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Meadow and low shrub vegetation of Tuxedni Wilderness Area, Alaska

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Abstract. Meadow and low shrub plant communities on Chisik Island, Tuxedni Wilderness Area in south-central Alaska were studied to identify the major community types. 38 relevés represent the range of structural and compositional variation in the matrix of vegetation and landform zonation. Data were analyzed by multivariate methods. Five major community types are distinguished: *Lupinus nootkatensis-Festuca rubra* beach terrace meadow, *Athyrium filix-femina-Chamerion angustifolium* meadow, *Calamagrostis canadensis-Sanguisorba canadensis* meadow, *Arnica latifolia-Erigeron peregrinus* snowbed meadow, and *Rubus spectabilis-Calamagrostis canadensis* deciduous thicket. These are interpreted as a complex gradient primarily influenced by elevation and soil moisture.

1 Introduction

Chisik Island is part of Tuxedni Wilderness Area, a remote, scenic, and relatively undisturbed bird sanctuary that is part of the Alaska Maritime National Wildlife Refuge managed by the U.S. Fish and Wildlife Service. Tuxedni Wilderness is a Class I air quality area and in accordance with its responsibility, the Service sought to assess the existing condition of its vegetation resources using guidelines proposed by FOX et al. (1987).

Chisik Island occurs within the 'Subalpine Zone' described by MITCHELL (1966) for south-central Alaska: glaciated uplands and moist mountain valleys that form a mosaic of alder thickets and tall-growing grass and forb communities. Previously TALBOT et al. (2005) described the alder thickets of southwestern Alaska including Chisik Island; herein we focus on herb meadow and *Rubus spectabilis* low shrub vegetation. Our study presents the first quantitative characterization of the upland meadow and low shrub vegetation on the western side of lower Cook Inlet. It includes forb-dominated early melt snowbeds, mesic meadows and their associated low deciduous thickets, and beach terrace meadows but excludes *Leymus*-dominated shorelines. The objectives of the study are: (1) describe major meadow and *Rubus spectabilis* low shrub communities of Chisik Island along representative gradients; (2) identify the main vegetation types using multivariate methods; (3) interpret the community types in relation to site factors; and (4) compare the communities identified for Chisik Island with those of neighboring and similar areas.

2 Study area

Tuxedni Wilderness Area is located at 60°08'N, 152°35'W at the head of Tuxedni Bay on the western side of lower Cook Inlet. The area includes two small maritime islands,

Chisik and Duck Islands. Chisik Island, the study area, is the larger of the two islands; it is 10.5 km long and encompasses about 2,297 ha. The topography of Chisik Island is rugged. From the southern end of the island, the land rises gradually along a ridge to the highest point at 815 m in the northern portion where it drops precipitously to the sea along rock cliffs (Fig. 1).

Fig. 1: The northern portion of Chisik Island (center), Alaska, from the west; the island is dominated by *Alnus viridis* thickets. The white areas atop the mountain are the location of *Arnica latifolia-Erigeron peregrinus* snowbed meadows; *Calamagrostis canadensis-Sanguisorba canadensis* and *Athyrium filix-femina-Chamerion angustifolium* meadows occur down slope to the right. The *Lupinus nootkatensis-Festuca rubra* beach terrace meadows are in the lowlands at the northernmost portion of the island. In the foreground are *Alnus viridis* shrubs partially surrounding a meadow of *Athyrium filix-femina-Chamerion angustifolium*. 10.06.1993.

Phytogeographically, Chisik Island occurs in the northern latitudinal limit of the 'maritime zone' (SELKREGG 1974: 5, Fig. 3), which is distinguished by heavy precipitation, cool summers, and warm winters. The Iniskin climatic station (59°45'N, 153°14'W) on western lower Cook Inlet, 55 km SW of Chisik Island, is the nearest available climatic site and its records are used herein to represent Chisik Island climate (ARCTIC ENVIRONMENTAL INFORMATION AND DATA CENTER 1989). Mean annual temperature and precipitation recorded for Iniskin (1954-1962) are 0.9°C and 1844 mm, respectively; August is the warmest month with a mean temperature of 11.7°C. Using an ecoclimatic-phytogeographical system, TUHKANEN (1984) classified the Tuxedni Wilderness Area within the middle boreal subzone, hyperoceanic (O_2) sector and humid (h) province.

The exposed bedrock of Chisik Island is Middle to Late Jurassic in age and is mainly marine arkosic sandstone, conglomerate, siltstone, and shale (DETTERMAN 1966, COBB & HUNTINGTON 1968). The surficial geology of the study area chiefly consists of discontinuous glacial till of Quaternary age, colluvium derived from bedrock outcrops and cliff faces, gravelly alluvial fan and beach deposits, and volcanic ash deposits. The dominant soils are Andisols (RIEGER et al. 1979). These volcanic soils, mainly Typic Fluvicryands, have multiple sequences of horizons formed by repeated deposition of volcanic ash followed by accumulation of organic materials and horizon differentiation. Their principal plant cover is tall herb or a combination of herb and alder (CLARK & PING 1995).

In a floristic study of Tuxedni Wilderness Area, TALBOT et al. (1995) distinguished several broad plant community types: 1) broadleaf deciduous thickets of *Alnus viridis, Rubus spectabilis, Salix pulchra*, *S. barclayi*; 2) dwarf shrub communities of *Arctostaphylos alpina, Harrimanella (Cassiope) stelleriana*, *Empetrum nigrum, Luetkea pectinata, Vaccinium uliginosum*; 3) herbaceous vegetation of *Athyrium filix-femina, Calamagrostis canadensis, Chamerion (Epilobium) angustifolium, Honckenya peploides, Leymus mollis, Lupinus nootkatensis*; 4) mire communities of *Andromeda polifolia, Drosera rotundifolia, Erigeron peregrinus, Eriophorum angustifolium, Trichophorum cespitosum*; 5) forests of *Picea sitchensis, Populus trichocarpa*. The vascular flora of Tuxedni Wilderness Area (290 species) primarily includes species of circumpolar (36.6 %), eastern Asian (22.9 %), and North American (20.4 %) distribution (TALBOT et al. 1995).

3 Methods

3.1 Field Procedures

This study of Chisik Island is based on a set of 38 relevés made according to Braun-Blanquet methods (WESTHOFF & VAN DER MAAREL 1973) in July 1987 (no. 11, 12, 23, 24), September 1988 (no. 13-22, 25-35) and June 1993 (no. 1-10, 36-38). Plots were laid out in units of homogeneous vegetation so as to represent conspicuous variation in meadow and low shrub communities from lower to upper mountain slopes. Relevé size, 100 m^2, equaled the minimal area for comparable types (WESTHOFF & VAN DER MAAREL 1973). Cover-abundance was estimated for all vascular plants according to the nine-point ordinal scale of WESTHOFF & VAN DER MAAREL (1973). Vascular plant nomenclature follows USDA, NRCS (2008); voucher specimens were deposited at BRY. Bryophytes and lichens were not included in the study because of their minor role in composition and abundance. Furthermore, the exclusion of bryophytes and lichens simplifies comparison with other studies in the neighboring areas because most did not include them. Environmental factors recorded were aspect (degrees), elevation (m), litter cover (%), slope inclination (degrees), ecological moisture regime (ordinal values: 2 = subxeric; 3 = submesic; 4 = mesic; and 5 = subhygric), and mesotopography (LUTTMERDING et al. 1990).

3.2 Data Analysis

From our data set of 160 Chisik Island relevés stored in TURBOVEG (HENNEKENS & SCHAMINÉE 2001), we selected a subset of herb meadow and *Rubus spectabilis* low shrub relevés. The resultant matrix comprised 38 relevés × 73 species and was exported for analysis. We used the method OPTIMCLASS in JUICE 6.5 (TICHÝ 2002) to determine the optimal number of clusters: the partition with maximum number of diagnostic species across all clusters and maximum number of clusters that have a preselected minimum number of diagnostic species. Diagnostic species were determined based on the *P*-value $10^{-3}$of the Fisher's exact test (TICHÝ & CHYTRÝ 2006).

Numerical analysis was accomplished with the classification and ordination methods of the MULVA-5 program (WILDI & ORLÓCI 1996). Relevés and species were initially arranged using a relatively standard approach described by WILDI (1989). This approach produces results similar to traditional phytosociological tabular classification. Relevé data were transformed based on a square root transformation of the ordinal cover-abundance scale and normalized. Resemblance of relevés was assessed via the VAN DER MAAREL coefficient (similarity ratio) based on normalized relevé vectors and of species using Euclidian distance (WILDI & ORLÓCI 1996).

Relevé and species classification were performed using complete linkage clustering. Correspondence analysis (CA; HILL 1974) was used to order the relevé and species groups externally and internally along the main floristic gradient. Analysis of concentration (AOC; FEOLI & ORLOCI 1979) arranged dense species-relevé blocks along the diagonal. Five relevé groups, or community types, and 20 species groups were identified; these were ordinated by analysis of concentration (AOC) along the main floristic gradient. AOC of a 5 × 20 contingency table showed block structure deviated significantly from random expectation; a mean square contingency coefficient of 0.440 indicated that group structure was relatively strong (WILDI & ORLÓCI 1996).

F-values (JANCEY 1979) were used to reduce the species set by ranking and to determine differentiating species; the list of diagnostic species was further refined using phi coefficient fidelity values (CHYTRÝ et al. 2002) to 32 species and seven species groups. Vegetation units are termed relevé groups (RG), or community types because units within the Braun-Blanquet system should be based on more data from a variety of localities.

A high-resolution dendrogram of the five relevé groups was prepared using CLUSTANGRAPHICS7 (WISHART 2003).

An ordination was performed using CANOCO 4.5 (TER BRAAK & ŠMILAUER 2002) with the WinKyst1.0 Add-On (ŠMILAUER 2003) to provide non-metric multidimensional scaling (NMDS). For NMDS the species data were transformed using a square-root transformation and a distance matrix was calculated using Bray-Curtis distance. The resulting file was treated in CANOCO 4.5 and CANODRAW 4.0 as suggested by ŠMILAUER (2003) with environmental data related to the sample scores in an unconstrained analysis.

4 Results

4.1 Dendrogram of relevés

Numerical-phytosociological analysis identified five relevé groups (RG), and seven species groups. A quantitative display of relationships between the five communities is presented in Fig. 2. These relevé groups were arranged by AOC along the main floristic gradient (Tab. 1). As indicated in the dendrogram, low shrub thickets (RG 5) are first separated from meadows followed by subxeric lowlands (RG 1), then subhygric snowbed upper mountain meadows (RG 2) from mesic mountain meadows (RG 3 and 4). These types showed differences in composition in diagnostic, constant, and dominant species, community structure, and site and geographic characteristics (Tab. 3). A summary of each type follows:

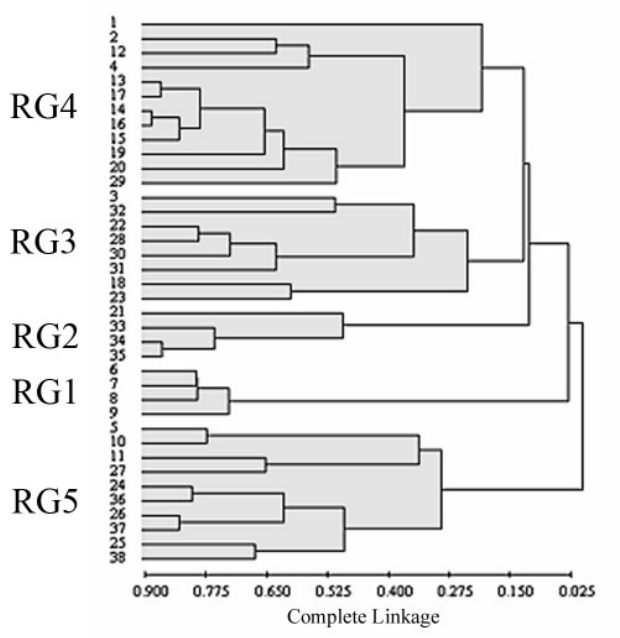

Fig. 2: Classification dendrogram of five relevé groups (community types) from Tuxedni Wilderness Area, Alaska, obtained using the VAN DER MAAREL coefficient (similarity ratio) and complete linkage clustering (WISHART 2003) of 38 relevés. Key:
RG 1 = *Lupinus nootkatensis-Festuca rubra* beach terrace meadow; RG 2 = *Arnica latifolia-Erigeron peregrinus* snowbed meadow; RG 3 = *Calamagrostis canadensis-Sanguisorba canadensis* meadow; RG 4 = *Athyrium filix-femina-Chamerion angustifolium* meadow; RG 5 = *Rubus spectabilis-Calamagrostis canadensis* deciduous thicket.

***Lupinus nootkatensis-Festuca rubra* beach terrace meadow** (RG 1) occurs on level terrain at the low elevation (ca. 4 m) on the north end of the island. Forbs are dominant (79 %), and there is a moderate cover of graminoids (19 %). Typical species are *Achillea millefolium* v. *borealis*, *Angelica lucida*, *Arabis lyrata*, *Festuca rubra*, *Geranium erianthum*, *Leymus mollis*, *Lupinus nootkatensis*, and *Poa pratensis*. The mean number of species per relevé is 13. The gravelly, subxeric beach soils are Typic Cryorthents (CLARK & PING 1995). In relation to all other types, this type is found at the lowest elevation and the site is the driest.

***Arnica latifolia-Erigeron peregrinus* snowbed meadow** (RG 2) is found at upper elevation sites (>500 m). Forbs are dominant (72 %) with graminoids second in importance (24 %); dwarf shrubs (17 %) form the largest component of all types investigated. Typical species are *Arnica latifolia*, *Artemisia arctica*, *Calamagrostis canadensis*, *Chamerion angustifolium*, *Erigeron peregrinus*, *Geranium erianthum*, *Luetkea pectinata*, and *Veronica wormskjoldii*. The community is highest in species diversity (ø = 24). The sites are subhygric and soils are mixed Typic Fluvicryands. The aspect is generally south-facing with a mean slope of 18°. Of all types investigated, this type occurs at the highest elevations, is the wettest, and has the lowest cover of litter, 50 %. Litter cover of all other types was nearly twice as high ranging from 90 to 99 % cover.

***Calamagrostis canadensis-Sanguisorba canadensis* meadow** (RG 3) occurs at low to middle elevations (ø = 254 m). The vegetation is dominated by graminoids (62 %) with forbs (43 %) second in importance. Typical species are *Calamagrostis canadensis*, *Geranium erianthum*, *Sanguisorba canadensis*, and *Veratrum viride*. The mean number of species per relevé is 11. The sites are mesic to subhygric and soils are mixed Typic Fluvicryands. The aspect is generally southeast-facing with a mean slope of 7°.

***Athyrium filix-femina-Chamerion angustifolium* meadow** (RG 4) occurs on middle mountain slope (ø = 304 m). The vegetation is dominated by forbs (72 %) with graminoids (27 %) second in importance. Typical species are *Aconitum delphinifoliium*, *Athyrium filix-femina*, *Calamagrostis canadensis*, *Chamerion angustifoliium*, *Phegopteris connectilis*, *Rubus spectabilis*, *Senecio triangularis*, and *Trientalis europaea*. The mean number of species per relevé is 14. Sites are mesic (subhygric) and most similar to type RG 3 in moisture regime; the soils are mixed Typic Fluvicryands. The aspect is generally southeast-facing with a mean slope of 17°.

***Rubus spectabilis-Calamagrostis canadensis* deciduous thicket** (RG 5) is found on lower mountain slopes (ø = 105 m). Deciduous low shrubs dominate (71 % cover) with moderate cover of graminoids (18 %), and forbs (16 %). Typical species are *Calamagrostis canadensis*, *Chamerion angustifolium*, *Dryopteris expansa*, and *Rubus spectabilis*. The mean number of species per relevé is five; the lowest of all types investigated. The sites are submesic (mesic) and soils are Cryands. The aspect is generally south south-east facing with a mean slope of 18°.

Tab. 1: Meadow and low shrub vegetation of Tuxedni Wilderness Area, Alaska.

Relevé group no.	1	2	3	4	5
Abbreviated relevé group name	*Lupinus-Festuca*	*Arnica-Erigeron*	*Calamagrostis-Sanguisorba*	*Athyrium-Chamerion*	*Rubus-Calamagrostis*
Relevé no.	9687	3321	3211880223	5934429760211	0754765861
Differential species of Lupinus nootkatensis-Festuca rubra beach terrace meadow					
Achillea millefolium v. *borealis*	6676	..2.			
Arabis lyrata	2334				
Leymus mollis	2333				
Moehringia lateriflora	23.2				
Festuca rubra	5665				
Poa pratensis	5555				
Lathyrus japonicus v. *maritimus*	222.				
Differential species of beach terrace and snowbed meadows					
Angelica lucida	2457	.112		2.....221..	1
Lupinus nootkatensis	8767	1113			
Differential species of Arnica latifolia-Erigeron peregrinus snowbed meadow					
Vahlodea atropurpurea	....	221.	...1....		
Erigeron peregrinus	....	5632	...2....	.....2..	
Luzula parviflora	....	3554	.....	..2.....	
Luetkea pectinata	....	672.			
Carex pyrenaica	....	221.			
Sibbaldia procumbens	....	211.			
Hieracium triste	....	355.			
Campanula lasiocarpa	....	122.			
Arnica latifolia	....	6661			
Lycopodium alpinum	....	123.			
Veronica wormskjoldii	....	2442			
Differential species of beach terrace, snowbed, and mesic meadows					
Geranium erianthum	3232	6764	2266532224	45.31365522	1
Trientalis europaea	....	121.	.2 2422254	2424243542443	3...3...
Sanguisorba canadensis	....	21..	2654832261	24.1..42..	
Athyrium filix-femina	....	113.	.2.....	6479649777 7.	..4....2..
Veratrum viride	....	...7	2217..14	2.32314352 3.	
Senecio triangularis	....	1327	.2.3114	565.5.1765..	
Aconitum delphiniifolium	....	11	...21...	113.2.2222..	
Castilleja unalaschcensis	....	2322	...2....	..2.1..2.2..	
Viola langsdorfii	....	2236	.2.53..5	444.3.456512	
Differential species of Athyrium filix-femina-Chamerion angustifolium meadow					
Phegopteris connectilis	....	.....	.....	2.72.2.322..	.....
Differential species of Rubus spectabilis-Calamagrostis canadensis deciduous thicket					
Rubus spectabilis	....	.....	.....	3.2221 2.3.25	6999992996
Dryopteris expansa	....	.....	.....	.....2....1.	6222.19.2.
Companion species:					
Chamerion angustifolium	2665	2252	226.237.	7664775576 58	5.33.1224.
Calamagrostis canadensis	.2.2	4236	9987896 9	7572676776 7.	8.244.5219
Carex macrochaeta	2...	7425	.4526 3..	1.2 1..223..	.....
Gymnocarpium dryopteris	....	.....	22	2.....4.4	4.2...2..2
Streptopus amplexifolius	....	.....	...2....	2.2.1.222..	5.....
Artemisia arctica	....	6674	...2....	..2....1.2..	.....
Heracleum maximum	....	...5	.11...7.	.9.2.....41.	.....
Fritillaria camschatcensis	13.1	....	2.....	...4.....2	.....
Equisetum arvense	....	.....	3.3.12..	.2.....	.....
Phleum alpinum	....	.223	.....	..1....2....	.....
Maianthemum dilatatum	....	.....	.....	.....4.....6	23
Spiraea stevenii	....	.....	.....	2.2.....2	1.....
Ligusticum scoticum	.43.	.....	.....	2	.....

Table 1 (cont.). Other species names are followed by relevé number and cover-abundance value: *Actaea rubra* 12: 1; *Agrostis borealis* 34: 2, 35: 2; *Angelica genuflexa* 3: 2; *Boschniakia rossica* 12: 2; *Botrychium lunaria* 9: 1; *Cardamine oligosperma* 3: 2; 4: 1; *Carex gmelinii* 7: 1, 9: 2; C. *macloviana* 16: 2; *Conioselinum gmelinii* 3:1; *Galium boreale* 32: 5; *G. triflorum* 32: 1; *Harrimanella stellariana* 33: 2; *Hippuris montanna* 34: 1; *Lycopodium annotinum* 10: 1; *Oxyria digyna* 31: 1; *Petasites frigidus* 31: 1; 34: 1; *Potentilla pensylvanica* 18: 2; *Prenanthes alata* 20: 2; *Ranunculus eschscholtzii* 31: 1; *Rhinanthus minor* 6:5, 9: 2; *Rubus arcticus* s. *stellatus* 23:3; S*ambucus racemosa* 26: 1; *Sorbus scopulina* 35: 1; 36 1; *Stellaria calycantha* 29: 2; *Urtica dioica* s. *gracilis* 3: 2; *Vaccinium uliginosum* 33: 1; *Viola glabella* 3: 2; *V. palustris* 32: 2.

Tab. 2: Ecological data for the five community types of Tuxedni Wilderness Area vegetation. Entries are expressed as mean values; range indicated in parentheses.

Relevé group no.	1	2	3	4	5
Abbreviated relevé group name	*Lupinus-Festuca*	*Arnica-Erigeron*	*Calamagrostis-Sanguisorba*	*Athyrium-Chamerion*	*Rubus-Calamagrostis*
Number of relevés	4	4	8	12	10
Mean number of species	13 (11-16)	24 (17-28)	11 (8-15)	14 (10-19)	5 (2-9)
Percent cover					
Shrub (0.5 - 2 m)	·	·	0.3 (0-2)	1 (0-8)	71 (2-99)
Dwarf shrub (< 0.5 m)	·	17 (0-35)	< 1 (0-1)	<1 (0-1)	< 1 (0-1)
Graminoid	19 (15-25)	26 (1-90)	62 (20-96)	27 (0-50)	18 (0-99)
Forb	79 (70-85)	72 (20-90)	43 (15-80)	72 (50-98)	16 (0-95)
Moss	7 (2-20)	5 (0-10)	0.8 (0-3)	1 (0-4)	·
Site factors					
Elevation (m)	4 (2.4-4.9)	566 (451-619)	254 (49-396)	304 (60-482)	105 (24-335)
Ecological moisture regime	Subxeric	Subhygric	Mesic - subhygric	Mesic (subhygric)	Submesic (mesic)
Slope (°)	·	18 (12-22)	7 (0-16)	17 (0-36)	18 (0-46)
Aspect (°)	·	174 (135-203)	151 (0-270)	145 (0-250)	164 (0-322)
% cover litter	90 (85-95)	50 (15-95)	96 (90-99)	92 (40-99)	99 (95-99)

4.2 Ordination of relevés

NMDS ordination (Fig. 3) showed 38 relevés in five relevé groups. The primary NMDS solution for two dimensions was found with 25 iterations out of 100, stress = 0.14649 indicating a good fit. The eigenvalues of the first (0.634) and second axis (0.366) indicate that only the first axis has a pronounced explanatory value. The five relevé groups are relatively distinct and there is separation between them indicating they are distinct in nature. The ordination biplot indicates that of five environmental factors ecological moisture regime (EMS), elevation, and litter cover were the three most important factors with EMS and elevation strongly correlated and inversely related to litter cover.

The ordination shows four of the RGs along axis one, with RG 5 on one end (low elevation, low EMS, high litter), 3 and 4 intermediate and 2 at the other end (highest elevations, highest moisture and lowest litter). RG 3 and 4 are similar in their relationship to those three environmental factors, but appear to be separated by slope with RG 4 more strongly inclined. RG 1 is clearly separated from the others, at low elevation, negatively related to EMS, positively to litter, and rather clearly negatively related with slope. The dendrogram and ordination are similar in that RG 1 and 5 differ the most from the others which form a rather close group, especially RG 3 and 4.

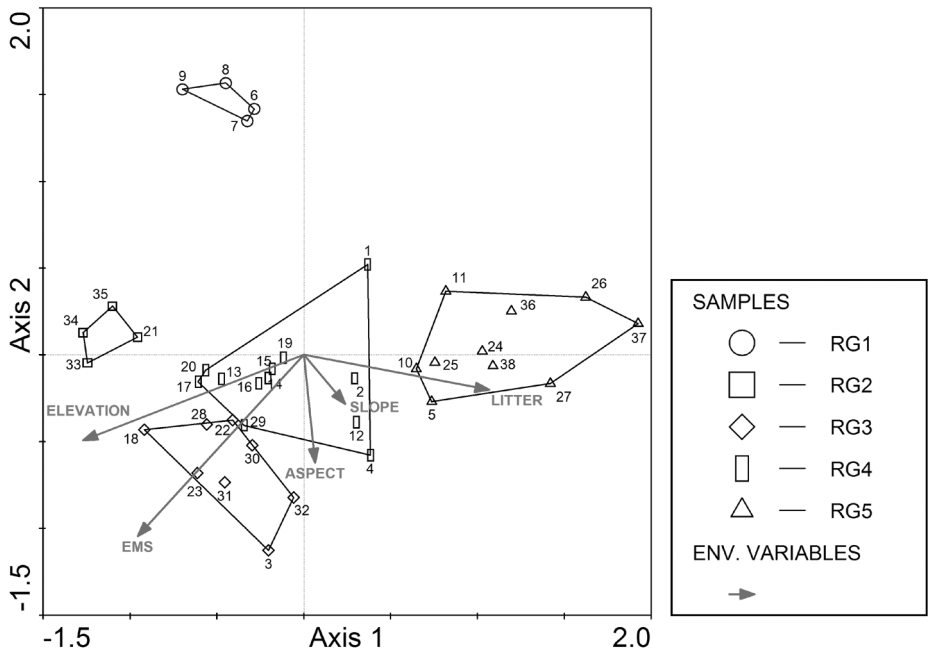

Fig. 3: Non-metric multidimensional scaling ordination (ŠMILAUER 2003, TER BRAAK & ŠMILAUER 2002) of 38 relevés from Tuxedni Wilderness Area, Alaska. The scatterplot shows the five cluster model of community types identified in Fig. 2 in relation to five environmental variables. For key to relevé group (RG) numbers refer to Fig. 2.

5 Discussion

For south central Alaska MITCHELL (1966) described the meadow vegetation as a mosaic of herbaceous community types dominated by *Calamagrostis canadensis, Chamerion (Epilobium) angustifolium, Athyrium filix-femina, Dryopteris expansa*, and *Festuca altaica*; all but the last species are common within the study area.

The meadow vegetation of Chisik Island might be recognized under varying names by different authors: The *Lupinus nootkatensis-Festuca rubra* beach terrace meadow (RG 1) was related to "Stand 23. *Lupinus nootkatensis-Lathyrus maritimus-Achillea borealis-Poa pratensis-Festuca rubra*" reported from a low coastal ridge on Kodiak Island (HANSON 1951). In an international context, RG 1 as well as RG 3 and RG 4 fit in the UNESCO (1973) classification within the formation "Low Forb Communities: Mainly perennial flowering forbs, and ferns." These forb communities are less than 1 m tall when fully developed and consist mainly of forbs. Graminoids may be present but they usually cover less than 50 %.

The *Calamagrostis canadensis-Sanguisorba canadensis* meadow (RG 3) is referable to the "Bluejoint-herb' type (VIERECK et al. 1992) that is widely distributed in the southern part of Alaska. Other apparently similar types include "Tall Grass-Forb Communities

with *Calamagrostis canadensis* as the chief dominant" in south-central Alaska (HANSON 1951), "*Epilobium angustifolium* mesic forb herbaceous" and "*Calamagrostis canadensis* mesic graminoid herbaceous" (in part) of the Chugach National Forest, south-central Alaska (DEVELICE et al. 1999).

The *Athyrium filix-femina-Epilobium angustifolium* meadow (RG 4) fits within the "Mesic forb herbaceous (subarctic herbs)" type (VIERECK et al. 1992) that occurs throughout most of Alaska; it also shares similarities with the "*Calamagrostis*/fireweed/fern" type (RACINE 1978) in adjacent Lake Clark National Park west of Chisik Island.

The *Rubus spectabilis-Calamagrostis canadensis* deciduous thicket (RG 5) is referable to the "*Rubus spectabilis-Calamagrostis canadensis* closed and open low scrub" occurring on the Kenai Peninsula (DEVELICE et al. 1999), and the "*Rubus spectabilis/Athyrium filix-femina* community type" in the Yakutat Foreland of southeastern Alaska (SHEPHARD 1995), but the *Rubus spectabilis* communities of Chisik Island are lower in species diversity than the previous types. RG1 is classified in the UNESCO (1973) system in the formation "Subalpine or subpolar deciduous thicket," within the subdivision "With primarily hemicryptophytic undergrowth, mainly forbs."

The *Arnica latifolia-Erigeron peregrinus* snowbed meadow (RG 2) forms a mantel to *Harrimanella stelleriana-Luetkea pectinata* communities on Chisik Island. The latter is reported for south-central Alaska (DEVELICE et al. 1999), but RG3 is appears to be unreported in the Alaska literature. In the UNESCO (1973) system, it fits best in the formation "Alpine and subalpine meadows of the higher latitudes," subdivision "Rich in dwarf shrubs;" it is usually moist much of the summer due to melt water.

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