 ASTE FOLI 007.0 FRAG VESC 014.0 PHLE ALPI 004.0
011 AREN MACR 000.5 MELI SUBU 001.0 CARE HOOD 000.5 CAMP ROTU 000.5
011 ELYM GLAU 001.0 CAST MINI 004.0 AGOS AURA 000.5 BROM SITC 001.0
011 ARAB HIRS 000.5 HERA LANA 001.0 POLY DOUG 000.5 VERO SERP 001.0
011 POA. PRAT 000.5 MONT PARV 000.5 TRIS SPIC 000.5 BRAC ASPE 002.0
011 RHAC CANE 002.0 EPIL GLAN 000.5 CRYP CRIS 000.5
012 LUPI LATI 012.0 ACHI MILL 016.0 CIRS EDUL 002.0 ANAP MARG 041.0
012 ASTE FOLI 035.0 FRAG VESC 008.0 PHLE ALPI 004.0 THAL OCCI 008.0
012 AREN MACR 000.5 MELI SUBU 004.0 CARE SPEC 002.0 BROM SITC 001.0
012 CAMP ROTU 001.0 ELYM GLAU 004.0 CAST MINI 000.5 AGOS AURA 000.5
012 CARE PACH 003.0 ERYT GRAN 000.5 BRAC ASPE 001.0 RHAC CANE 000.5
013 LUPI LATI 004.0 ACHI MILL 014.0 CIRS EDUL 002.0 ANAP MARG 020.0
013 ERIO LANA 001.0 ASTE FOLI 008.0 FRAG VESC 016.0 PHLE ALPI 006.0
013 THAL OCCI 012.0 AREN MACR 000.5 MELI SUBU 003.0 CARE HOOD 000.5
013 BROM SITC 004.0 CAMP ROTU 000.5 ELYM GLAU 003.0 LATH NEVA 007.0
013 CAST MINI 000.5 LILI COLU 001.0 RHAC CANE 000.5 CLAD SP.. 000.5
013 CETR SP.. 000.5 VALE SITC 000.5 BRAC ASPE 000.5 TORT NORV 000.5
013 DESM LATI 000.5 HERA LANA 001.0
014 LUPI LATI 015.0 ACHI MILL 018.0 CIRS EDUL 008.0 ANAP MARG 018.0
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014 ERIO LANA 008.0 ASTE FOLI 016.0 FRAG VESC 013.0 PHLE ALPI 004.0
014 AREN MACR 000.5 MELI SUBU 004.0 CARE HOOD 000.5 BROM SITC 007.0
014 CAMP ROTU 001.0 ELYM GLAU 005.0 LATH NEVA 008.0 CAST MINI 000.5
014 LILI COLU 001.0 AGOS AURA 005.0 ERIG PERE 000.5 SILE DOUG 002.0
014 EPIL GLAN 000.5 CRYP CRIS 000.5 PACH MYRS 001.0 POLY LONC 000.5
014 MITE TRIF 000.5 PHLO DIFF 000.5 POTE DRUM 000.5 CARE SPEC 003.0
014 TORT NORV 001.0 BRAC ASPE 006.0
015 LUPI LATI 011.0 ACHI MILL 018.0 CIRS EDUL 012.0 ANAP MARG 055.0
015 ERIO LANA 006.0 ASTE FOLI 040.0 FRAG VESC 018.0 PHLE ALPI 003.0
015 THAL OCCI 003.0 AREN MACR 000.5 MELI SUBU 000.5 CARE HOOD 000.5
015 CARE PACH 000.5 BROM SITC 001.0 CAMP ROTU 000.5 ELYM GLAU 001.0
015 LATH NEVA 003.0 CAST MINI 002.0 LILI COLU 001.0 AGOS AURA 000.5
015 SEDU DIVE 001.0 EPIL GLAN 000.5 POLY LONC 001.0 MITE TRIF 000.5
015 POA. PRAT 000.5 RHAC CANE 002.0 DRYP PATE 004.0 CLAD SP.. 000.5
015 CETR SP.. 000.5 TORT NORV 001.0 HERA LANA 000.5
016 PHLO DIFF 018.0 JUNI COMM 006.0 FRAG VESC 003.0 LUPI LATI 002.0
016 CAST MINI 000.5 ERIO LANA 004.0 CRYP CRIS 004.0 SAXI OCCI 000.5
016 ACHI MILL 001.0 PENS DAVI 004.0 PHLE ALPI 000.5 RHAC CANE 006.0
016 POLY PILI 006.0 SELA WALL 027.0 STER TOME 003.0 CLAD GRAC 006.0
016 CLAD SP.. 000.5 CAMP ROTU 000.5 PSEU PATE 001.0 CAST HISP 002.0
016 CETR SP.. 000.5 MONT PARV 003.0 AREN MACR 000.5 ERYT GRAN 000.5
016 MELI SUBU 001.0 ELYM GLAU 000.5 POA. LEPT 000.5 CLAD ROBB 006.0
017 PTER AQUI 090.0 BROM SITC 020.0 ELYM GLAU 030.0 CARE MERT 003.0
017 CARE HOOD 000.5 POA. PRAT 000.5 FRAG VESC 008.0 LILI COLU 000.5
017 ASTE FOLI 006.0 ACHI MILL 006.0 AREN MACR 000.5 HEUC MICR 001.0
017 SEDU DIVE 001.0 ERIG PERE 000.5 ANAP MARG 001.0 CAMP ROTU 000.5
017 ERIO LANA 003.0 HERA LANA 000.5 MONT PARV 000.5 CAST HISP 000.5
017 CRYP CRIS 001.0 CARE PACH 000.5 CARE SPEC 000.5 CETR SP.. 000.5
017 CLAD SP.. 000.5 RHAC CANE 001.0 OPEG SP.. 000.5 DRYP PATE 001.0
017 PSEU PATE 001.0 SELA WALL 000.5 BRAC ASPE 001.0
018 PTER AQUI 080.0 BROM SITC 020.0 ELYM GLAU 052.0 MELI SUBU 003.0
018 PHLE ALPI 001.0 ANAP MARG 012.0 ASTE FOLI 014.0 HERA LANA 002.0
018 FRAG VESC 008.0 ACHI MILL 012.0 LUPI LATI 004.0 THAL OCCI 008.0
018 LILI COLU 001.0 CAMP ROTU 000.5 AREN MACR 000.5 LATH NEVA 002.0
018 ACHL TRIP 002.0 AGOS AURA 000.5 EPIL GLAN 000.5 VACC ALAS 001.0
018 CAST MINI 000.5 POA. PRAT 000.5 PENS SERR 001.0 CETR SP.. 000.5
018 TORT NORV 000.5 PSEU PATE 000.5 BRAC ASPE 001.0 DRYP PATE 001.0
019 PTER AQUI 085.0 VERA VIRI 020.0 ELYM GLAU 035.0 BROM SITC 008.0
019 CALA CANA 001.0 LATH NEVA 020.0 THAL OCCI 004.0 ASTE FOLI 003.0
019 ANAP MARG 004.0 FRAG VESC 007.0 MELI SUBU 004.0 CARE HOOD 000.5
019 CIRS EDUL 002.0 AREN MACR 000.5 PHLE ALPI 000.5 CARE SPEC 000.5
019 SMIL STEL 001.0 BOTR MULT 000.5 ACHI MILL 003.0 PLAG INSI 000.5
019 TORT NORV 000.5 PSEU PATE 000.5 BRAC ASPE 000.5 DRYP PATE 000.5
019 HABE HYPE 000.5
020 PTER AQUI 095.0 ELYM GLAU 055.0 BROM SITC 008.0 MELI SUBU 006.0
020 PHLE ALPI 000.5 CARE HOOD 000.5 LILI COLU 000.5 CAMP ROTU 000.5
020 ANAP MARG 004.0 FRAG VESC 007.0 HERA LANA 001.0 RUBU URSI 004.0
020 LATH NEVA 006.0 THAL OCCI 008.0 ASTE FOLI 004.0 AREN MACR 000.5
020 CIRS EDUL 002.0 CARE PACH 000.5 AGOS AURA 000.5 BRAC ASPE 000.5
021 PTER AQUI 090.0 ANAP MARG 007.0 LUPI LATI 001.0 THAL OCCI 014.0
021 FRAG VESC 007.0 CAMP ROTU 000.5 LILI COLU 003.0 ELYM GLAU 035.0
021 MELI SUBU 002.0 PHLE ALPI 000.5 BROM SITC 004.0 ASTE FOLI 002.0
021 AREN MACR 000.5 AGOS AURA 000.5 ACHI MILL 002.0 VALE SITC 002.0
021 CIRS EDUL 001.0 LACT MURA 000.5 VERA VIRI 000.5 STEN OCCI 001.0
021 ERIG PERE 000.5 TRIS CANE 000.5 PYRO SECU 000.5 RHAC CANE 000.5
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021 DRYP PATE 001.0 PORE ROEL 000.5 TORT NORV 000.5 CLAD ROBB 000.5
021 TRIS SPIC 000.5 LUZU MULT 000.5
022 PTER AQUI 085.0 SENE TRIA 008.0 ANAP MARG 017.0 CIRS EDUL 004.0
022 VERA VIRI 004.0 CAMP ROTU 001.0 ACHI MILL 008.0 THAL OCCI 004.0
022 LILI COLU 001.0 ASAR CAUD 008.0 VALE SITC 009.0 AREN MACR 000.5
022 LATH NEVA 003.0 FRAG VESC 007.0 ACHL TRIP 012.0 CAST MINI 002.0
022 SAUS AMER 002.0 ELYM GLAU 026.0 BROM SITC 006.0 MELI SUBU 003.0
022 PHLE ALPI 000.5 HERA LANA 000.5 CETR SP.. 000.5 CLAD SP.. 000.5
022 PSEU PATE 002.0 DRYP PATE 002.0 PORE ROEL 000.5
023 PTER AQUI 090.0 BROM SITC 014.0 ELYM GLAU 020.0 MELI SUBU 004.0
023 CARE HOOD 001.0 CARE MERT 000.5 PHLE ALPI 001.0 ANAP MARG 014.0
023 ASAR CAUD 003.0 HERA LANA 004.0 ACHI MILL 003.0 LATH NEVA 017.0
023 FRAG VESC 006.0 CAST MINI 001.0 THAL OCCI 011.0 LUPI LATI 004.0
023 ASTE FOLI 012.0 CIRS EDUL 002.0 CAMP ROTU 000.5 AREN MACR 000.5
023 BRAC ASPE 001.0 PSEU PATE 000.5
024 PTER AQUI 080.0 BROM SITC 012.0 ELYM GLAU 040.0 PHLE ALPI 002.0
024 MELI SUBU 002.0 ANAP MARG 020.0 CAMP ROTU 001.0 VERA VIRI 026.0
024 LATH NEVA 017.0 HERA LANA 008.0 CALA CANA 002.0 FRAG VESC 001.0
024 SENE TRIA 002.0 CIRS EDUL 001.0 ACHL TRIP 017.0 VALE SITC 006.0
024 ACHI MILL 004.0 AREN MACR 000.5 VIOL GLAB 003.0 ASTE FOLI 004.0
024 CAST MINI 000.5 ASAR CAUD 004.0 LUZU MULT 002.0 CARE PACH 000.5
024 AGOS AURA 000.5 CAST HISP 000.5 LUPI LATI 000.5 BRAC ASPE 003.0
025 RIBE LACU 027.0 SAMB RACE 004.0 RUBU PARV 007.0 PTER AQUI 004.0
025 DRYO AUST 003.0 HEUC MICR 014.0 CRYP CRIS 001.0 SEDU DIVE 000.5
025 ANAP MARG 000.5 CALA CANA 002.0 ELYM GLAU 002.0 ASAR CAUD 000.5
025 RHAC CANE 004.0 DRYP PATE 035.0 RHIZ GEOG 003.0 CLAD ROBB 000.5
025 MONT PARV 001.0 VIOL GLAB 000.5 PHLO DIFF 000.5 CLAD SP.. 000.5
025 SENE TRIA 001.0 POLY LONC 000.5 AREN MACR 000.5 EPIL GLAN 000.5
025 FRAG VESC 000.5 TELL GRAN 001.0
026 RIBE LACU 016.0 SAMB RACE 004.0 PTER AQUI 006.0 DRYO AUST 002.0
026 HEUC MICR 007.0 CRYP CRIS 002.0 SEDU DIVE 001.0 ANAP MARG 004.0
026 TRIS SPIC 002.0 ASAR CAUD 004.0 RHAC CANE 002.0 DRYP PATE 032.0
026 RHIZ GEOG 002.0 CLAD SP.. 000.5 SENE TRIA 008.0 POLY LONC 002.0
026 AREN MACR 000.5 FRAG VESC 003.0 TELL GRAN 001.0 ELYM GLAU 004.0
026 VACC ALAS 002.0 VACC OVAL 002.0 POA. PRAT 002.0 ACHL TRIP 006.0
026 VALE SITC 004.0 PENS SERR 001.0 VERA VIRI 001.0 DICE FORM 000.5
026 LATH NEVA 000.5 CARE HOOD 000.5
027 RIBE LACU 018.0 VACC ALAS 020.0 PACH MYRS 004.0 PTER AQUI 007.0
027 HEUC MICR 006.0 ANAP MARG 002.0 ASAR CAUD 002.0 ACHI MILL 002.0
027 CRYP CRIS 003.0 PHLO DIFF 004.0 AREN MACR 000.5 SEDU DIVE 001.0
027 ELYM GLAU 003.0 TRIS SPIC 000.5 VALE SITC 000.5 MONT PARV 000.5
027 ADIA PEDA 000.5 EPIL ANGU 000.5 PENS SERR 000.5 POLY DOUG 000.5
027 DRYP PATE 020.0 RHAC CANE 004.0 CLAD SP.. 000.5
028 RIBE LACU 028.0 VACC MEMB 002.0 PHLO DIFF 004.0 CIRS EDUL 003.0
028 PTER AQUI 007.0 ACHI MILL 002.0 ELYM GLAU 005.0 BROM SITC 002.0
028 PHLE ALPI 001.0 CRYP CRIS 002.0 ASAR CAUD 002.0 ACHL TRIP 002.0
028 PENS SERR 006.0 VALE SITC 003.0 FRAG VESC 002.0 THAL OCCI 000.5
028 AREN MACR 001.0 SEDU DIVE 000.5 HEUC MICR 004.0 ANAP MARG 000.5
028 EPIL ANGU 000.5 GALI TRIF 000.5 POLY DOUG 001.0 SENE TRIA 000.5
028 VIOL GLAB 000.5 MONT PARV 001.0 CARE HOOD 000.5 MELI SUBU 001.0
028 TELL GRAN 001.0 RHAC CANE 004.0 DRYP PATE 024.0 CETR SP.. 000.5
028 CARE PACH 000.5 DICE FORM 001.0 EPIL GLAN 001.0 CLAD SP.. 000.5
028 CLAD ROBB 000.5
029 RIBE LACU 021.0 VACC MEMB 004.0 RUBU PARV 007.0 ACHL TRIP 008.0
029 ANAP MARG 003.0 SEDU DIVE 002.0 SENE TRIA 003.0 CALA CANA 004.0
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029 ELYM GLAU 006.0 BROM SITC 001.0 MELI SUBU 000.5 HEUC MICR 002.0
029 ASTE FOLI 001.0 CAMP ROTU 000.5 DICE FORM 002.0 VALE SITC 002.0
029 EPIL ANGU 001.0 ASAR CAUD 006.0 POLY LONC 001.0 PTER AQUI 012.0
029 AREN MACR 000.5 CRYP CRIS 001.0 THAL OCCI 000.5 GALI TRIF 003.0
029 EPIL GLAN 000.5 ACHI MILL 001.0 POLY DOUG 000.5 FRAG VESC 000.5
029 MONT PARV 000.5 LATH NEVA 000.5 CLAD SP.. 000.5 RHAC CANE 004.0
029 DRYP PATE 023.0
030 RIBE LACU 020.0 SAMB RACE 012.0 RUBU PARV 003.0 ACHL TRIP 004.0
030 HEUC MICR 006.0 VERA VIRI 002.0 SENE TRIA 006.0 AREN MACR 000.5
030 CRYP CRIS 002.0 PTER AQUI 012.0 DRYO AUST 003.0 ASAR CAUD 004.0
030 SELA WALL 000.5 CIRS EDUL 002.0 TELL GRAN 001.0 ANAP MARG 004.0
030 BROM SITC 003.0 MELI SUBU 000.5 PHLE ALPI 002.0 GALI TRIF 002.0
030 CARE DEWE 006.0 ACHI MILL 000.5 FRAG VESC 002.0 POLY LONC 002.0
030 CARE HOOD 000.5 THAL OCCI 000.5 SEDU DIVE 000.5 DRYP PATE 015.0
030 RHAC CANE 003.0 CLAD SP.. 000.5 CETR SP.. 000.5 CLAD ROBB 000.5
030 RHIZ GEOG 000.5
031 RIBE LACU 026.0 HEUC MICR 014.0 ANAP MARG 008.0 VACC MEMB 009.0
031 ACHL TRIP 004.0 CRYP CRIS 002.0 CIRS EDUL 001.0 ASAR CAUD 001.0
031 ELYM GLAU 003.0 ACHI MILL 001.0 AREN MACR 000.5 CAMP ROTU 000.5
031 MELI SUBU 000.5 POLY DOUG 001.0 THAL OCCI 001.0 DRYO AUST 002.0
031 POLY LONC 001.0 VIOL GLAB 000.5 FRAG VESC 001.0 TRIS SPIC 002.0
031 SEDU DIVE 000.5 SELA WALL 000.5 POLY MINI 000.5 PENS SERR 000.5
031 CLAD SP.. 000.5 RHAC CANE 008.0 DRYP PATE 014.0
032 ANAP MARG 000.5 THAL OCCI 003.0 HERA LANA 002.0 FRAG VESC 003.0
032 LILI COLU 000.5 CIRS EDUL 000.5 LATH NEVA 007.0 MELI SUBU 004.0
032 ELYM GLAU 008.0 CALA CANA 006.0 AREN MACR 000.5 PTER AQUI 050.0
032 VERA VIRI 065.0 VIOL GLAB 002.0 TELL GRAN 001.0 URTI DIOI 000.5
033 TRIS CANE 000.5 ANAP MARG 012.0 ACHI MILL 006.0 CIRS EDUL 002.0
033 VACC MEMB 000.5 PTER AQUI 007.0 ASTE FOLI 009.0 HEUC MICR 001.0
033 THAL OCCI 006.0 ASAR CAUD 000.5 MITE TRIF 000.5 CARE HOOD 008.0
033 ELYM GLAU 002.0 MELI SUBU 003.0 AREN MACR 000.5 CRYP CRIS 000.5
033 CYST FRAG 000.5 ERIO LANA 003.0 CAMP ROTU 000.5 PENS SERR 001.0
033 PHLO DIFF 003.0 SEDU DIVE 000.5 AGOS AURA 000.5 CARE PACH 001.0
033 ARAB HIRS 000.5 BROM SITC 002.0 LUPI LATI 003.0 CAST MINI 001.0
033 CAST HISP 000.5 FRAG VESC 012.0 EPIL GLAN 000.5 ERYT GRAN 000.5
033 PELT SP.. 000.5 POLY DOUG 000.5 MONT PARV 000.5 PACH MYRS 000.5
033 PSEU PATE 003.0 PHLE ALPI 000.5
034 FRAG VESC 018.0 HEUC MICR 003.0 ARAB HIRS 000.5 PTER AQUI 006.0
034 CIRS EDUL 008.0 ACHI MILL 003.0 AGOS AURA 000.5 JUNI COMM 003.0
034 PHLO DIFF 016.0 AREN MACR 000.5 LUPI LATI 004.0 PRUN VULG 008.0
034 ERIO LANA 003.0 CAST HISP 000.5 CAST MINI 000.5 TRIS CANE 000.5
034 POA. LEPT 000.5 TRIS SPIC 000.5 BROM SITC 001.0 LUZU MULT 000.5
034 SEDU DIVE 000.5 CAMP ROTU 000.5 EPIL GLAN 000.5 CARE HOOD 006.0
034 ERIG PERE 001.0 PHLE ALPI 000.5 MONT PARV 000.5 CRYP CRIS 001.0
034 PSEU PATE 004.0
035 ANAP MARG 014.0 ERIO LANA 004.0 TRIS CANE 001.0 CARE HOOD 005.0
035 TRIS SPIC 001.0 BROM SITC 003.0 ARAB HIRS 000.5 PTER AQUI 005.0
035 ASAR CAUD 000.5 HERA LANA 000.1 CIRS EDUL 003.0 CAMP ROTU 000.5
035 PHLE ALPI 000.5 PACH MYRS 000.5 SEDU DIVE 001.0 CAST HISP 002.0
035 ACHI MILL 002.0 ASTE FOLI 006.0 ELYM GLAU 003.0
035 FRAG VESC 014.0 PHLO DIFF 004.0 EPIL GLAN 000.5 PSEU PATE 002.0
035 PELT SP.. 000.5 CRYP CRIS 000.5 AREN MACR 000.5 POLY DOUG 000.5
035 CARE PACH 000.5 AGOS AURA 000.5 POA. LEPT 000.5 MITE TRIF 000.5
035 CAST MINI 000.5 LUPI LATI 002.0
036 ANAP MARG 010.0 ERIO LANA 007.0 PTER AQUI 002.0 ACHI MILL 008.0
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036 ASTE FOLI 004.0 LUPI LATI 009.0 CIRS EDUL 016.0 DANT INTE 000.5
036 CARE HOOD 003.0 PHLE ALPI 001.0 LUZU MULT 001.0 TRIS SPIC 001.0
036 TRIS CANE 000.5 BROM SITC 001.0 AGOS AURA 000.5 CAMP ROTU 000.5
036 FRAG VESC 018.0 EPIL GLAN 000.5 CAST HISP 004.0 MONT PARV 000.5
036 PHLO DIFF 006.0 PSEU PATE 002.0 AREN MACR 000.5 HEUC MICR 001.0
036 JUNI COMM 001.0 CAST MINI 000.5 CRYP CRIS 000.5
037 ELYM GLAU 002.0 CARE HOOD 002.0 CARE MERT 001.0 PHLE ALPI 001.0
037 TRIS SPIC 000.5 TRIS CANE 000.5 POA. LEPT 000.5 LUZU MULT 000.5
037 PHLO DIFF 015.0 FRAG VESC 015.0 CIRS EDUL 001.0 HEUC MICR 002.0
037 CRYP CRIS 000.5 PENS SERR 001.0 ACHI MILL 002.0 VERO SERP 000.5
037 SEDU DIVE 000.5 MONT PARV 000.5 MITE TRIF 000.5 ANAP MARG 002.0
037 CAST HISP 000.5 CAST MINI 000.5 LUPI LATI 001.0 CAMP ROTU 000.5
037 ARAB HIRS 000.5 HERA LANA 000.5 AGOS AURA 000.5 PSEU PATE 002.0
037 AREN MACR 000.5 CARE PACH 000.5
038 ANAP MARG 014.0 ASTE FOLI 026.0 LUPI LATI 014.0 CIRS EDUL 008.0
038 FRAG VESC 016.0 ARAB HIRS 000.5 HEUC MICR 002.0 PHLE ALPI 000.5
038 MELI SUBU 004.0 BROM SITC 003.0 ACHI MILL 006.0 CAST HISP 000.5
038 AGOS AURA 000.5 CARE HOOD 009.0 CAMP ROTU 001.0 PTER AQUI 008.0
038 CRYP CRIS 000.5 MONT PARV 000.5 AREN MACR 000.5 ERIO LANA 000.5
038 SEDU DIVE 000.5 PSEU PATE 002.0 RHAC CANE 001.0
039 CIRS EDUL 014.0 POLY LONC 003.0 SILE DOUG 008.0 ACHI MILL 006.0
039 ARAB HIRS 000.5 SEDU DIVE 000.5 LUPI LATI 007.0 HERA LANA 000.5
039 HEUC MICR 002.0 PHLO DIFF 008.0 ERIO LANA 004.0 ANAP MARG 003.0
039 CAST MINI 000.5 CAST HISP 002.0 CRYP CRIS 001.0 AREN MACR 000.5
039 CAMP ROTU 000.5 TRIS SPIC 000.5 PHLE ALPI 000.5 MONT PARV 000.5
039 TRIS CANE 000.5 ELYM GLAU 002.0 BROM SITC 000.5 CARE HOOD 003.0
039 CARE PACH 000.5 ASTE FOLI 001.0 EPIL GLAN 000.5 CYST FRAG 000.5
039 FRAG VESC 009.0 AGOS AURA 000.5 LUZU MULT 000.5 PSEU PATE 003.0
039 RHAC CANE 001.0
040 VERA VIRI 020.0 SENE TRIA 020.0 SAUS AMER 030.0 HERA LANA 003.0
040 LILI COLU 002.0 LATH NEVA 018.0 THAL OCCI 004.0 ACHI MILL 001.0
040 VALE SITC 002.0 VIOL GLAB 007.0 ANAP MARG 002.0 ERYT GRAN 000.5
040 FRAG VESC 000.5 ELYM GLAU 018.0 MELI SUBU 006.0 CIRS EDUL 002.0
040 CARE SPEC 001.0 ASTE FOLI 000.5
041 VERA VIRI 035.0 SAUS AMER 016.0 SENE TRIA 025.0 CALA CANA 006.0
041 CARE SPEC 007.0 ELYM GLAU 006.0 BROM SITC 002.0 CIRS EDUL 002.0
041 HERA LANA 004.0 LATH NEVA 014.0 VIOL GLAB 006.0 ANAP MARG 001.0
041 AREN MACR 000.5 TELL GRAN 000.5 VALE SITC 002.0 FRAG VESC 000.5
042 VERA VIRI 055.0 SENE TRIA 020.0 ELYM GLAU 008.0 CALA CANA 008.0
042 MELI SUBU 006.0 VALE SITC 001.0 TELL GRAN 002.0 CAST MINI 000.5
042 ANAP MARG 002.0 VIOL GLAB 006.0 AREN MACR 000.5 LATH NEVA 012.0
042 CARE SPEC 003.0 CIRS EDUL 000.5 ERYT GRAN 000.5 BROM SITC 002.0
042 FRAG VESC 000.5 CARE HOOD 000.5 BOTR MULT 000.1 ASTE FOLI 000.5
042 HERA LANA 001.0 ACHI MILL 000.5
043 VERA VIRI 030.0 SENE TRIA 045.0 SAUS AMER 005.0 THAL OCCI 003.0
043 HERA LANA 006.0 VIOL GLAB 004.0 TELL GRAN 002.0 ELYM GLAU 007.0
043 MELI SUBU 005.0 CARE SPEC 009.0 LILI COLU 000.5 LATH NEVA 008.0
043 STEL CRIS 000.5 VALE SITC 001.0 AREN MACR 000.5
044 VERA VIRI 035.0 THAL OCCI 016.0 GALI TRIF 001.0 LATH NEVA 014.0
044 TELL GRAN 001.0 ANAP MARG 002.0 FRAG VESC 002.0 PSEU PATE 001.0
044 ACHI MILL 001.0 ELYM GLAU 020.0 CARE SPEC 009.0 CAMP ROTU 000.5
044 BROM SITC 004.0 MELI SUBU 006.0 VIOL GLAB 005.0 ASTE FOLI 000.5
044 CARE HOOD 000.5 CIRS EDUL 000.5 HERA LANA 000.5 SAUS AMER 000.5
045 VERA VIRI 045.0 CALA CANA 016.0 ELYM GLAU 026.0 HERA LANA 003.0
045 ANAP MARG 000.5 LATH NEVA 014.0 CIRS EDUL 000.5 FRAG VESC 001.0
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045 TELL GRAN 002.0 VIOL GLAB 006.0 ASAR CAUD 001.0 GALI TRIF 001.0
045 THAL OCCI 002.0 CARE SPEC 004.0 BROM SITC 003.0 AREN MACR 000.5
046 VERA VIRI 030.0 PTER AQUI 080.0 CARE PACH 002.0 BROM SITC 006.0
046 ELYM GLAU 016.0 CALA CANA 007.0 MELI SUBU 007.0 HERA LANA 003.0
046 VICI AMER 012.0 ANAP MARG 001.0 VIOL GLAB 004.0 LATH NEVA 002.0
046 LATH NEVA 002.0 THAL OCCI 004.0 FRAG VESC 001.0 AREN MACR 000.5
046 LILI COLU 000.5
047 VERA VIRI 015.0 SENE TRIA 030.0 HERA LANA 008.0 ELYM GLAU 015.0
047 MELI SUBU 006.0 BROM SITC 002.0 LATH NEVA 012.0 THAL OCCI 014.0
047 VIOL GLAB 004.0 TELL GRAN 001.0 CIRS EDUL 000.5 FRAG VESC 000.5
047 ASTE FOLI 000.5 ARAB HIRS 000.5 EPIL GLAN 000.5 MONT PARV 000.5
047 ACHI MILL 000.5 ERIO LANA 000.5 GALI TRIF 000.5 CARE SPEC 003.0
048 ADIA PEDA 016.0 PTER AQUI 007.0 DRYO AUST 009.0 TELL GRAN 001.0
048 SENE TRIA 001.0 VERA VIRI 001.0 AQUI FORM 018.0 ERIG PERE 000.5
048 CIRS EDUL 000.5 ARNI LATI 001.0 ASTE FOLI 002.0 HABE HYPE 000.5
048 STEN OCCI 000.5 CAMP ROTU 000.5 ACHI MILL 000.5 ANAP MARG 000.5
048 PRUN VULG 000.5 CALA CANA 003.0 GALI TRIF 000.5 MONT SIBI 000.5
048 POTE DRUM 000.5 PHLE ALPI 000.5 ELYM GLAU 005.0 CARE SPEC 004.0
048 MITE TRIF 000.5 MONT PARV 000.5 TRIS SPIC 000.5 AGRO THUR 001.0
048 POLY LONC 000.5 CAST MINI 000.5 PSEU PATE 001.0 DICR FUSC 000.5
048 BRAC ASPE 000.5 TORT NORV 001.0 VERO WORM 000.5
049 LUPI LATI 030.0 CIRS EDUL 006.0 ASTE FOLI 012.0 ACHI MILL 006.0
049 VICI AMER 008.0 LATH NEVA 008.0 ARAB HIRS 000.5 THAL OCCI 007.0
049 FRAG VESC 000.5 ERIO LANA 001.0 ELYM GLAU 012.0 BROM SITC 012.0
049 MELI SUBU 007.0 AGOS AURA 000.5 PHLE ALPI 000.5 CARE HOOD 004.0
049 CAMP ROTU 001.0 AREN MACR 000.5
050 RUBU URSI 030.0 POLY LONC 001.0 ACHL TRIP 001.0 AREN MACR 000.5
050 ACHI MILL 003.0 LILI COLU 000.5 VICI AMER 009.0 AGOS AURA 000.5
050 ASTE FOLI 012.0 CAMP ROTU 000.5 ELYM GLAU 008.0 BROM SITC 008.0
050 MELI SUBU 004.0 CARE HOOD 002.0 THAL OCCI 009.0 LATH NEVA 006.0
050 FRAG VESC 004.0 LUPI LATI 001.0 RHAC CANE 004.0 PSEU PATE 006.0
050 LACT MURA 000.5 PHLE ALPI 000.5 CIRS EDUL 000.5 ARAB HIRS 000.5
051 LUPI LATI 011.0 CIRS EDUL 004.0 ASTE FOLI 035.0 VICI AMER 005.0
051 FRAG VESC 006.0 ERIO LANA 002.0 CAMP ROTU 000.5 AGOS AURA 000.5
051 ELYM GLAU 006.0 MELI SUBU 004.0 BROM SITC 007.0 CARE HOOD 007.0
051 PHLE ALPI 000.5 ARAB HIRS 000.5 LILI COLU 000.5 THAL OCCI 002.0
051 PSEU PATE 000.5 RHAC CANE 000.5 LATH NEVA 002.0 AREN MACR 000.5
051 HERA LANA 000.5
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59 SAMPLES WITH LUMPED SPECIES READY FOR USE IN DECORANA (SEE DECORANA REFERENCE MANUAL).

SAMPLES 001-051 ARE THOSE FROM HALEY LAKE AS OUTLINED ABOVE.
SAMPLES 052-059 ARE THE 8 SAMPLES CHOSEN RANDOMLY TO REPRESENT THE VEGETATION OF THE GEMINI PEAK SITE. (COMMUNITY TYPE, VACCINIUM-CAREX).

NUMBERS ON THE LEFT ARE THE SAMPLE NUMBERS.

NUMBERS WITHOUT DECIMAL NOTATION ARE THE SPECIES NUMBERS WHICH RELATE DIRECTLY TO THE LIST OF ABBREVIATIONS BELOW THE DATA SET.

NUMBERS WITH DECIMALS ARE THE COVER VALUES.

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91   59 HALEY LAKE LUMP AND MGREPS                                    TCHLMG** S
(I5,5(I5,F10.4))                                                       5
    1    1   25.0000    2   35.0000    3   15.0000    4    3.0000    5   10.0000
    1    6   11.0000    7    3.0000    8    0.5000    9    1.0000   10    0.5000
    1   11   70.0000   12    6.5000   13    0.5000   14    1.0000   15    0.5000
    1   16    0.5000   17    0.5000
    2    1   25.0000    2   20.0000    3   34.0000    4    6.0000    5    1.0000
    2    6    7.0000    8    2.0000    9    4.0000   11   40.0000   12    8.5000
    2   13    0.5000   14    3.0000   15    1.0000   16    3.0000   18   15.0000
    2   19    2.0000   20    0.5000
    3    1   15.0000    2   45.0000    3   40.0000    4    2.0000    5    4.0000
    3    6   21.0000    8    1.0000    9    8.0000   10    1.0000   11   32.0000
    3   12    3.5000   13    3.0000   14    4.0000   15    0.5000   16    6.0000
    3   18    4.0000   20    0.5000   21    0.5000   22    2.0000   23    1.0000
    3   24    0.5000   25    0.5000   26    0.5000   27    0.5000
    4    1    8.0000    2   35.0000    3   25.0000    4    3.0000    5    6.0000
    4    6    3.5000    7    2.0000    9    4.0000   10    1.0000   11   38.0000
    4   12    7.0000   14    4.0000   15    0.5000   16    6.0000   18    6.0000
    4   19    0.5000   21    0.5000   23    0.5000   24    0.5000   25    0.5000
    4   27    3.0000   28    0.5000   29    0.5000   30    0.5000
    5    1   15.0000    2   53.0000    4    3.0000    5    4.0000    6    4.5000
    5    7    1.0000    8    0.5000    9    4.0000   10    1.0000   11   22.0000
    5   12    2.0000   13    2.0000   14    0.5000   15    1.0000   16    4.0000
    5   18   25.0000   20    9.0000   21    1.0000   22    2.0000   23    0.5000
    5   25    0.5000   27    0.5000   31    2.0000   32    0.5000   33    0.5000
    5   34    6.0000
    6    1    3.0000    2   30.0000    3    8.0000    4    3.0000    5    7.0000
    6    6    9.0000    8    1.0000    9    1.0000   10    3.0000   11   29.0000
    6   14    3.0000   15    0.5000   16    2.0000   18    2.0000   21    0.5000
    6   25    0.5000   29    2.0000   30    0.5000   34    1.0000   35    0.5000
    7    1   30.0000    2   40.0000    3    1.0000    4    7.0000    5    7.0000
    7    6    3.0000    7    1.0000   10    2.0000   11   16.0000   12    1.0000
    7   13    3.0000   14    3.0000   16    4.0000   18    2.0000   20    3.0000
    7   21    0.5000   23    4.0000   25    1.0000   36    3.0000   37    6.0000
    7   38    1.0000   39    0.5000
    8    1   18.0000    4   20.0000    5   18.0000    6   18.0000    7    2.5000
    8   11    4.0000   12    1.0000   20    0.5000   21    0.5000   22    8.0000
    8   25    0.5000   31   40.0000   33    3.0000   38   18.0000   40    6.0000
    8   41    6.0000   42    3.0000   43    0.5000   44    1.0000   45    0.5000
    9    1    2.0000    4   20.0000    5   18.0000    6   13.0000   11    4.5000
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 9   21   1.0000   22    9.0000   25    1.0000   31   30.0000   33    6.0000
 9   38  23.0000   40    1.0000   41    2.0000   43    0.5000   45    0.5000
 9   46   0.5000
10    1  12.0000    2    2.0000    4   10.0000    5   15.0000    6    5.5000
10    7   0.5000   11   26.0000   12    1.0000   14    1.0000   16    0.5000
10   21   0.5000   22   12.0000   25    0.5000   31   35.0000   33    0.5000
10   38   7.0000   41    2.0000   42    0.5000   43    0.5000   44    0.5000
10   47   3.0000   48    0.5000
11    1   2.0000    4   20.0000    5   14.0000    6    8.0000    7    0.5000
11   11   4.0000   14    0.5000   16    0.5000   21    0.5000   22   30.0000
11   25   0.5000   31   36.0000   33    4.0000   38    7.0000   42    4.0000
11   43   0.5000   45    0.5000   46    0.5000   48    1.0000   49    1.0000
11   50   0.5000
12    4  16.0000    5    8.0000    6   13.0000    7    5.0000   11    1.5000
12   21   0.5000   22   12.0000   25    1.0000   28    0.5000   31   41.0000
12   33   2.0000   38   35.0000   40    8.0000   42    0.5000   43    0.5000
12   51   0.5000
13    1   1.0000    4   14.0000    5   16.0000    6   16.0000    7    0.5000
13   11   2.0000   12    1.0000   21    0.5000   22    4.0000   25    0.5000
13   31  20.0000   33    2.0000   38    8.0000   40   12.0000   41    7.0000
13   42   0.5000   44    1.0000   49    1.0000   51    0.5000
14    1   8.0000    2    0.5000    4   18.0000    5   13.0000    6   20.0000
14    7   3.5000   11    7.0000   14    0.5000   21    0.5000   22   15.0000
14   25   1.0000   31   18.0000   33    8.0000   36    1.0000   37    2.0000
14   38  16.0000   41    8.0000   42    0.5000   43    5.0000   44    1.0000
14   47   0.5000   50    0.5000   52    0.5000   53    0.5000   54    0.5000
15    1   6.0000    4   18.0000    5   18.0000    6    6.0000    7    1.0000
15   11   7.0000   12    1.0000   20    1.0000   21    0.5000   22   11.0000
15   25   0.5000   31   55.0000   33   12.0000   38   40.0000   40    3.0000
15   41   3.0000   42    2.0000   43    0.5000   44    1.0000   49    0.5000
15   50   0.5000   52    1.0000   53    0.5000
16    1   4.0000    2   18.0000    3   27.0000    4    1.0000    5    3.0000
16    6   2.5000    8    0.5000   11   13.0000   12   16.0000   14    4.0000
16   16   3.0000   18    6.0000   21    0.5000   22    2.0000   23    2.0000
16   25   0.5000   28    0.5000   39    4.0000   42    0.5000   55    6.0000
17    1   3.0000    3    0.5000    4    6.0000    5    8.0000    6   50.5000
17    7   4.5000   10    1.0000   11    4.0000   12    1.5000   14    1.0000
17   16   0.5000   20    1.0000   21    0.5000   23    0.5000   25    0.5000
17   31   1.0000   38    6.0000   44    0.5000   47    0.5000   49    0.5000
17   55  90.0000
18    4  12.0000    5    8.0000    6   81.0000   11    3.0000   21    0.5000
18   22   4.0000   25    0.5000   31   12.0000   38   14.0000   40    8.0000
18   41   2.0000   42    0.5000   43    0.5000   44    1.0000   49    2.0000
18   50   0.5000   55   80.0000   56    2.0000   57    1.0000   58    1.0000
18   59   1.0000
19    4   3.0000    5    7.0000    6   48.5000    7    1.0000   11    2.5000
19   21   0.5000   30    0.5000   31    4.0000   33    2.0000   38    3.0000
19   40   4.0000   41   20.0000   55   85.0000   59   20.0000   60    1.0000
19   61   0.5000
20    5   7.0000    6   69.5000    7    1.0000   11    1.5000   21    0.5000
20   25   0.5000   31    4.0000   33    2.0000   38    4.0000   40    8.0000
20   41   6.0000   43    0.5000   44    0.5000   49    1.0000   55   95.0000
20   62   4.0000   63    0.5000
21    4   2.0000    5    7.0000    6   42.5000   15    0.5000   21    0.5000
21   22   1.0000   25    0.5000   31    7.0000   33    1.0000   38    2.0000
```

21	40	14.0000	43	0.5000	44	3.0000	47	0.5000	51	2.0000	
21	55	90.0000	59	0.5000	63	0.5000	64	1.0000	65	0.5000	
22	4	8.0000	5	7.0000	6	35.5000	11	4.5000	12	1.0000	
22	21	0.5000	25	1.0000	31	17.0000	33	4.0000	40	4.0000	
22	41	3.0000	42	2.0000	44	1.0000	49	0.5000	51	9.0000	
22	55	85.0000	56	12.0000	59	4.0000	66	8.0000	67	8.0000	
22	68	2.0000									
23	4	3.0000	5	6.0000	6	39.0000	7	1.5000	11	1.5000	
23	21	0.5000	22	4.0000	25	0.5000	31	14.0000	33	2.0000	
23	38	12.0000	40	11.0000	41	17.0000	42	1.0000	49	4.0000	
23	55	90.0000	67	3.0000							
24	4	4.0000	5	1.0000	6	58.0000	7	0.5000	11	3.0000	
24	15	2.0000	21	0.5000	22	0.5000	23	0.5000	25	1.0000	
24	31	20.0000	33	1.0000	38	4.0000	41	17.0000	42	0.5000	
24	43	0.5000	49	8.0000	51	6.0000	55	80.0000	56	17.0000	
24	59	26.0000	66	2.0000	67	4.0000	69	3.0000			
25	2	0.5000	5	0.5000	6	4.0000	10	14.0000	11	39.0000	
25	12	4.0000	14	1.0000	16	1.0000	20	0.5000	21	0.5000	
25	31	0.5000	50	0.5000	52	0.5000	55	4.0000	66	1.0000	
25	67	0.5000	69	0.5000	70	27.0000	71	4.0000	72	7.0000	
25	73	3.0000	74	1.0000							
26	5	3.0000	6	8.0000	7	0.5000	10	7.0000	11	34.0000	
26	12	2.5000	14	2.0000	20	1.0000	21	0.5000	31	4.0000	
26	41	0.5000	51	4.0000	52	2.0000	55	6.0000	56	6.0000	
26	57	4.0000	58	1.0000	59	1.0000	66	8.0000	67	4.0000	
26	70	16.0000	71	4.0000	73	2.0000	74	1.0000	75	0.5000	
27	2	4.0000	4	2.0000	6	3.5000	10	6.0000	11	24.0000	
27	14	3.0000	16	0.5000	20	1.0000	21	0.5000	31	2.0000	
27	36	4.0000	46	0.5000	51	0.5000	55	7.0000	57	20.0000	
27	58	0.5000	67	2.0000	70	18.0000	76	0.5000	77	0.5000	
28	2	4.0000	4	2.0000	5	2.0000	6	9.0000	7	1.0000	
28	10	4.0000	11	28.0000	12	1.5000	14	2.0000	16	1.0000	
28	20	0.5000	21	1.0000	31	0.5000	33	3.0000	40	0.5000	
28	46	1.0000	50	1.0000	51	3.0000	55	7.0000	56	2.0000	
28	57	2.0000	58	6.0000	66	0.5000	67	2.0000	69	0.5000	
28	70	28.0000	74	1.0000	75	1.0000	77	0.5000	78	0.5000	
29	4	1.0000	5	0.5000	6	11.5000	10	2.0000	11	27.0000	
29	14	1.0000	16	0.5000	20	2.0000	21	0.5000	25	0.5000	
29	31	3.0000	38	1.0000	40	0.5000	41	0.5000	46	0.5000	
29	50	0.5000	51	2.0000	52	1.0000	55	12.0000	56	8.0000	
29	57	4.0000	66	3.0000	67	6.0000	70	21.0000	72	7.0000	
29	75	2.0000	77	1.0000	78	3.0000					
30	3	0.5000	4	0.5000	5	2.0000	6	5.5000	7	6.5000	
30	10	6.0000	11	18.0000	12	2.0000	14	2.0000	20	0.5000	
30	21	0.5000	31	4.0000	33	2.0000	40	0.5000	52	2.0000	
30	55	12.0000	56	4.0000	59	2.0000	66	6.0000	67	4.0000	
30	70	20.0000	71	12.0000	72	3.0000	73	3.0000	74	1.0000	
30	78	2.0000									
31	3	0.5000	4	1.0000	5	1.0000	6	5.5000	10	14.0000	
31	11	22.0000	14	2.0000	17	0.5000	20	0.5000	21	0.5000	
31	25	0.5000	31	8.0000	33	1.0000	40	1.0000	46	1.0000	
31	52	1.0000	56	4.0000	57	9.0000	58	0.5000	67	1.0000	
31	69	0.5000	70	26.0000	73	2.0000					
32	5	3.0000	6	14.0000	21	0.5000	31	0.5000	33	0.5000	
32	40	3.0000	41	7.0000	44	0.5000	49	2.0000	55	50.0000	

44	41	14.0000	49	0.5000	59	35.0000	68	0.5000	69	5.0000
44	74	1.0000	78	1.0000	81	0.5000				
45	5	1.0000	6	45.0000	7	4.0000	21	0.5000	31	0.5000
45	33	0.5000	40	2.0000	41	14.0000	49	3.0000	59	45.0000
45	67	1.0000	69	6.0000	74	2.0000	78	1.0000	81	26.0000
46	5	1.0000	6	36.0000	7	2.0000	21	0.5000	31	1.0000
46	40	4.0000	41	2.0000	44	0.5000	49	3.0000	55	80.0000
46	59	30.0000	69	4.0000	81	12.0000				
47	1	0.5000	4	0.5000	5	0.5000	6	23.0000	7	3.0000
47	16	0.5000	33	0.5000	38	0.5000	40	14.0000	41	12.0000
47	45	0.5000	49	8.0000	50	0.5000	59	15.0000	66	30.0000
47	69	4.0000	74	1.0000	78	0.5000	82	2.0000		
48	4	0.5000	6	10.0000	7	4.0000	9	0.5000	11	3.0000
48	16	0.5000	24	0.5000	25	0.5000	30	0.5000	31	0.5000
48	33	0.5000	38	2.0000	42	0.5000	47	0.5000	52	0.5000
48	53	0.5000	54	0.5000	55	7.0000	59	1.0000	64	0.5000
48	66	1.0000	73	9.0000	74	1.0000	76	16.0000	78	0.5000
48	82	18.0000	83	1.0000	84	0.5000				
49	1	1.0000	4	6.0000	5	0.5000	6	31.5000	7	4.0000
49	21	0.5000	22	30.0000	25	1.0000	33	6.0000	38	12.0000
49	40	7.0000	41	8.0000	43	0.5000	45	0.5000	81	8.0000
50	4	3.0000	5	4.0000	6	20.5000	7	2.0000	11	10.0000
50	21	0.5000	22	1.0000	25	0.5000	33	0.5000	38	12.0000
50	40	9.0000	41	6.0000	43	0.5000	44	0.5000	45	0.5000
50	52	1.0000	56	1.0000	62	30.0000	63	0.5000	81	9.0000
50	85	4.0000								
51	1	2.0000	5	6.0000	6	17.5000	7	7.0000	11	1.0000
51	21	0.5000	22	11.0000	25	0.5000	33	4.0000	38	35.0000
51	40	2.0000	41	2.0000	43	0.5000	44	0.5000	45	0.5000
51	49	0.5000	81	5.0000						
52	5	10.0000	6	4.0000	7	12.0000	22	4.0000	25	0.5000
52	38	8.0000	47	6.0000	57	32.0000	83	10.0000	85	8.0000
53	6	9.0000	7	12.0000	22	2.0000	25	0.5000	34	1.0000
53	38	4.0000	47	6.0000	57	40.0000	69	0.5000	83	12.0000
53	85	3.0000	86	1.0000	87	1.0000	88	2.0000	89	4.0000
54	2	1.0000	4	2.0000	5	2.0000	6	20.0000	7	9.0000
54	18	12.0000	20	0.5000	21	0.5000	22	14.0000	25	0.5000
54	33	1.0000	43	0.5000	47	2.0000	53	0.5000	57	24.0000
54	83	1.0000	85	7.0000	89	5.0000				
55	2	9.0000	4	1.0000	5	1.0000	6	3.0000	7	3.0000
55	11	0.5000	15	0.5000	17	0.5000	20	0.5000	22	26.0000
55	25	0.5000	38	9.0000	47	3.0000	57	40.0000	58	0.5000
55	83	0.5000	85	1.0000	90	0.5000	91	1.0000		
56	2	3.0000	4	0.5000	5	8.0000	6	2.0000	7	20.0000
56	11	2.0000	18	2.0000	21	0.5000	22	4.0000	25	1.0000
56	47	8.0000	57	1.0000	83	4.0000	91	1.0000		
57	4	3.0000	5	7.0000	6	18.0000	7	40.0000	21	0.5000
57	22	7.0000	25	0.5000	43	0.5000	47	4.0000	51	2.0000
57	57	24.0000	85	2.0000						
58	4	4.0000	5	4.0000	6	18.0000	7	42.0000	11	0.5000
58	18	8.0000	21	0.5000	22	25.0000	25	0.5000	33	0.5000
58	57	4.0000								
59	4	0.5000	5	20.0000	6	3.0000	7	8.0000	11	1.0000
59	17	2.0000	22	1.0000	25	0.5000	33	1.0000	43	0.5000
59	50	1.0000	51	2.0000	53	0.5000	57	3.0000	59	3.0000