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Scientific paper

## Chemical property of live and dead leaves of tundra plant species in Oobloyah Valley, Ellesmere Island, high arctic Canada

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**Abstract:** The chemical property of live and dead leaves was investigated regarding 14 plant species, including shrubs, forbs, graminoids, and mosses. Leaves were collected from a deglaciated terrain in Ellesmere Island, high arctic Canada. The contents of organic chemical components (lignin, total carbohydrates, extractives), carbon, and nutrients (N, P, K, Ca, Mg) were examined and compared among the species. In general, forbs had high content of nutrients and low content of carbon and organic chemical components; shrubs had high content of carbon and lignin and low content of nutrients; graminoids had high content of total carbohydrates and low content of lignin and nutrients; and mosses had high content of total carbohydrates and markedly low content of nutrients. Principal component analysis showed separation of clusters of shrubs, forbs, graminoids, and mosses. The trend was generally similar between live and dead leaves.

**key words:** glacier foreland, leaf, lignin, nitrogen, phosphorus

### 1. Introduction

The chemical property of leaves is an important aspect of leaf traits of plants; it represents the ecophysiological activity, nutritional status, and strategy for nutrient acquisition of plants, and the quality as food resources for herbivore animals and decomposer organisms (Chapin, 1989; Kudo, 1999; Aerts and Chapin, 2000; Berg and McClaugherty, 2003). Chemical properties of leaves thus provide basic information for the understanding of arctic ecosystems, where plant growth is strongly limited by such environmental factors as low temperature, low moisture, low nutrient availability, and a short growing season (Svoboda and Freedman, 1994). Chemical properties of leaves of arctic plants have been studied in relation to growth form, mycorrhizal status, seasonal changes, soil conditions, and climatic gradients (Skre *et al.*, 1975; Wielgolaski *et al.*, 1975; Maessen *et al.*, 1983; Nams and Freedman, 1987a; Woodley and Svoboda, 1994; Michelson *et al.*, 1996; Kudo *et al.*, 2001; Kume *et al.*, 2003). Few studies, however, have examined the contents of both organic chemical components and nu-

trients at the same time, and more studies are needed that compare the chemical properties across arctic plants of various growth forms.

The purpose of the present study was to investigate the chemical property of live and dead leaves of 14 plant species, including deciduous and evergreen shrubs, forbs, graminoids, and mosses, in Oobloyah Valley, Ellesmere Island, high arctic Canada. The study area was a well-vegetated proglacial field that can be divided into several habitats for plant exploitation based on soil moisture conditions and establishment periods after deglaciation. Plants of different growth forms, such as shrubs, forbs, graminoids, and mosses, were encountered along these gradients (Kojima, 1991, 1999; Okitsu *et al.*, 2004; Ueno and Kanda, unpublished data; Osono *et al.*, unpublished data). Leaves of these plants were collected, and contents of organic chemical components (lignin, total carbohydrates, extractives), carbon, and nutrients (N, P, K, Ca, Mg) were examined and compared among the species. Principal component analysis was used to ordinate the 14 plant species based on the chemical property of leaves, to examine the similarity of chemical property between species or growth forms.

## 2. Study area

The study was carried out in a deglaciated terrain in the southern front of Arklio Glacier of the Kreiger Mountains, located on the right bank of the Arklio River. The area is near the mouth of Oobloyah Valley, about 6 km east of Oobloyah Bay (80° 50' N, 82° 45' W), Ellesmere Island, Nunavut, Canada. The area is rich in well-preserved moraines. No climate data are available in the study area, but the climate, as represented by the weather station at Eureka (80° 00' N, 85° 56' W), located 130 km south of the study area, is extremely harsh. The annual mean temperature is -19.7°C, and the monthly mean temperature of the warmest (July) and coldest (February) months is 3.3°C and -38.0°C, respectively. Annual precipitation is 64 mm (Atmospheric Environmental Service, 1982; after Kojima, 1994).

Arklio Glacier has developed at least five glacial moraines (moraines in relative ages of 1, 2, 3, 4, and 5) with different development periods since the Last Glacial (Hasegawa *et al.*, 2004; Fig. 1). Relative ages of the moraines were estimated based on geomorphological observations, and relative dating was estimated by means of weathering rind thickness and lichenometry (Hasegawa *et al.*, 2004; Okitsu *et al.*, 2004). Moraines located just below Arklio Glacier consist of fresh, sharp ridges that apparently originated during the Little Ice Age, whereas moraines located in the outermost part of the study area, which has a fairly gentle slope, have had their morphology modified by cryogenic processes. Moraines of intermediate ages lie between the "Little Ice Age" moraines and the outermost moraines, and still show clear moraine morphology.

Okitsu *et al.* (2004) reported the vegetation development on the upper parts of moraines. The "Little Ice Age" moraines were covered thoroughly with fresh, sharp-edged rocks, and the colonization of vascular plants, mosses, and lichens is very limited, with plant coverage of less than 1% of the surface. The plant cover was higher in the older moraines, and increased to 61% in the outermost moraines. The dominant vascular species on these moraines included *Salix arctica*, *Dryas integlifolia*, and *Cassiope tetragona*. Two mosses: *Racomitrium lanuginosum* and *Hylocomium splendens*, were

also dominant on these moraines (Ueno and Kanda, unpublished data). The vegetation that is developed in the study area is similar to the *Cassiope*-dominated dwarf shrub heath in the low arctic, according to Okitsu *et al.* (2004). This vegetation type is relatively uncommon in the high arctic, which is generally represented by polar desert with sporadic occurrence of vascular plants (Nams and Freedman, 1987b), and it is commonly called a “polar oasis” (Svoboda and Freedman, 1994).

In the study area, mesic habitats were distinguishable on depressions between some moraines (Fig. 1) that were characterized by higher accumulation of deposited till and deeper soil depth, and by higher coverage and a higher number of vascular plant species than xeric habitats on the upper parts of moraines (Osono *et al.*, unpublished data). Soil moisture contents in mesic habitats were consistently higher than in xeric habitats, despite the increase of soil moisture contents in xeric habitats in relation to the developmental periods (Osono *et al.*, unpublished data). The dominant species in mesic habitats include not only shrubs: *S. arctica*, *D. integrifolia*, and *C. tetragona*, but also forbs, such as *Oxyria digyna*, *Pedicularis lanata*, and *Polygonum viviparum*; graminoids, such as *Carex* spp. and *Arctagrostis lactifolia*, and mosses, such as *H. splendens* (Ueno and Kanda, unpublished data; Osono *et al.*, unpublished data). Relative ages of mesic habitats can be estimated with reference to the relative ages of nearby moraines, unless the local topography was modified by glacio-fluvial activities (Hasegawa *et al.*, 2004).

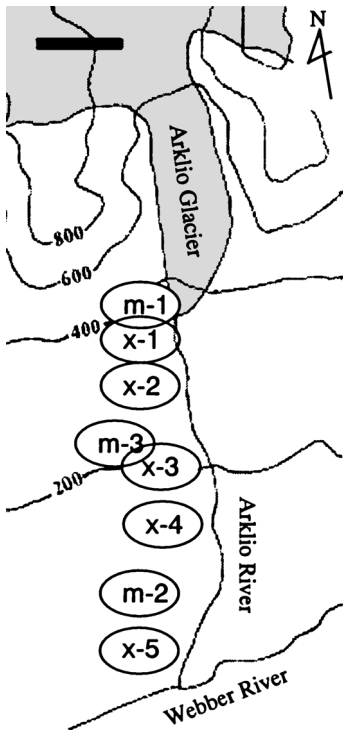


Fig. 1. Schematic representation of the distribution of eight habitats with different moisture conditions and development periods. x-1 and m-3, for example, indicate xeric habitat in relative age 1 and mesic habitat in relative age 3, respectively. Circles show the approximate area of sample collection. The bar indicates 1 km.



one month after collection.

### 3.2. Chemical analyses

The leaves from five individuals of a single species in each habitat were combined to make one sample. The leaves were then oven-dried at 40°C for one week, followed by grinding in a laboratory mill, to make particles that would pass through a 0.5-mm screen. Lignin and extractive contents were measured by sulfuric acid digestion and alcohol-benzene extraction, respectively (King and Heath, 1967). Total carbohydrate content was measured by a phenol-sulfuric acid method (Dubois *et al.*, 1956). Total C and total N contents were measured by automatic gas chromatography (NC analyzer SUMIGRAPH NC-900, Sumitomo Chemical Co., Osaka, Japan). After acid wet oxidation in HNO<sub>3</sub>+HClO<sub>4</sub>, an ascorbic acid method was performed for P (Olsen and Sommers, 1982); flame photometry was performed for K, and atomic absorption was performed for Ca and Mg. Details of the methods were described by Osono and Takeda (2004a, b, 2005). The contents were expressed in percentage (w/w). The original data of live and dead leaves are listed in Appendices 1 and 2, respectively.

No “true” lignin has been found in moss, but other phenolic cell wall material has been found (Erickson and Miksche, 1974). For the purpose of the present study, however, the term sulfuric acid-insoluble lignin is used for “lignin-like substances” of moss, even if not fully correct.

### 3.3. Statistical analysis

Principal component analysis was used to ordinate the plant species based on chemical property (contents of lignin, total carbohydrates, extractives, C, N, P, K, Ca, and Mg) of live and dead leaves (Systat, 1992).

## 4. Results

### 4.1. Chemical property of leaves

Figure 2 shows the chemical property of live and dead leaves of 14 plant species. Lignin content in live and dead leaves was higher in shrubs and *Polygonum viviparum* than in the other forbs, graminoids, and mosses. The total carbohydrate content in live and dead leaves was higher in graminoids and mosses than in shrubs and forbs. Extractives content in live leaves was highest in *Dryas integrifolia* and *Cassiope tetragona*, whereas the difference was small in dead leaves. The C content in live and dead leaves was similar among species, but *O. digyna* had lower content. Nitrogen and phosphorus contents in live leaves were lowest in *C. tetragona* and mosses, whereas the differences were small in dead leaves. The K content in live leaves was highest in *O. digyna* and lowest in *C. tetragona* and mosses but the difference was small in dead leaves. The Ca content in live and dead leaves was higher in some forbs than in the other species. The Mg content in live leaves was also higher in *O. digyna* and *P. viviparum* than in the other forbs, shrubs, graminoids, and mosses, whereas the difference was small in dead leaves.

### 4.2. Principal component analysis

Principal component (PC) analysis was used to ordinate these species based on

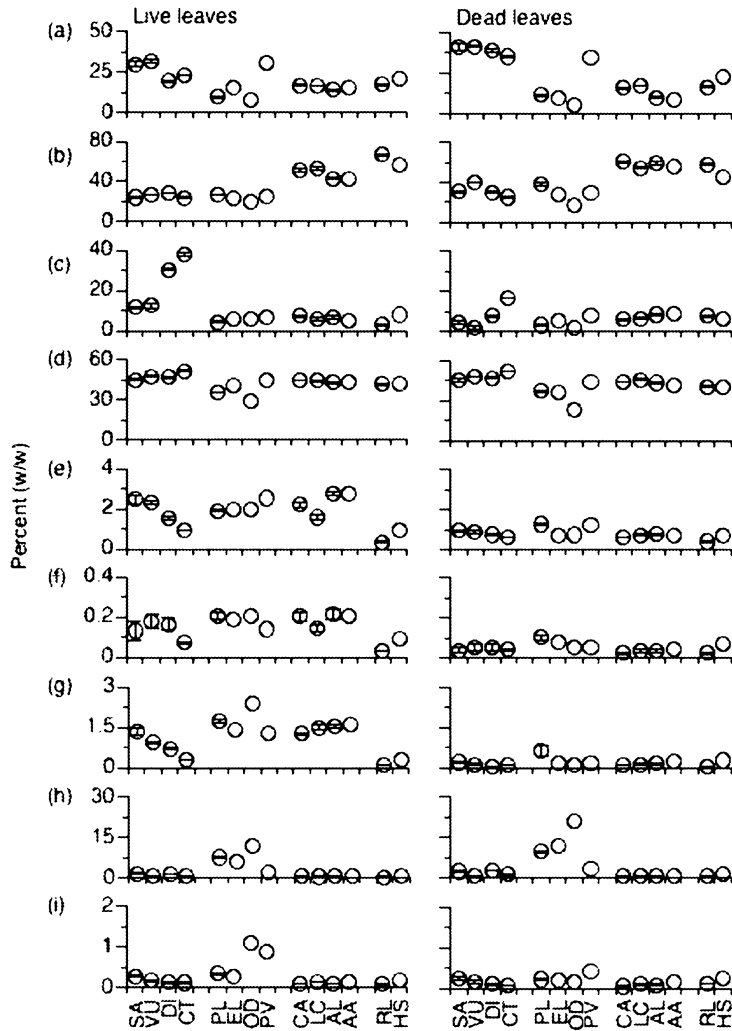


Fig. 2. Chemical property of leaves. ○ live leaves, ● dead leaves. Values indicate means ± se in % (w/w). (a) lignin, (b) total carbohydrates, (c) extractives, (d) carbon, (e) nitrogen, (f) phosphorus, (g) potassium, (h) calcium, (i) magnesium. SA *Salix arctica*, VU *Vaccinium uliginosum*, DI *Dryas integrifolia*, CT *Cassiope tetragona*, PL *Papaver lapponicum*, EL *Epilobium latifolium*, OD *Oxyria digyna*, PV *Polygonum viviparum*, CA *Carex* spp., LC *Luzula confusa*, AL *Arctagrostis lactifolia*, AA *Alopecurus alpinus*, RL *Racomitrium lanuginosum*, HS *Hylocomium splendens*.

chemical properties (Fig. 3). The first two principal components accounted for 70% (live leaves) and 66% (dead leaves) of the total variance in the data (Table 2).

In live leaves, the first principal component (PC1) accounted for 49% of the total variance, and it was significantly positively correlated with N, P, K, Ca, and Mg contents, and significantly negatively correlated with lignin and C contents. PC2 accounted for 21% of the total variance, and it was significantly positively correlated with lignin and N contents, and significantly negatively correlated with total carbohydrate

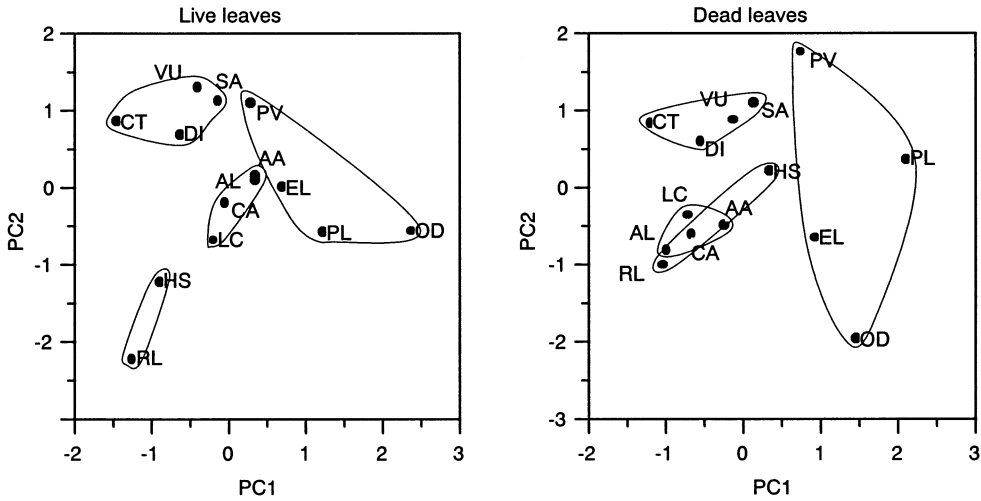


Fig. 3. Scatter plot of PC1 and PC2 of live and dead leaves. Abbreviations are the same as in Fig. 2.

Table 2. Result of the principal component analysis on leaf properties of 14 plant species. \*\*\* $P < 0.001$ , \*\* $P < 0.01$ , \* $P < 0.05$ .

Variable	Loading			
	Live leaves		Dead leaves	
	PC1	PC2	PC1	PC2
Lignin	-0.54 *	0.62 *	-0.27	0.84 ***
Total carbohydrates	-0.45	-0.73 **	-0.53	-0.27
Extractives	-0.50	0.49	-0.61 *	0.21
Carbon	-0.83 ***	0.51	-0.70 **	0.66 **
Nitrogen	0.56 *	0.60 *	0.68 **	0.60 *
Phosphorus	0.75 **	0.30	0.82 ***	0.22
Potassium	0.94 ***	0.15	0.70 **	0.15
Calcium	0.84 ***	-0.13	0.76 **	-0.45
Magnesium	0.70 **	0.11	0.66 *	0.48
Proportion (%)	48.8	21.2	42.7	23.7

contents. In dead leaves, PC1 accounted for 43% of the total variance, and it was significantly positively correlated with N, P, K, Ca, and Mg contents, and significantly negatively correlated with extractives and C contents. PC2 accounted for 24% of the total variance and was significantly positively correlated with lignin, C, and N contents.

Scatter plots of PC1 and PC2 of live and dead leaves showed clusters of different growth forms (Fig. 3). In live leaves, PC1 separated forbs from graminoids, shrubs, and mosses, and further graminoids from mosses; and PC2 separated shrubs, graminoids, and mosses from each other, and forbs from mosses. In dead leaves, PC1 separated forbs from shrubs, graminoids, and mosses; and PC2 separated shrubs from graminoids and mosses.

## 5. Discussion

This study showed the chemical property of live and dead leaves of 14 plant species, which were markedly different between growth forms. PC1 positively correlated with inorganic nutrients, and negatively with C and organic chemical components; it separated forbs rich in nutrients and poor in C and organic chemical components, from shrubs, graminoids, and mosses. PC2 positively correlated with lignin, C, and N, and negatively with total carbohydrates; it separated shrubs rich in lignin and poor in total carbohydrates, from graminoids poor in lignin and mosses rich in total carbohydrates. These differences among growth forms were consistent with previous reports on the chemical property of arctic plant leaves (Wielgolaski *et al.*, 1975; Maessen *et al.*, 1983). The levels of N, K, and Mg contents at the study area were similar to those reported by Maessen *et al.* (1983) from an Alexandra Fjord lowland oasis approx. 200 km south east of Oobloyah Bay, but live and dead leaves of forbs had half the content of P and a tenfold higher content of Ca compared with the findings of Maessen *et al.* (1983). The reason for the difference is unclear but may be attributable to the difference in geological situations between the locations. Besides, the present study showed not only nutrient contents but contents of organic chemical components in both vascular plants and mosses. Our data indicated that *Polygonum viviparum* was similar to deciduous shrubs in terms of organic chemical composition of live and dead leaves, and that graminoids and mosses were similar in terms of low nutrient content and intermediate lignin content of dead leaves.

The effect of soil moisture condition and establishment periods after deglaciation on the chemical property of plant leaves was not determined in the present study, but generally the effect seems smaller than the difference between growth forms. In *S. arctica*, however, the contents of N and P are generally higher in live and dead leaves from mesic habitats compared with leaves from xeric habitats (Appendices 1 and 2). In fact, some previous studies indicated the effect of soil moisture condition on the chemical property of plant leaves within individual species (Karlsson, 1985; Woodley and Svoboda, 1994) and changes in chemical property in the course of primary succession (Matthews, 1992). Further studies are thus needed on the effects of soil moisture conditions and establishment periods after deglaciation on the chemical property of leaves and the related implications for development in the high arctic ecosystem.

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Appendix I. Chemical property of live leaves. Values in % (w/w).

Species	Growth form	Moisture condition	Relative age	Lignin	Total carbohydrates	Extractives	C	N	P	K	Ca	Mg
<i>Salix arctica</i>	S	x	1	27.9	24.4	12.1	43.6	2.09	0.080	1.91	2.16	0.270
<i>Salix arctica</i>	S	x	2	32.6	25.9	11.5	46.2	2.20	0.049	1.07	1.21	0.257
<i>Salix arctica</i>	S	x	3	32.4	23.2	13.5	46.1	2.03	0.044	1.01	1.57	0.254
<i>Salix arctica</i>	S	x	4	32.9	23.4	11.2	45.9	2.10	0.038	1.08	1.51	0.304
<i>Salix arctica</i>	S	x	5	34.7	22.9	11.2	46.1	2.04	0.035	1.04	1.45	0.245
<i>Salix arctica</i>	S	m	1	23.6	27.3	11.1	44.5	3.26	0.324	1.56	1.77	0.350
<i>Salix arctica</i>	S	m	2	28.3	24.7	12.1	44.6	2.54	0.186	1.49	1.90	0.221
<i>Salix arctica</i>	S	m	3	26.1	22.6	10.8	44.2	3.31	0.317	1.61	1.48	0.356
<i>Vaccinium uliginosum</i>	S	x	3	33.5	27.2	9.4	46.6	2.45	0.256	0.97	0.63	0.165
<i>Vaccinium uliginosum</i>	S	x	4	31.1	27.9	14.6	47.3	2.10	0.137	1.02	0.67	0.122
<i>Vaccinium uliginosum</i>	S	x	5	31.0	26.2	13.5	48.9	2.35	0.161	0.90	0.69	0.195
<i>Dryas integrifolia</i>	S	x	1	18.5	29.8	32.7	46.0	1.37	0.287	0.83	1.56	0.123
<i>Dryas integrifolia</i>	S	x	2	20.7	27.0	29.2	46.9	1.57	0.146	0.71	1.76	0.124
<i>Dryas integrifolia</i>	S	x	3	21.1	26.8	31.1	47.0	1.77	0.154	0.71	1.48	0.117
<i>Dryas integrifolia</i>	S	x	4	17.9	30.7	30.5	47.6	1.28	0.118	0.65	1.61	0.086
<i>Dryas integrifolia</i>	S	x	5	19.0	28.3	29.3	46.9	1.49	0.128	0.72	1.59	0.111
<i>Cassiope tetragona</i>	S	x	2	23.5	24.6	38.5	50.3	0.95	0.090	0.31	0.74	0.114
<i>Cassiope tetragona</i>	S	x	3	23.8	25.8	36.8	51.5	0.89	0.073	0.36	0.59	0.105
<i>Cassiope tetragona</i>	S	x	4	22.5	22.6	39.0	51.6	0.94	0.066	0.31	0.83	0.099
<i>Cassiope tetragona</i>	S	x	5	22.9	21.8	38.4	52.4	0.90	0.069	0.31	0.91	0.115
<i>Papaver lapponicum</i>	F	x	1	10.1	28.0	3.2	34.7	1.60	0.191	1.49	8.62	0.358
<i>Papaver lapponicum</i>	F	x	2	10.7	27.0	5.8	35.5	2.03	0.212	1.93	7.04	0.299
<i>Papaver lapponicum</i>	F	x	3	9.1	26.5	4.2	35.5	2.07	0.284	1.77	6.63	0.396
<i>Papaver lapponicum</i>	F	x	4	10.6	26.4	6.8	36.2	1.98	0.217	1.92	6.60	0.242
<i>Papaver lapponicum</i>	F	x	5	10.7	28.2	1.5	37.3	1.95	0.244	1.88	6.43	0.326
<i>Papaver lapponicum</i>	F	m	1	9.6	30.1	4.1	35.4	1.84	0.164	1.81	6.94	0.278
<i>Papaver lapponicum</i>	F	m	2	6.0	24.5	6.0	33.9	1.93	0.172	1.49	10.21	0.418
<i>Papaver lapponicum</i>	F	m	3	8.6	26.0	4.7	36.6	1.75	0.190	1.53	8.22	0.379
<i>Epilobium latifolium</i>	F	x	1	16.2	24.6	5.2	41.1	1.94	0.206	1.53	4.68	0.239
<i>Epilobium latifolium</i>	F	m	1	13.9	21.4	6.0	39.9	2.04	0.173	1.34	6.96	0.281
<i>Oxyria digyna</i>	F	m	2	7.1	18.2	6.4	27.4	1.79	0.263	2.61	12.70	1.128
<i>Oxyria digyna</i>	F	m	3	8.8	21.5	5.4	31.5	2.13	0.159	2.25	10.65	1.091
<i>Polygonum viviparum</i>	F	m	2	32.0	26.1	6.5	45.2	2.58	0.134	1.34	1.69	0.710
<i>Polygonum viviparum</i>	F	m	3	28.7	24.2	7.0	43.3	2.48	0.151	1.19	2.98	1.042
<i>Carex</i> spp.	G	x	2	15.9	51.0	8.4	43.4	1.87	0.127	1.19	0.46	0.070
<i>Carex</i> spp.	G	x	3	15.3	49.8	7.4	44.4	2.37	0.201	1.27	0.56	0.083
<i>Carex</i> spp.	G	x	4	15.5	56.5	6.1	44.5	2.02	0.227	1.29	0.51	0.081
<i>Carex</i> spp.	G	m	2	18.1	50.5	6.8	44.7	2.17	0.191	1.21	0.40	0.073
<i>Carex</i> spp.	G	m	3	18.7	49.6	7.6	45.3	2.57	0.280	1.37	0.26	0.088
<i>Luzula confusa</i>	G	x	3	16.3	55.6	3.8	44.0	1.75	0.128	1.69	0.46	0.141
<i>Luzula confusa</i>	G	x	5	16.4	49.5	7.6	44.8	1.51	0.136	1.40	0.50	0.131
<i>Luzula confusa</i>	G	m	3	16.5	53.0	6.4	43.3	1.46	0.184	1.40	0.32	0.149
<i>Arctagrostis lactifolia</i>	G	x	5	12.8	46.1	7.9	43.9	2.84	0.227	1.64	0.56	0.077
<i>Arctagrostis lactifolia</i>	G	m	2	12.8	41.9	7.4	41.9	2.56	0.166	1.41	0.76	0.077
<i>Arctagrostis lactifolia</i>	G	m	3	15.5	41.6	5.5	43.3	2.79	0.263	1.63	0.55	0.113
<i>Alopecurus alpinus</i>	G	m	3	15.7	42.8	5.4	43.0	2.75	0.210	1.63	0.54	0.119
<i>Racomitrium lanuginosum</i>	M	x	2	18.8	65.3	2.9	40.5	0.30	0.032	0.09	0.24	0.061
<i>Racomitrium lanuginosum</i>	M	x	3	17.8	68.7	3.8	42.1	0.41	0.037	0.09	0.38	0.070
<i>Racomitrium lanuginosum</i>	M	x	4	15.6	67.2	2.7	41.5	0.34	0.033	0.10	0.54	0.080
<i>Racomitrium lanuginosum</i>	M	x	5	16.9	66.1	2.9	42.5	0.34	0.032	0.10	0.28	0.065
<i>Hylocomium splendens</i>	M	m	3	21.1	56.8	8.1	42.0	0.89	0.095	0.33	0.86	0.157

Growth form: S shrub, F forb, G graminoid, M moss.  
Moisture: x xeric, m mesic.

Appendix 2. Chemical property of dead leaves. Values in % (w/w).

Species	Growth form	Moisture condition	Relative age	Lignin	Total carbohydrates	Extrac-	C	N	P	K	Ca	Mg
<i>Salix arctica</i>	S	x	1	40.2	30.9	6.5	44.6	0.92	0.055	0.33	2.62	0.138
<i>Salix arctica</i>	S	x	2	43.5	29.3	6.8	46.8	0.95	0.021	0.26	1.69	0.172
<i>Salix arctica</i>	S	x	3	44.9	29.8	5.3	46.5	0.81	0.009	0.12	1.99	0.143
<i>Salix arctica</i>	S	x	4	42.9	30.1	5.2	46.2	0.82	0.009	0.24	2.17	0.167
<i>Salix arctica</i>	S	x	5	42.6	25.6	5.5	45.8	0.82	0.009	0.26	2.40	0.215
<i>Salix arctica</i>	S	m	1	28.2	34.0	2.3	36.7	0.87	0.079	0.26	2.88	0.533
<i>Salix arctica</i>	S	m	2	41.6	34.7	1.3	46.8	1.24	0.055	0.11	2.93	0.187
<i>Salix arctica</i>	S	m	3	44.3	33.8	3.0	45.5	1.15	0.101	0.13	2.33	0.361
<i>Vaccinium uliginosum</i>	S	x	3	41.0	39.2	2.2	47.7	0.94	0.094	0.19	0.68	0.153
<i>Vaccinium uliginosum</i>	S	x	4	43.2	40.8	0.5	47.2	0.99	0.036	0.10	1.07	0.112
<i>Vaccinium uliginosum</i>	S	x	5	40.0	39.6	2.8	47.4	0.75	0.037	0.09	1.00	0.204
<i>Dryas integrifolia</i>	S	x	1	36.3	30.5	7.6	44.7	0.69	0.125	0.07	2.74	0.133
<i>Dryas integrifolia</i>	S	x	2	40.1	30.0	8.4	48.0	0.79	0.034	0.04	2.49	0.096
<i>Dryas integrifolia</i>	S	x	3	41.5	29.5	7.6	47.8	0.79	0.032	0.05	2.28	0.077
<i>Dryas integrifolia</i>	S	x	4	38.6	29.0	7.9	46.7	0.67	0.034	0.07	2.85	0.072
<i>Dryas integrifolia</i>	S	x	5	37.8	32.6	7.6	47.7	0.78	0.038	0.07	2.55	0.091
<i>Cassiope tetragona</i>	S	x	2	35.6	25.6	16.8	52.6	0.65	0.050	0.09	1.15	0.071
<i>Cassiope tetragona</i>	S	x	3	35.5	24.9	17.2	52.7	0.65	0.047	0.10	0.80	0.078
<i>Cassiope tetragona</i>	S	x	4	34.7	24.2	17.0	51.3	0.63	0.039	0.09	1.23	0.076
<i>Cassiope tetragona</i>	S	x	5	34.0	26.2	16.0	50.5	0.61	0.041	0.10	1.36	0.074
<i>Papaver lapponicum</i>	F	x	1	13.3	42.2	1.7	36.7	1.13	0.078	1.01	9.75	0.204
<i>Papaver lapponicum</i>	F	x	2	14.0	43.0	1.3	38.7	1.37	0.123	0.35	9.20	0.148
<i>Papaver lapponicum</i>	F	x	3	13.7	35.2	2.9	38.3	1.69	0.183	1.04	9.80	0.194
<i>Papaver lapponicum</i>	F	x	4	11.1	40.8	2.2	38.6	1.21	0.102	1.55	9.10	0.126
<i>Papaver lapponicum</i>	F	x	5	9.4	36.9	6.4	37.2	1.20	0.123	0.39	10.96	0.153
<i>Papaver lapponicum</i>	F	m	1	11.7	38.6	2.6	35.9	1.11	0.068	0.38	6.09	0.316
<i>Papaver lapponicum</i>	F	m	2	7.2	31.7	4.1	34.3	1.13	0.091	0.19	11.15	0.339
<i>Papaver lapponicum</i>	F	m	3	8.6	34.3	5.1	35.9	1.30	0.086	0.23	10.78	0.266
<i>Epilobium latifolium</i>	F	x	1	10.9	29.9	6.2	39.1	0.74	0.073	0.20	8.69	0.158
<i>Epilobium latifolium</i>	F	m	1	8.2	25.0	4.8	33.9	0.69	0.085	0.19	14.85	0.269
<i>Oxyria digyna</i>	F	m	2	4.2	16.1	2.3	23.3	0.70	0.056	0.13	20.86	0.183
<i>Oxyria digyna</i>	F	m	3	5.7	17.0	1.8	22.7	0.78	0.048	0.13	20.71	0.154
<i>Polygonum viviparum</i>	F	m	2	35.3	28.6	8.3	44.4	1.33	0.050	0.26	2.70	0.382
<i>Polygonum viviparum</i>	F	m	3	34.4	29.5	7.2	43.2	1.19	0.066	0.12	3.99	0.410
<i>Carex</i> spp.	G	x	2	16.2	60.7	4.8	44.3	0.58	0.019	0.09	0.51	0.038
<i>Carex</i> spp.	G	x	3	14.7	60.3	6.5	43.9	0.70	0.032	0.19	0.69	0.038
<i>Carex</i> spp.	G	x	4	14.8	59.4	5.0	44.0	0.59	0.023	0.12	0.75	0.036
<i>Carex</i> spp.	G	m	2	15.4	63.0	7.6	44.6	0.53	0.023	0.13	0.80	0.040
<i>Carex</i> spp.	G	m	3	17.0	57.4	7.1	44.5	0.60	0.046	0.12	0.58	0.066
<i>Luzula confusa</i>	G	x	3	16.9	55.3	5.8	46.6	0.80	0.035	0.17	0.65	0.084
<i>Luzula confusa</i>	G	x	5	16.9	53.2	7.2	45.2	0.64	0.028	0.08	0.69	0.068
<i>Luzula confusa</i>	G	m	3	16.7	54.9	6.9	44.9	0.70	0.051	0.17	0.55	0.120
<i>Arctagrostis lactifolia</i>	G	x	5	9.1	59.8	8.5	43.1	0.77	0.042	0.22	0.78	0.059
<i>Arctagrostis lactifolia</i>	G	m	2	9.8	61.9	8.4	42.9	0.65	0.026	0.11	0.95	0.062
<i>Arctagrostis lactifolia</i>	G	m	3	10.2	56.5	8.8	44.1	0.87	0.053	0.18	0.71	0.121
<i>Alopecurus alpinus</i>	G	m	3	8.6	55.3	8.7	41.1	0.71	0.051	0.26	0.82	0.159
<i>Racomitrium lanuginosum</i>	M	x	2	16.4	59.3	8.5	39.9	0.40	0.026	0.07	0.66	0.102
<i>Racomitrium lanuginosum</i>	M	x	3	15.5	60.2	9.0	40.7	0.36	0.020	0.06	0.61	0.107
<i>Racomitrium lanuginosum</i>	M	x	4	16.0	55.6	7.1	39.3	0.42	0.033	0.09	1.00	0.149
<i>Racomitrium lanuginosum</i>	M	x	5	17.5	55.9	6.8	41.7	0.41	0.028	0.06	0.63	0.111
<i>Hylocomium splendens</i>	M	m	3	22.7	45.3	6.5	39.8	0.70	0.076	0.28	1.28	0.249

Growth form: S shrub, F forb, G graminoid, M moss.  
Moisture: x xeric, m mesic.