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Scientific note

A two-year change of arctic vegetation as observed in a permanent plot established in Ny-Ålesund, Svalbard

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***Abstract*:** In 1997, a permanent plot was established in an abandoned coal mine site on the outskirts of Ny-Ålesund, Svalbard, to describe the present vegetation structure and to monitor future vegetation change. A 1 m × 1 m quadrat was set up and was further divided into 100 small cells (subquadrats). All the vascular species were listed and their presence was recorded for each of the subquadrats. In 1999, the plot was revisited and all the subquadrats were rechecked for any change of species occurrence.
The field data of 1997 and 1999 were compared and change of species occurrences was scrupulously examined for each subquadrat. In general, a considerable increase of occurrences of plants as expressed in the number of subquadrats took place during the two years. This suggested that even during the observation period the vegetation kept changing rapidly along with the progress of vegetation succession.

key words: arctic, Ny-Ålesund, permanent plot, vegetation monitoring

It is generally anticipated that, if global climate warming due to increase of greenhouse gases really takes place, the arctic biome would be the one most pronouncedly affected by the warming (IPCC, 1996). It is not only an interesting subject academically but also important socio-economically to assess how the arctic vegetation would respond to climate change because it may eventually alter the biospheric characteristics of the Arctic and in turn may influence human society considerably in unpredictable ways.

In the Arctic, because of the extremely harsh environment, progress of vegetation succession is considered to be very slow or even might practically not progress (Churchill and Hansen, 1958; Webber, 1978). However, if climate becomes warmed, it will naturally influence the rate of vegetation succession and may eventually alter the course of vegetation succession.

In the southern outskirts of Ny-Ålesund town site, there was once a large coal mine which had been in operation since the 1910s. But after repeated accidents in the late 1950s and particularly after a big explosion in 1962, the mine was completely shut down and the whole area was deserted (Hjelle, 1993). Since then, the mine site has been left free from human interference and natural vegetation succession has started. The mine site, thus, provides a good opportunity to observe how the vegetation succession will advance in such an abandoned coal mine site under the changing arctic environment. In 1997, a permanent plot of 1 m × 1 m size was established to monitor vegetation change in

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such a condition.

The present note is intended to describe, as an interim report, vegetation change that took place in the plot after two years since 1997. A more thorough study as to vegetation succession will be made in 2002 after five years since the establishment of the permanent plot.

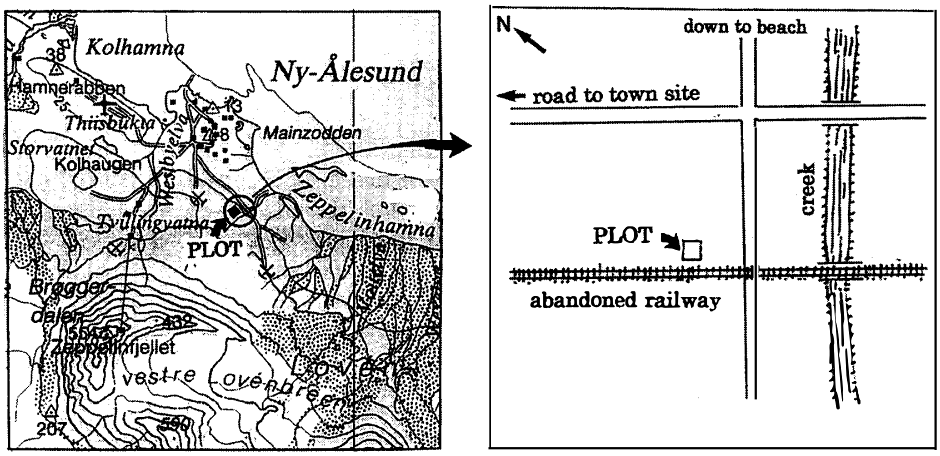

Fig. 1. Location of the plot site. The plot is located approximately 1 km southeast of Ny-Ålesund in an abandoned coal mine field.

The study site is located approximately 1 km southeast of Ny-Ålesund near the base of Mt. Zeppelin (Fig. 1). Its latitude is 78°51.79′N and longitude 11°51.93′E. Elevation is approximately 30 m above sea level. For 1998, mean annual temperature was −5.4°C with mean monthly temperature of the warmest month 6.2°C and that of the coldest month −17.3°C at Ny-Ålesund (Morimoto *et al.*, 2000). Mean annual total precipitation generally ranges 200–400 mm for Svalbard (Elvebakk and Spjelkavik 1995). Relief is irregularly and gently undulating with piles of heaves of mining waste material, which predominantly consist of Carboniferous and Permian rocks of limestone and dolomitic nature. The ground surface was covered with fine dark-colored platy gravel. Vegetation is typically open tundra with very low vegetative cover.

The study site was situated on level ground beside an abandoned railway track. When the coal mine was in operation, the site was under heavy and continuous disturbance due to the mining operations. Then, there would have been no chance for natural vegetation to develop until the mine was completely abandoned. Vegetation is, therefore, very young. It is at most 40 years old approximately.

In August 13, 1997, a 1 m × 1 m quadrat was set up on level ground near the abandoned railway track (Fig. 2). Red plastic pegs were placed at the four corners of the quadrat and a yellow plastic rope was tied at each corner to make a 1 m × 1 m square. The quadrat was then subdivided into 100 contiguous small cells (subquadrats) of 10 cm × 10 cm size. A thin yellow plastic string demarcated the 100 subqudrats (Fig 3). All the subquadrats were co-ordinated in combination of alphabetical letter and numerical number, such as A5, F6, etc. They were closely examined for presence of vascular plants and any occurrence was recorded for each subquadrat. At that stage, only the

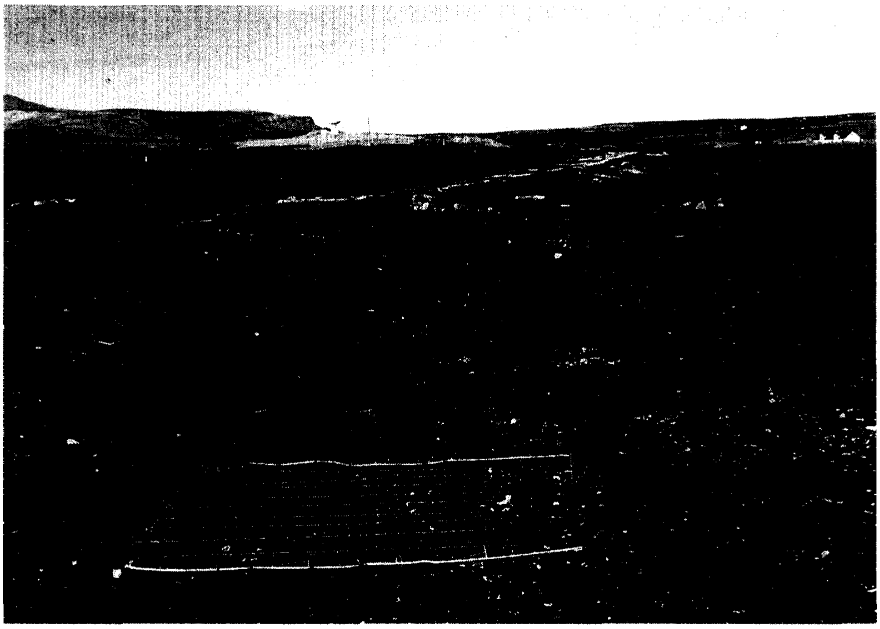

Fig. 2. The plot and surroundings, showing an abandoned railway track in the background.

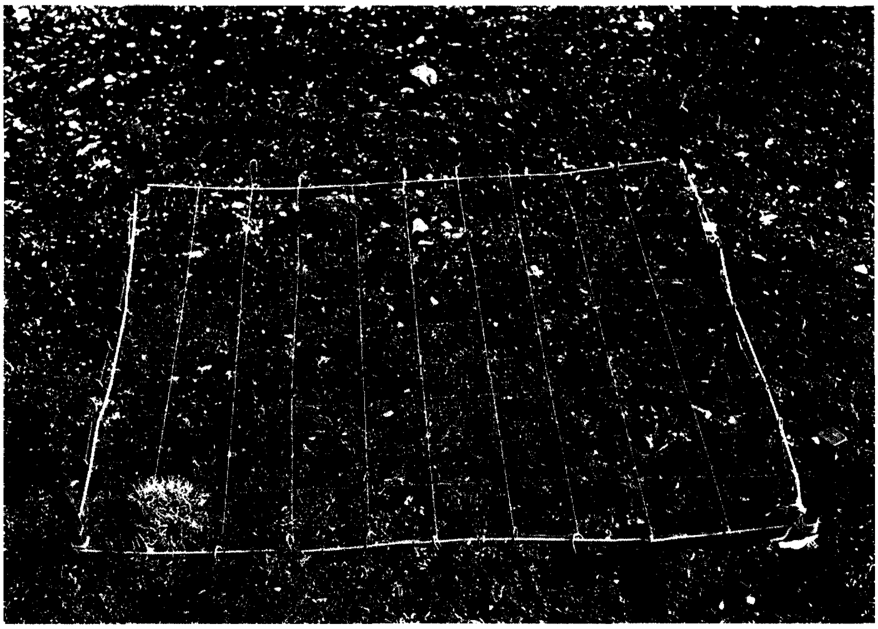

Fig. 3. The plot divided into 100 small cells of 10 cm × 10 cm size. Each cell represents a subquadrat in which all the vascular plants were recorded.

presence or absence of the species was recorded and areal coverage was not assessed. Although, besides vascular plants, lichens and bryophytes were indispensable elements of the arctic vegetation, they were not included in this study because of technical and practical difficulty to determine the species and assess accurately their occurrences in the field. After two years, in August 8, 1999, the plot was revisited and all the subquadrats were rechecked for the occurrences of vascular plants with the same procedures as in 1997. The field documentation of 1997 and 1999 was then compared and changes of occurring patterns were examined.

A total of seven vascular species were recognized in 1997. They were *Carex misandra, Luzula confusa, Polygonum viviparum, Salix polaris, Saxifraga caespitosa, S. oppositifolia* and *Silene acaulis*. In 1999, however, in addition to the above, *Juncus biglumis* and *Pedicularis* sp. were found in the plot. The most common species was *Salix polaris*, followed by *Polygonum viviparum*, *Saxifraga oppositifolia* and *Luzula confusa*. Table 1 shows occurrences of the species as expressed in the number of subquadrats both in 1997 and 1999, respectively. In general, occurrence substantially increased from 1997 to 1999. Nevertheless, if we closely look at each subquadrat, we will notice that occurrences of the species vary from subquadrat to subquadrat. In some subquadrats, new emergence of plants took place while in others they disappeared.

Table 1. Numbers of subquadrats containing the species in 1997 and 1999.

Species \ year	1997	1999
Salix polaris	78	90
Polygonum viviparum	60	76
Saxifraga oppositifolia	33	56
Luzula confusa	14	18
Carex misandra	4	4
Silene acaulis	4	4
Saxifraga caespitosa	2	2
Juncus biglumis	0	2
Pedicularis sp.	0	2

The patterns of the species in each subquadrat may be categorized as follows: case 1: the species was present both in 1997 and 1999, case 2: the species was present in 1997 but disappeared in 1999, and case 3: the species did not exist in 1997 but emerged in 1999. The patterns of the species are illustrated in Fig. 4. Such diagrams will be useful for checking species' behavior in the future. Table 2 shows net changes of the species from 1997 to 1999 as shown in the number of subquadrats. In net change, *Saxifraga oppositifolia* increased most followed by *Polygonum viviparum* and *Salix polaris*. In terms of manner of species increase, it is conceivable that there would be two different types of increase, *i.e.*, vegetative expansion by shoot elongation or tuft expansion and by seed germination. At this stage of the study, types of species expansion have not been distinguished. However, from general observation, new emergence of *Saxifraga oppositifolia* and *Salix polaris* may belong to the former case, those of *Polygonum viviparum, Luzula confusa, Juncus biglumis* and *Pedicularis* sp. the latter case.

Vegetation of the study site is rather young in terms of vegetation succession as vegetation recovery has started since the 1960s after the closure of the coal mine. Vegetation succession appears to be still rapidly progressing. Indeed, a considerable increase of vegetation was recognized even during the two years of this observation.

Despite the very early stage of the vegetation succession at the site, all the vascular

Table 2. Net change of species as expressed in number of subquadrats.

Spesies \ Status	Present in 1997	Survived in 1999	Disappeared in 1999	New emergence in 1999	Net change in two years
Salix polaris	78	76	2	14	+12
Polygonum viviparum	60	59	1	17	+16
Saxifraga oppositifolia	33	32	1	24	+23
Luzula confusa	14	11	3	7	+4
Carex misandra	4	4	0	0	0
Silene acaulis	4	3	1	1	0
Saxifraga caespitosa	2	2	0	0	0
Juncus biglumis	0	0	0	2	+2
Pedicularis sp.	0	0	0	2	+2

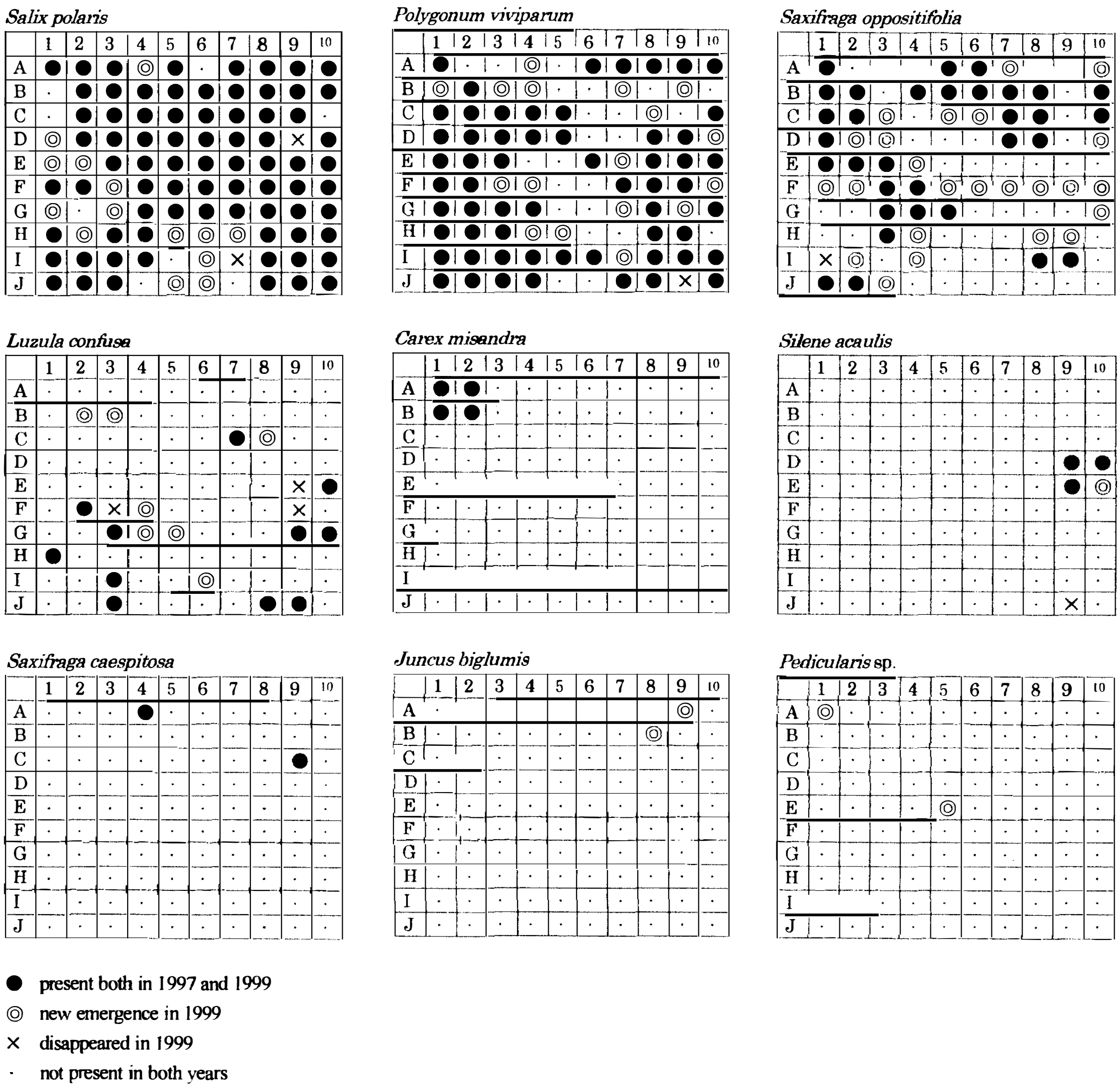

Fig. 4. Two-year changes of species occurrences.

species potentially represent the final climax stage. In other words, there is no difference in vascular species composition between the early and final stages of vegetation succession. Pioneer species could be also the final ones. This is quite different from the case of the vegetation succession in the temperate region, where the pioneer species are replaced by climax species as the succession progresses. One possible explanation of this may be that arctic plants are generally heliophytic and short in height. No plants shade over other plants even as the succesional stage advances. Such a succession is unique to the high Arctic and is termed a "nondirectional and species nonreplacement succession" (Bliss and Peterson, 1992). Another peculiar feature is that there is no weedy or introduced plants in the plot despite it represents an initial stage of the succession and used to be under heavy disturbances by human activities until recently. In a temperate region, it is usual for weedy and ruderal plants to dominate in disturbed sites. But in this case, there are no such plants. All the plants occurring are indigenous and possibly climax species.

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