

## Mitteilungen/Notes

### Early Stages of Plant Recovery on Tracked Vehicle Paths in the High Arctic (West Coast of Vestspitsbergen)

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**Summary:** The paper describes an early succession stages on the newly exposed substrata of abandoned tracked vehicle paths in two distinct physiographical regions on the Vestspitsbergen west coast. Prevailing willow-moss mesic tundra on Mount Ruscolen slopes and terrains can be related to *Salicion polaris* Du Rietz 1943 em. Hadač 1989, association *Luzulo confusae-Salicetum polaris* Hadač 1989. Meadow-like slightly halophytic plant communities in the Grøndalelven delta fall in two orders: *Puccinellion phryganodis* Hadač 1946 (ass. *Caricetum subspathaceae* Hadač 1946) and *Eriophorion scheuchzerii* Hadač 1939. Species composition and cover of „pioneering“ plant communities are described in context of the secondary succession. Open communities with prevailing „ruderal“ species - drabas, saxifragas, graminoids and apocarpic mosses - are reported to be an early successional stage on gravely sandy substrata in mesic dwarf shrub tundra. The prospects for natural recovery of primary communities are unlikely because of low ability of native prevailing species (pleurocarpic mosses and dwarf shrubs) to re-establish themselves. Only the meadow-like vegetation of wettest sites studied showed high ability to return to pre-disturbance level.

**Zusammenfassung:** Der Aufsatz beschreibt eine Folge einzelner Sukzessionsstadien auf frisch exponiertem Substrat in einer verlassenen Fahrzeugspur in zwei unterschiedlichen geomorphologischen Regionen an der Westküste Westspitzbergens. Die auf den Hängen und den Ebenen des Ruscolen-Berges vorherrschende Weiden-Moos-Tundra kann in Verbindung gebracht werden mit *Salicion polaris* Du Rietz 1943 em. Hadač 1989 und *Luzulo confusae-Salicetum polaris* Hadač 1989. Im Grøndalelven-Delta wurden die wiesenähnlichen und die leicht halophytischen Pflanzengesellschaften in zwei Gruppen eingeteilt: *Puccinellion phryganodis* Hadač 1946 (*Caricetum subspathaceae* Hadač 1946) und *Eriophorion scheuchzerii* Hadač 1939. Die Artenzusammensetzung und die Bedeckung mit erstmals auftretenden Pflanzengesellschaften wird im Zusammenhang mit der zweiten Sukzession beschrieben. Es wird berichtet, daß die offenen Gesellschaften mit vorherrschend ruderalen Arten (*Draba*, *Saxifraga*, *Gramineen* und Moosen) einer frühen Entwicklungsstufe auf kiesig-sandigem Substrat der feuchten Zwergstrauchtundra zugeordnet werden können. Eine natürliche Regeneration in Richtung der Primärgesellschaften ist unwahrscheinlich, da die Regenerationsfähigkeit der einheimisch vorherrschenden Arten (der nassen Moose und Zwergsträucher) gering ist. Nur die wiesenähnliche Vegetation der nassen Standorte zeigte eine hohe Regenerationsfähigkeit, um in den ursprünglichen Zustand zurückzukehren.

#### INTRODUCTION

The accelerated pressure of human activity on the tundra ecosystems and high sensibility of arctic plant cover to disturbances, such as caused by trails, roads and pits, give the prior importance to the problem of reclamation and restoration of disturbed tundra landscape.

Intensive studies concerned with natural degrees and rates of tundra vegetation recovery have been carried out in Alaska

(EVERETT et al. 1985) and the Canadian Arctic Archipelago (FORBES 1992a). Few studies have addressed revegetation of destroyed tundra sites in the European Arctic although geological reconnaissance, coal mining, drilling and pipe-laying had resulted in extensive plant cover disturbances.

The studies of natural recovery provide data on succession course and rate. The problem of short-term successions in the low Arctic has been analyzed in papers of HERNANDEZ (1978) and FORBES (1992b). Vegetation dynamics in the European Arctic still has been poorly covered. These studies on Spitsbergen can provide additional information to numerous papers concerning the plant cover of the archipelago (THANNHEISER & MÖLLER 1992). The only paper dealing with primary successions on Spitsbergen (TISHKOV 1986) studies colonization of substrata after the glaciers retreat and gives a scheme of chronochorological series on several kinds of substrata.

Presented here are some results of a plant recovery study from destroyed tundra habitat along the road at two high-arctic sites on the Vestspitsbergen west coast. The disturbances caused by tracked vehicles are considered to be typically associates with human activity in this area. The disturbances reported here include single spring and multiple winter passages of heavy and light tracked vehicles. Plant communities observed are representative of mesic and wet sites on the mountain terrains and coastal lowland. The objectives of this study are: (i) to analyse vegetation composition and structure of disturbed sites in connection with different microtopography and habitat conditions, (ii) to study species richness, rates of life forms and life strategies associated with disturbed sites and (iii) to discuss the data in the context of short-term syn-dynamics of high arctic plant cover.

#### SITE DESCRIPTION

The investigated sites were situated (1) at the south-exposed slope of Mount Ruscolen (Vestspitsbergen, Isfjord coast, 78° 10' N, 14° 10' E) and (2) in the Grøndalelven delta (Vestspitsbergen, Isfjord coast, 78° N, 14° E). Climate and soil conditions as well as flora and major plant communities of the Vestspitsbergen west coast have been described in papers of RONNING (1965) and HADAC (1989).

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The sites studied are considered to be associated with two distinct physiographic regions: (a) gentle low slopes and terrains of Mount Ruscolen covered by turf-hummocky willow moss mesic tundra and (b) level lowlands at the sea coast, where wet meadows on clayey silty and silty-sandy deposits are common.

Two clearly distinct study areas were chosen to examine recovery processes and patterns in different microclimatic regimes. In the first case (slope of Mount Ruscolen) the cover has been scraped after the single spring passage of heavy tracks. In the second case (coastal lowland) multiple winter passages of light tracks resulted in the disturbances of vegetation reported for this site. Both roads have been abandoned in the middle of the 80s. Since abandonment both sites had not received additional human modification with exception of assisted revegetation using sod-replacing, which has been attempted partly on the road on Mount Ruscolen.

## MATERIAL AND METHOD

The present study has been carried out during August 1991. Description of vegetation has been made using Braun-Blanquet methods (WESTHOFF & VAN DER MAAREL 1978). Plots described were subjectively located to represent (a) the variety of vegetation types on disturbed sites, and (b) the variety of correspondent undisturbed vegetation. In all, 12 plots were sampled on the road and the surroundings at the Ruscolen slope, and seven plots were sampled in the Grøn valley. Sizes of plots described varied from 100 m<sup>2</sup> (on coastal lowland) and 0.2-0.5 m<sup>2</sup> (in the turf-hummock tundra and mosaic-like plant cover on the road). Phytocoenoses sampled were uniform. Cover of each taxa has been estimated according to the 5-ball scale (WESTHOFF & VAN DER MAAREL 1978). The higher plants were identified as far as possible in the field; critical specimens have been collected to be studied in the laboratory. The same applies to the mosses and lichens. The plants were identified according to following literature: higher plants: A.M. TOLMACHEV, VV 1-10 (1964-1987); mosses: A.L. ABRAMOVA et al. (1961), A.J.E. SMITH (1978); liverworts: R.N. SCHLJAKOV, VV 2-5 (1979-1981); lichens: Handbook of the lichens of the USSR, V.1 (1971), V.2 (1975), V.5 (1978). Several specialists advised on the identification of critical specimens. A list of species mentioned is given in Appendix.

## RESULTS

The undisturbed vegetation of the site at the Ruscolen area (RC) can be related to order *Salicion polaris* Du Rietz 1943 em. Hadač 1989, association *Luzulo confusae-Salicetum polaris* Hadač 1989. It exhibits a turf-hummock complex with hummocks of 50-70 cm in diameter and 10-15 cm in height, often slightly elongated in the downslope direction. In the lower part of the slopes plant cover looks more homogeneous and comprises dwarf shrubs *Salix polaris*, *Empetrum harmaphroditum*, grami-

noids and herbs *Alopecurus alpinus*, *Poa alpina*, *Ranunculus sulphureus*, *Polygonum viviparum*. A dense moss-layer consists of *Drepanocladus uncinatus*, *Aulacomnium turgidum*, *Homalothecium nitens*, (record 157, Tab.1). Analogous vegetation was described in hollows of the turf-hummock complex (rec. 179, Tab.1). In sites affected by lateral current of water *Sphagnum squarrosum*-patches and *Calliergon stramineum* occur and graminoids are more numerous (rec. 178, Tab.1).

On hummocks of the turf-hummock complex scattered *Salix polaris* and *Luzula confusa* are almost the only vascular plants. Cryptogams occupy about 25 % and are rather numerous: *Bryoeritrophyllum recurvirostrum*, *Oncophorus wahlenbergii*, *Timmia norvegica*, *Gymnomitrium corallioides* and *G. apiculatum*.

The trail studied consisted of two 20 cm deep tracks and a prominent 1.2-1.5 m wide bank. The newly exposed unevenness of the substratum and different moisture distribution provides a number of different disturbance regimes and three relatively different plant communities: (1) scattered forbs on dry prominent banks, (2) moss turfs on seasonally moist tracks, and (3) a small moist meadow-like community along the water current in the track.

Scattered saxifragas, drabas and some graminoids (*Saxifraga caespitosa*, *Draba alpina*, *Phippsia algida*, *Poa alpina*) cover no more than 1-5 % of trail banks (rec. 170, Tab.1).

Tracks being not only somewhat moister, but also better drained and probably warmer than banks were characterized by a closed plant cover (rec. 171, 174). Vascular plants colonizing are *Phippsia algida*, *Poa alpina*, *Koenigia islandica*, *Cerastium alpinum* and saxifragas. Bryophytes that took part in colonization are apocarpic mosses with plentiful capsules, *Ceratodon purpureus*, *Leptobryum pyriforme*, *Oncophorus wahlenbergii*, *Bryum* sp. and *Pohlia prolifera* with numerous bulbs. They cover to 75 % of plots described. Mosses forming ground-layer of adjacent native plant cover (*Homalothecium nitens*, *Drepanocladus uncinatus*, *Aulacomnium turgidum*) were described with high constancy but lower coverage.

The part of the road covered using sod-replacing of turfs taken from meadow-like ruderal vegetation in surroundings of Barentsburg (rec. 162, Tab.1) represents a closed plant cover consisting of sods and gaps that were filled by invasion of rhizomatous species (*Poa alpina*, *Trisetum spicatum*). Some other vascular plants (*Saxifraga caespitosa*, *Salix polaris*, *Oxyria digyna*) were found as minor component of plant cover. Moss layer consisted of patches of *Drepanocladus uncinatus*, *Polytrichum alpinum*.

Differences in species composition of primary and native plant communities are obvious. Only 16 % of all taxa recorded from both disturbed and undisturbed sites were shared (groups A, A1, Tab.1).

It should be emphasized that the set of species on naturally unstable sites („frost scars“ of turf-hummock complex, rec.179 of Tab.1) differs from the set of „pioneering“ species on the track; only 9 % of the set of species were shared.

Botanically adjusted vegetation within vehicle track and „pioneering“ communities shared 34 % of all taxa recorded (group B of Tab.1). Almost a third (31 %, group C of Tab.1) of the species on newly bare substrata was found neither in the undisturbed adjacent plant cover, nor on the sods. Some species from undisturbed plant communities (*Salix polaris*, *Dicranum-mosses* and lichens *Peltigera leucophlebia*, *Cetraria islandica*) were not found in any disturbed site after up to 6-8 years.

The undisturbed vegetation of the sea coast in the Grøndalel-vendelta (GD) falls into two orders defined by HADAC (1989): *Puccinellion phryganodis* HADAC 1946, association *Caricetum subspathaceae* HADAC 1946 and *Eriophorion scheuchzerii* HADAC 1989. The first alliance comprised halophytic plant communities in general near the tide water level. *Carex subspathaceae* and *Dupontia pelligera* are characteristic taxa and often dominants of the low meadow-like extensive plant communities.

*Eriophorion scheuchzerii* comprises wetlands occurring in shallow, slightly salty habitats near the seashore (rec. 189, Tab. 2). *Dupontia pelligera* and *Equisetum arvense* are characteristic taxa. In sites described *Alopecurus alpinus* shared dominance in the field-layer, the moss cover consisted of *Calliergon stramineum*, *C. sarmentosum*, *Drepanocladus uncinatus*, *D. badius*, *Paludella squarrosa*.

The disturbance studied included multiple passages of light vehicle performed mainly in winter. After the exploitation of the road was completed, no attempts were made to restore and no further use was made of it. Since abandonment in the middle of the 80s recovery of vegetation on both banks and tracks of the seashore vehicle path resulted in re-establishing a closed native-like plant cover, with vascular plant richness increasing on the banks, despite their small area. *Polygonum viviparum*, *Cardamine nymantii*, *Saxifraga cernua* were described here as additional components to the native plant cover (rec. 190, Tab. 2). Species composition and cover on the tracks (rec. 188, Tab. 2) principally did not differ from adjacent extensive halophytic meadow-like vegetation. Almost all species registered in the primary community were present in the adjacent plant cover (groups A, B, C and D of Tab.2).

The part of the trail which crossed the sea terrain wetlands (ord. *Eriophorion scheuchzerii*) is represented by records 202 and 202b.

The habitat differentiation resulted in two distinct types of plant communities: patches of graminoids and mosses on prominent banks and closed plant communities in the 10-15 cm tracks. *Luzula confusa* was the only vascular plant species on the banks. Small turfs of *Leptobryum pyriforme* with plentiful capsules and

*Polytrichum*-species cover no more than 1-5 % of the surface. Wetter sites on tracks were occupied by closed plant communities with dominance of mosses. Moss cushions consist of *Drepanocladus uncinatus*, *Calliergon sarmentosum*, *C. giganteum* with patches of liverworts *Gymnomitrium corallioides*, *Scapania obcordata*, *Sphenolobus saxicola*. Grasses *Luzula confusa*, *Dupontia pelligera*, *Poa alpina*, *Phippisia algida* and forbs *Ranunculus hyperboreus*, *Saxifraga foliolosa*, *S. rivularis* were representatives of the field layer. Groups of species B and C of Tab. 2 of these track-communities show the transitional character between described natural communities of *Puccinellion phryganodis* and *Eriophorion scheuchzerii*.

## DISCUSSION

Results obtained give an opportunity to study the initial stages of invasion and succession on newly exposed substrata in the High Arctic. The data presented here revealed short-term succession courses in disturbance-sites in two distinct physiographic areas: in the willow-moss mesic tundra on mountain terrains and on the coastal lowlands amongst wet meadow-like plant communities.

As it has been found in context of succession in the Low Arctic (FORBES 1992b) each disturbance habitat exhibits a distinctive successional pattern reflecting differences in conditions of substrata. However, some general features of a succession course exist. All disturbance habitats in both areas investigated get readily occupied with invaders - saxifragas, drabas, graminoids - that are known to be successively spreading by stolons and runners (*Phippisia algida*, *Ranunculus pygmaeus*, *Carex subspathaceae*) and producing bulbs (*Saxifraga cernua*, *Polygonum viviparum*). All these vascular plants can be characterized as typical „successional explorers“ (sensu RABOTNOV 1978).

At the cryptogamic level, the bryophytes took advantage in colonization of the wettest sites (tracks of the path).The character of cryptogamic invaders in both areas shows some similarity. Mainly apocarpic mosses were found on new substrata with plentiful capsules (*Leptobryum pyriforme*, *Ceratodon purpureus*, *Oncosporus wahlenbergii*) or numerous bulbs (*Pohlia proligerica*), some of these species being lacking in adjacent plant communities. Clonal growth during the first years of colonization and shifting then to sexual production is referred to as important feature of a „colonists“ life strategy (DURING 1992).

The succession on tracks in mesic-tundra results in secondary communities which comprise mainly „pioneering“ species. These plants are of minor occurrence in tundra communities. Most advantage have species-invaders from replaced sods, that were used for botanical adjustment. The number of shared species (34 %) gives evidence of the comparative success of the ruderal meadow-like plant community representatives. „Colonist“-species as grasses, sedges, and mosses are suggested (1) to originate from propagules carried (stretched) from adjacent natural plant communities, such as *Poa alpina*, *Cerastium al-*

Releve no	157	179	178	175	170	171	174	162
Reference no	1	2	3	4	5	6	7	8
s.p.s., m <sup>2</sup>	4	1	4	0.5	0.5	0.2	0.2	4
Total cover %	95	50	95	75	1	75	95	95
Cover of dwarf shrubs %	75	25	50	-	-	-	-	5
Cover of herbs %	5	5	75	35	1	25	75	75
Cover of mosses %	65	50	75	75	1	50	75	95
Cover of lichens %	3							
Altitude a.s.l. in m	100	150	60	50	50	50	50	15
Exposure	S	S	S	S	S	S	S	-
Slope	3	-	5	-	-	-	-	-
Number of taxa	23	13	11	19	19	17	18	12
<i>Polygonum viviparum</i>	+	+	2	-	-	-	+	1
<i>Luzula confusa</i>	+	+	-	+	-	-	+	+
<i>Poa alpina</i>	+	2	1	-	3	3	-	2
<i>Alopecurus alpinus</i>	+	+	1	-	+	+	-	+
<i>Oncophorus wahlenbergii</i>	-	2	-	4	-	5	-	-
<i>Saxifraga rivularis</i>	-	-	+	+	-	+	+	-
<i>Equisetum boreale</i>	+	-	2	+	+	-	+	-
<i>Homalothecium nitens</i>	-	+	3	A1	1	+	-	- A
<i>Drepanocladus uncinatus</i>	-	-	+	+	+	-	-	-
<i>Calliergon stramineum</i>	-	-	+	+	-	-	-	-
<i>Hylocomnium alaskanum</i>	+	-	-	+	-	-	-	-
<i>Timmia norvegica</i>	-	+	-	+	-	-	-	-
<i>Ranunculus sulphureus</i>	-	-	+	-	+	-	-	-
<i>Salix polaris</i>	4	3	4	-	-	-	-	1
<i>Saxifraga cernua</i>	-	-	-	+	-	1	+	+
<i>Cerastium alpinum</i>	-	-	-	+	+	+	+	+
<i>Koenigia islandica</i>	-	-	-	+	+	3	+	+
<i>Phippsia algida</i>	-	-	-	+	+	1	+	+
<i>Ranunculus pygmaeus</i>	-	-	-	1	-	-	+	+
<i>Bryum sp.</i>	-	-	-	-	4	+	-	+
<i>Polytrichum alpinum</i>	-	-	-	-	+	-	+	+
<i>Saxifraga caespitosa</i>	-	-	-	-	-	+	B	+
<i>Saxifraga foliolosa</i>	-	-	-	-	+	-	-	+
<i>Cochlearia groenlandica</i>	-	-	-	-	-	+	-	+
<i>Draba alpina</i>	-	-	-	-	-	-	+	+
<i>Trisetum spicatum</i>	-	-	-	-	-	-	+	+
<i>Stellaria crassipes</i>	-	-	-	+	-	+	+	-
<i>Pohlia prolifera</i>	-	-	-	1	+	1	-	-
<i>Cerastium cerastioides</i>	-	-	-	-	-	+	+	-
<i>Sagina intermedia</i>	-	-	-	-	-	+	1	-
<i>Minuartia rubella</i>	-	-	-	-	+	-	+	-
<i>Pogonatum urnigerum</i>	-	-	-	-	+	C	+	-
<i>Ceratodon purpureus</i>	-	-	-	+	-	+	-	-
<i>Rhizomnium pseudopunctatum</i>	-	-	-	+	+	-	-	-
<i>Leptobryum pyriforme</i>	-	-	-	-	4	-	-	-
<i>Marchantia polymorpha</i>	-	-	-	3	-	-	-	-

Reference no	1	2	3	4	5	6	7
Releve no	189	190	188	187	202	200	200b
s.p.s. m <sup>2</sup>	0.2	0.2	4	4	0.5	4	0.2
Total cover %	100	100	50	55	75	100	5
Cover of herbs %	95	95	50	25	5	75	5
Cover of mosses %	5	95	25	25	75	100	1
Altitude a.s. l. in m	5	5	5	5	6-7	6	6-7
Number of taxa	3	10	6	18	13	12	6
<i>Dupontia pelligera</i>	-	3	-	2	+	4	-
<i>Stellaria humifusa</i>	1	+	2	2	-	-	-
<i>Carex subspathacea</i>	5	2	A	1	-	-	-
<i>Bryum arcticum</i>	5	5	3	-	-	-	-
<i>Puccinellia phryganodes</i>	-	-	4	2	-	-	-
<i>Ceratodon purpureus</i>	-	-	+	2	-	-	-
<i>Distichium sp.</i>	-	-	+	+	-	-	-
<i>Phippsia algida</i>	-	1	-	+	+	-	-
<i>Poa alpina</i>	-	+	-	-	+	-	-
<i>Cardamine nymanii</i>	-	+	-	+	-	-	-
<i>Saxifraga rivularis</i>	-	-	-	+	+	-	-
<i>Saxifraga foliolosa</i>	-	-	-	+	B	+	-
<i>Ranunculus hyperboreus</i>	-	-	-	+	+	-	-
<i>Calliergon sarmentosum</i>	-	-	-	1	3	2	-
<i>Drepanocladus uncinatus</i>	-	-	-	2	+	2	-
<i>Alopecurus alpinus</i>	-	-	-	+	-	C	3
<i>Ditrichum flexicaule</i>	-	-	-	-	+	+	-
<i>Bryum sp.</i>	-	-	-	+	-	-	+
<i>Luzula confusa</i>	-	-	-	-	-	1	D
<i>Scapania obcordata</i>	-	-	-	-	-	3	1
							+

**Tab.2:** Plant communities of disturbed and undisturbed sea lowland sites. Groups of species mean: group A = common species of disturbed and undisturbed habitats in *Caricetum subspathaceae*; group B = common species of undisturbed communities of *Caricetum subspathaceae* and vehicle track in communities of *Eriophorion scheuchzerii*; group C = common species as in the group B plus undisturbed communities of *Eriophorion scheuchzerii*; group D = common species of undisturbed communities and banks of track of *Eriophorion scheuchzerii*.

In one releve only: 190: *Phippsia concinna* (1), *Polygonum viviparum* (+), *Saxifraga cernua* (+). 187: *Dupontia psilosantha* (+), *Sagina intermedia* (+), *Festuca cryophila* (+), *Campylium polygamum* (+). 202: *Koenigia islandica* (+), *Calliergon giganteum* (+), *Sphenolobus saxicola* (+), *Cephalozia bicuspidata* (+), *Gymnomitrium coralloides*. 202b: *Leptobryum pyriforme* (+), *Polytrichum alpinum* (+), *P. juniperinum* (+). 200: *Equisetum arvense* (+), *Palutella squarrosa* (1), *Calliergon stramineum* (2), *Drepanocladus badius* (+), *Sphagnum squarrosum* (1).

Localities: 189: The rut of winter vehicle track on the sea lowland, in the site affected by tide-water, 1-2 m a.s.l. and 1.5 km to the south from Barentsburg. 190: Prominent banks of the same track. 187: Meadow-like plant communities on the sea lowland in site affected by tide-water, 1-1.5 km to the south from Barentsburg. 188, 200: Meadow-like wetlands on the sea terrain, at about 5-7 m a.s.l. and 2 km to the south from Barentsburg. 202: The track of vehicle path in the meadow-like wetlands. 202b: Prominent bank of the vehicle track.

**Tab. 2:** Pflanzengesellschaften auf gestörten und unberührten Standorten der Küstenniederung. Die Artengruppen bedeuten: Gruppe A = gemeine Arten gestörter und unberührter Verbreitungsgebiete im *Caricetum subspathaceae*; Gruppe B = gemeine Arten unberührter Gesellschaften im *Caricetum subspathaceae* sowie auf der Erdpiste von Gesellschaften des *Eriophorion scheuchzerii*; Gruppe D = gemeine Arten von unberührten Gesellschaften und auf der Böschung der Piste des *Eriophorion scheuchzerii*.

**Tab. 1:** Plant communities of disturbed and undisturbed willow-shrub tundra (Mt. Ruscolen, Vestspitsbergen). Groups of species mean: group A = common species of disturbed and undisturbed native habitats; group A1 = common species between undisturbed native and disturbed habitats affected by current water; group B = common species between disturbed habitats and meadow-like communities used for sod-replacing; group C = species presented in disturbed habitats only.

In one releve only: 157: *Empetrum hermaphroditum* (1), *Saxifraga hieracifolia* (+), *Pedicularis hirsuta* (+), *P. dasyantha* (+), *Sphagnum warnstorffii* (+), *Dicranum bonjeanii* (+), *D. elongatum* (+), *D. congestum* (+), *Polytrichum juniperinum* (+), *Kiaeria starkei* (+), *Blepharostoma trichophyllum* (+), *Lophozia groenlandica* (+), *Tritomaria quinqueedentata* (+), *Sphenolobus minutus* (+), *Peltigera leucophlebia* (+), *Cetraria islandica* (+). 179: *Bryoeritrophyllum recurvirostrum* (3), *Distichium sp.* (+), *Tortula ruralis* (+), *Gymnomitrium coralloides* (+), *Gapiculatum* (+). 178: *Sphagnum squarrosum* (+). 171: *Aulacomnium palustre* (+). 170: *Draba lactea* (+), *Cardamine bellidifolia* (+). 162: *Dupontia psilosantha* (3), *Oxyria digyna* (+). 157: Undisturbed site at south exposed gentle slope, above abandoned mining-factory „Colesbay“. 179: Scattered patches on the hummock of turf-hummock complex. 178: Undisturbed meadow-like cover with lateral water-current 56 m above vehicle path. 171, 174, 175: Seasonally inundated tracks of the heavy vehicle path. 170: Dry prominent bank of the heavy vehicle track.

**Tab. 1:** Pflanzengesellschaften auf einer gestörten und einer unberührten Weiden-Strauch-Tundra (Ruscolen-Berg, Westspitzbergen). Die Artengruppen bedeuten: Gruppe A = gemeine Arten gestörter und unberührter einheimischer Verbreitungsgebiete. Gruppe A<sub>1</sub> = gemeine Arten zwischen unberührten einheimischen und gestörten Verbreitungsgebieten, die durch fließendes Wasser beeinträchtigt sind. Gruppe B = gemeine Arten zwischen gestörten Verbreitungsgebieten und wiesenähnlichen Gesellschaften, die zur Sodenausschöpfung benutzt werden. Gruppe C = Arten, die nur in gestörten Verbreitungsgebieten vorkommen.

## I. Vascular plants

*Salix polaris* Wahlenb.  
*Polygonum viviparum* L.  
*Koenigia islandica* L.  
*Oxyria digyna* (L.) Hill.  
*Cerastium alpinum* Lange  
*Cerastium cerastoides* (L.) Britton  
*Sagina intermedia* Fenzl  
*Minuartia rubella* (Wahlenb.) Hiern  
*Ranunculus hyperboreus* Rottb.  
*Ranunculus pygmaeus* Wahlenb.  
*Ranunculus sulphureus* Sol.  
*Draba alpina* L.  
*Draba lactea* Adams  
*Cardamine nymanii* Gand.  
*Cardamine bellidifolia* L.  
*Cochlearia groenlandica* (L.) A. et D. Love  
*Saxifraga rivularis* L.  
*Saxifraga foliolosa* R. Br.  
*Saxifraga cernua* L.  
*Saxifraga caespitosa* L.  
*Saxifraga hieracifolia* Waldst. & Kit.  
*Stellaria humifusa* Rottb.  
*Stellaria crassipes* Hulten  
*Empetrum hermaphroditum* Hager.  
*Pedicularis hirsuta* L.  
*Pedicularis dasyantha* Hadac  
*Dupontia pelligera* Rupr.  
*Dupontia psilosantha* Rupr.  
*Puccinellia phryganodes* s.l. (Trin.) Scribn. & Merr.  
*Phippsia algida* (Sol.) R. Br.  
*Phippsia concinna* (Th. Fr.) Lindb.  
*Poa alpina* L.  
*Trisetum spicatum* (L.) Right.  
*Festuca cryophila* Krecz. et Bobr.  
*Alopecurus alpinus* Sm.  
*Carex subspathacea* Wormskj.  
*Luzula confusa* (Hartm.) Lindeb.  
*Equisetum boreale* Bong.  
*Equisetum arvense* L.

## II. Mosses

*Sphagnum squarrosum* Crome  
*Sphagnum warnstorffii* Russ  
*Pogonatum urnigerum* (Hedw.) P. Beauv.  
*Polytrichum alpinum* Hedw.  
*Polytrichum juniperinum* Hedw.  
*Dicranum bonjeanii* De Not  
*Dicranum elongatum* Schleich. ex Schwaegr.  
*Dicranum congestum* Brid.  
*Kiaeria starkei* (Web. & Mohr) I. Hag.  
*Oncophorus wahlenbergii* Brid.  
*Ceratodon purpureum* Brid.  
*Ditrichum flexicaule* (Schwaegr.) Hampe  
*Distichium* sp.  
*Tortula ruralis* (Hedw.) Gaertn, Meyer & Schreb.  
*Bryoeritrophyllum recurvirostrum* (Hedw.) Chen.  
*Leptobryum pyriforme* (Hedw.) Lindb.

*Pohlia proligera* (Kindb.ex Breidl.) Lindb. ex H. Arn.  
*Bryum arcticum* (R.Brown) B., S. & G.  
*Bryum* sp.  
*Rhizomnium pseudopunctatum* (B. & S.) T. Kop.  
*Aulacomnium palustre* (Hedw.) Schwaegr.  
*Paludella squarrosa* (Hedw.) Brid.  
*Timmia norvegica* Zett.  
*Campylium polygamum* (B., S. & G.) Lange & C. Jens  
*Drepanocladus uncinatus* (Hedw.) Warnst.  
*Drepanocladus badius* (Hartm.) G. Roth.  
*Calliergon stramineum* (Brid.) Kindb.  
*Calliergon sarmentosum* (Wahlenb.) Kindb.  
*Calliergon giganteum* (Schimp.) Kindb.  
*Aulacomnium turgidum* (Wahlenb.) Schwaegr.  
*Homalothecium nitens* (Hedw.) Robins  
*Hylocomium alaskanum* (Lesq. & James) Aust.

## III. Liverworts

*Blepharostoma trichophyllum* (L.) Dum.  
*Cephalozia bicuspidata* (L.) Dum.  
*Lophozia groenlandica* (Nees) Macoun  
*Tritomaria quinqueidentata* (Huds.) Ruch  
*Sphenolobus minutus* (Schreb.) Berggr.  
*Sphenolobus saxicola* (Schrad.) Steph.  
*Gymnomitrium corallioides* Nees  
*Gymnomitrium apiculatum* (Schiffn.) K. Mull.  
*Scapania obcordata* (Berggr.) S. Arn.  
*Marchantia polymorpha* L.

## IV. Lichens

*Peltigera leucophlebia* (Nyl.) Gyeln.  
*Cetraria islandica* (L.) Ach.

Tab. 3: List of species mentioned.

Tab. 3: Zusammenstellung der erwähnten Arten

*pinum*, *Ranunculus pygmaeus*, *Charex subspathacea*, (2) to re-establish from diaspores saved in the „seed bank“ (*Leptobryum pyriforme*, *Ceratodon purpureus*, *Bryum* sp., group D of Tab. 1).

The invasion of pleurocarpic mosses from adjacent plant communities remains minimal, although they have high constancy. Re-establishing of the natural community through gradual invasion of undisturbed tundra vegetation is not likely to recover to pre-disturbance status of the community in mesic sites, because of low ability of dwarf shrubs and pleurocarpic mosses to occupy bare substrata. This failure of many native tundra species to re-establish themselves in disturbed sites after up to 6-8 years gives evidence that bare substrata arising in dwarf shrubs lowlands and terrain tundra will be occupied by rather heterogeneous plant communities with prevailing species-ruderals, mainly graminoids and apocarpic mosses. These plant communities are supposed to be replaced gradually by closed graminoid-dominated communities related to ass. *Oxyrio-Trisetum spicati* HADAC 1989. This association has been described in surroundings of Barentsburg, with noteworthy anthropic influence.

Successful re-invasion by rhizomatous species from adjacent undisturbed vegetation is reported only for the wettest sites on the coastal lowlands (GD, Tab. 2, rec. 187-190), where primary plant cover on both tracks and banks of the path did not differ essentially from undisturbed vegetation and eventually obtained their pre-disturbance status. Early successional course on the bare sandy-silty marine deposits is determined directly by species composition of adjacent plant communities.

The successional course on bare substrata at the west coast of Vestspitsbergen is similar to those reported from Northern Alaska (EVERETT et al. 1985) and the Canadian Arctic Archipelago (FORBES 1992a), where pioneer mosses and rhizomatous graminoids were reported to have success at the first succession stage.

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