In situ observations of injuruy and damage on vegetation in the period 1987-2011

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Diagnosis of abiotic and biotic stress factors using the visible symptoms in foliage

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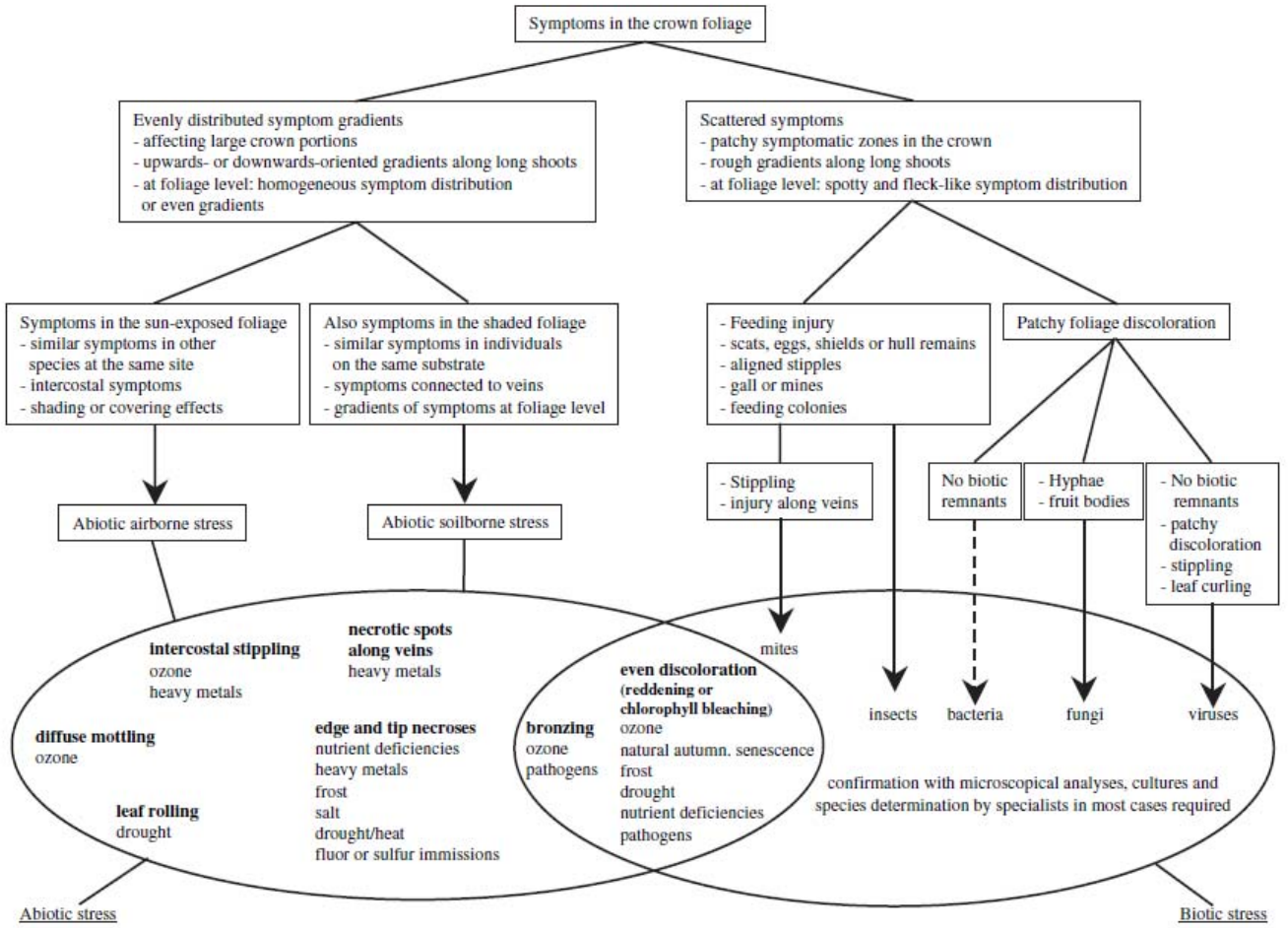

Fig. 1. Diagnosis flow chart for the identification of visible symptom types in the foliage. Application range: deciduous bush and tree species from central Europe, but also usable for conifers in the same temperate zone. The arrows in the model indicate the class of stress factors causing the visible symptoms, on the basis of the symptom morphology in the foliage and the symptom distribution and frequency at the foliage, branch and crown level.

Symptoms of sulphur dioxide injury to some boreal plants

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Abstract

High concentration of sulphur dioxide is known to be harmful to plants. Damage to several boreal plants caused by sulphur dioxide is here reported from the border areas between Norway and Russia. The symptoms are described in text and colourplates. High levels of pollutants in plant tissue are documented through chemical analysis.

Introduction

Atmospheric sulphur dioxide (SO_2) originates from both natural and man made sources with volcanic activity being the main natural source. Heavy industry, and specifically metal smelters, are common man made sources of SO_2 emissions in the boreal areas of NW Russia. SO_2 is a gas under normal conditions. The major effects of SO_2 on forest plants are well known (Linzon 1978, Tamm & Aronsson 1972) with severity of damage depending on SO_2 concentration. At relative low concentrations SO_2 may not be harmful to plants or it may even have a positive effect where soil sulphur is a limiting factor. Severity of damage depends on the plant species and age (Linzon 1978), but SO_2 is normally harmful to plants, especially near the source of emissions. A common effect in many plant species is destruction and reduction of chlorophyll (Singh 1989). Major damage is mostly related to episodes of very high SO_2 concentrations and results in necrosis of plant tissues. However, destruction of chlorophyll can occur without subsequent necrosis (Lauenroth & Dodd 1981), e.g., under chronic exposure to low concentrations of SO_2. Sublethal amounts of SO_2 may stunt plant growth (Lendzian & Unsworth 1983). Factors such as light, pH and age of tissue determine the effect on the plant.

This paper describes symptoms of SO_2 injury on some common boreal plants. When observing such symptoms it is important to bear in mind the mediating influence of various factors such as those mentioned above.

In: Jalkanen, R., Aalto, T. & Lahti, M-L (eds.). Forest pathological research in northern forests with a special reference to abiotic stress factors. Extended SNS meeting in forest pathology in Lapland, Finland, 3–7 August, 1992. Metsäntutkimuslaitoksen tiedonantoja 451: 93–102.

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Figure 2. *Pinus sylvestris*, Sør-Varanger, Norway, 1987.

Figure 3. *Betula pubescens*, Sør-Varanger, Norway, 1991.

Figure 4. *Betula nana*, Sør-Varanger, Norway, 1991.

Figure 5. *Salix caprea*, Nikel, Russia, 1990.

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SO_2 injury Nikel - Kola August 1990

Observations of coloration and injury to leaves and needles of rowan, birch, pine and aspen. Suc
observations were done mainly on single trees in forest edges or areas with low density of trees
Phenological observations for the sites in Esrange and Karasjok carried out by METLA (www. Metl

Site	Rowan	Date	Comments	Birch	Date	Pine needles	Aspen	Phe
Tromsø (Norway)	Indication of chlorosis, Bronzing, undeveloped leaves	20.05.06 - 10.06.06	Confirmed: I. Børja, 18-06-06	Slight yellowing leaves	05-06-06	Yellowing in May		Yel
Målselv (Norway)	Chlorosis, Bronzing, undeveloped leaves	15-06-06		Slight yellowing leaves	15-06-06			Yel
Nordreisa (Norway)	Chlorosis, Yellowing of leaves, undeveloped leaves	01-07-06			01-07-06			Yel M
Esrange (Sweden)	Yellowing of leaves, undeveloped leaves	03-08-06		Yellowing, mottling and bronzing of leaves. Indication of necrosis. Some oxidative stress due to prevailing ozone, low temperatures, pathogens and nutrient imbalance	03-08-06	Yellowing	Yellow and reddening of leaves	Buc 08-0 Yel 07-0
Karasjok (Norway)				Yellowing, mottling and bronzing of leaves. Indication of necrosis. Some oxidative stress due to	04-08-06	Yellowing	Yellow and reddening of leaves	Bu 17-05-0

Rowan with indications of chlorosis in Tromsø June 8th 2006 (left) and 30rd July 2006 (right). Also yellowing/mottling and some bronzing dominates the leaves. Chlorosis confirmed by The Norwegian Institute for Forest and Landscape (I. Børja)

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Box 1. *Sorbus aucuparia* (L.), rowan, an example of an O_3 bioindicator?

Rowan is one of the species recommended as an O_3 bioindicator tree species (56). It is also one of the species that has lengthened its vegetative growth period as a result of the advancement of spring in Finnish Lapland (11). The unprecedented O_3 concentrations measured in northern Fennoscandia in April and May 2006 (Fig. 1) were due to a severe transport episode of highly polluted air masses partly linked to extensive agricultural fires in the Baltic region (5). These high O_3 concentrations coincided with high temperatures and a very early start in the growing season. For example, rowan was observed to burst its buds on the 6th of May and birch on the 7th of May in the Tromsø area in NW Norway. This was followed by a cool period—with rain and even snow in mid-May—which lasted until the end of May. Relatively low temperatures were also measured at the end of July (58). The long-lasting O_3 episode at the beginning of the growing season combined with episodes of elevated O_3 at the beginnings of June and July may have caused the observed injury to rowan (e.g., stippling and necrosis) and birch (mottling and bronzing). These injuries were observed in Tromsø and Karasjok, northern Norway, and in Esrange, northern Sweden, from the start of June to the end of August (Box Fig. 1). These observations are in accordance with the results of Mortensen (25) and because no plausible alternative explanations exists according to the diagnostic schemes (59), we assume that there is a causal relationship between the episodes of elevated O_3—in combination with low air temperature—and the observed injuries to rowan and birch leaves.

Box Figure 1. Rowan (*Sorbus aucuparia*) leaves showing chlorotic and brown-reddish stippling and red-brown necrotic areas in the leaf margins. Photographed in Tromsø (69°38′ N, 18°55′ E), NW Norway, on 30 July 2006. (Photo: H. Tømmervik)

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Tromsø July 30rd 2006

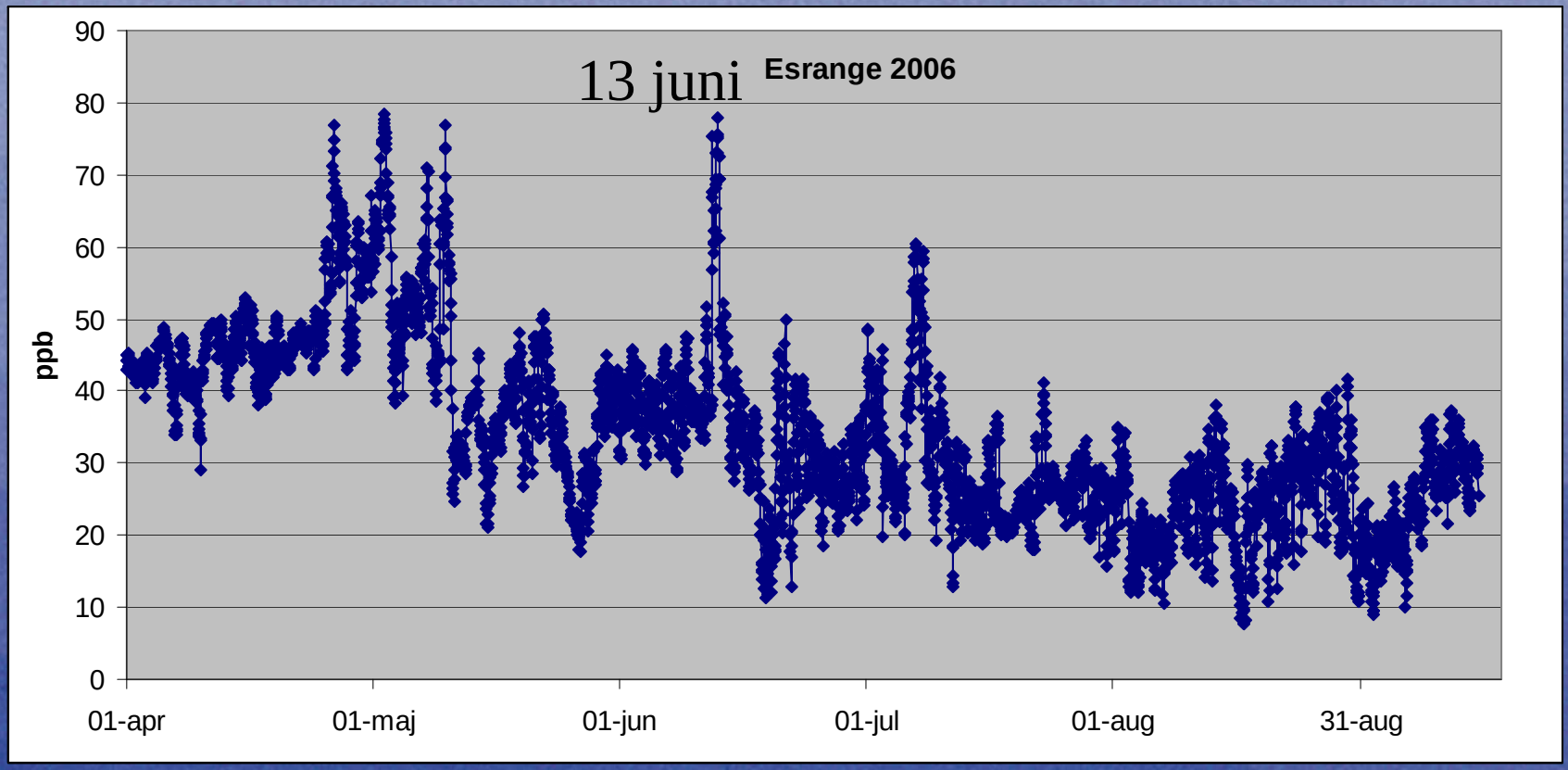
Tromsø Birch June 8th 2006

Tromsø July 30rd 2006

Tromsø July 30rd 2006

Tromsø July 30rd 2006

Tromsø June 3rd 2007



Preliminära data, ej korrigerade för kalibrering

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Esrange Birch August 3rd 2006

Esrange Birch August 3rd 2006

Esrange Birch August 3rd 2006

Esrange Birch August 3rd 2006

Esrange Birch August 3rd 2006

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Esrange – Jukkasjærvi Rowan August 3rd 2006

Esrange – Jukkasjærvi Rowan August 3rd 2006

Esrange Rowan August 3rd 2006

Esrange Rowan August 3rd 2006

Esrange Rowan August 3rd 2006

Karasjok Birch August 4th 2006

Karasjokfjellet Birch August 4th 2006

Karasjok Birch August 4th 2006

Bronzing in birch leaves in a forest edge near by the EMEP-station in Karasjok. The other trees on the picture are mostly green.

Karasjok Birch August 4th 2006

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In Figures 17- 20, injuries on leaves of rowan and birch which are presented that may be caused by a combination of different air pollutants (mix of O3, ammonia and other compounds). Similar injuries to the species like we observed in 2006, have not been observed during other periods. Hence, there may be a connection between these leaf injuries and high ammonia episodes in combination with other pollutants like O3 or other compounds. Microscopy revealed injuries that may have a connection to elevated O3-levels in combination with ammonia or other pollutants, since injuries to the vax-layer were frequent. Marbling, mottling, stipling, brown spots, fungi-attacks as well as change in coloration were also frequent. Other drivers could also have reinforced the injuries observed, such as climate conditions (frost in spring and drier weather conditions). On the other hand, normal conditions due to precipitation were observed in northernmost Sweden and in northern Norway during spring and summer 2006 (www.met.no; www.smhi.se).

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Figure 17. Rowan leaves (june 2006) from Veltvatn-Dividal (Øverbygd-Målselv), enhanced 10x.

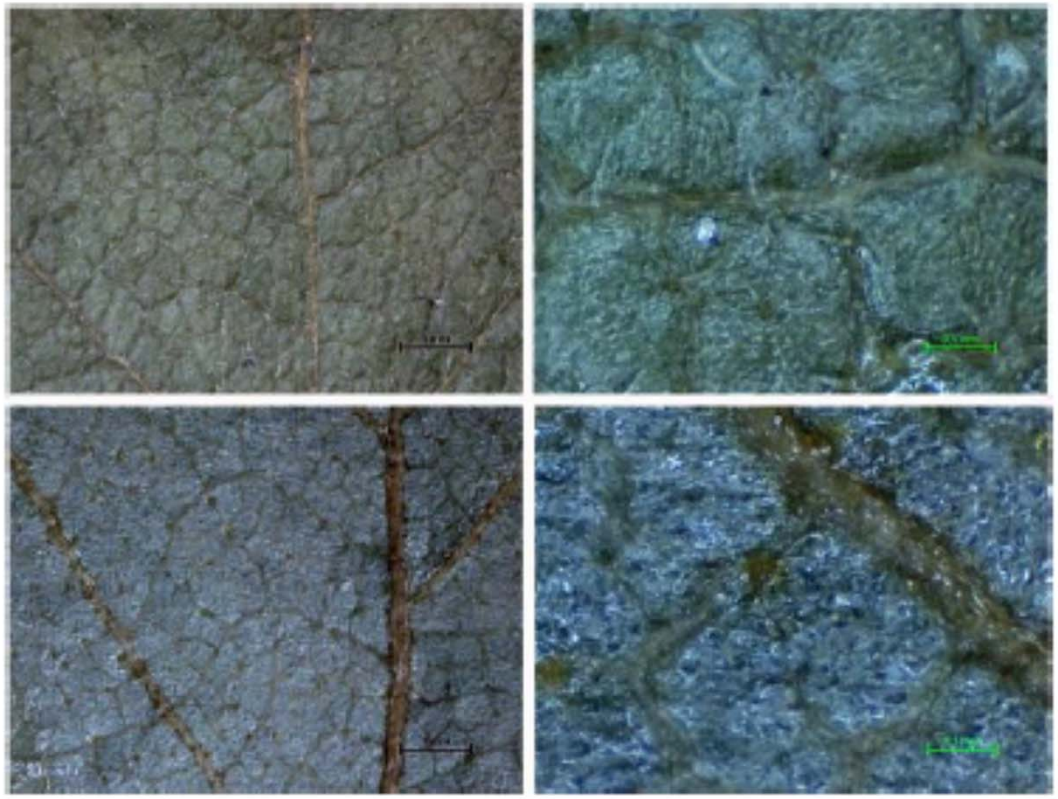


Figure 18. Birch leaves from (june 2006) sampled in Veltvatn-Dividal (Øverbygd-Målselv), enhanced 10x (left) and 60x (right).

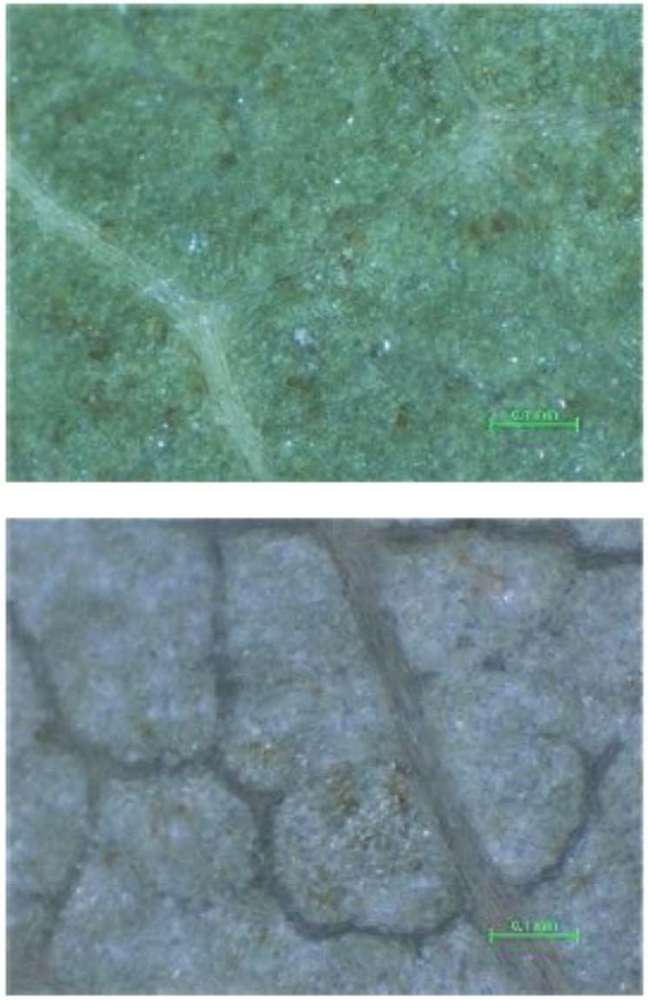
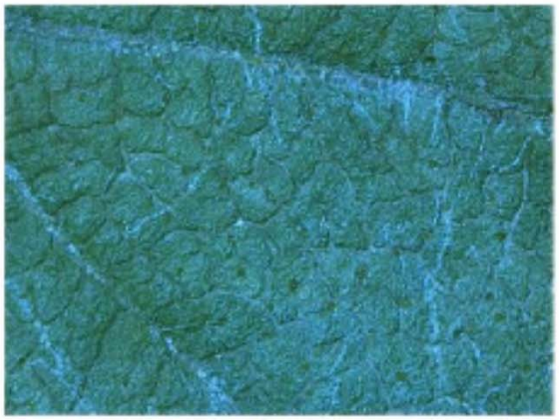
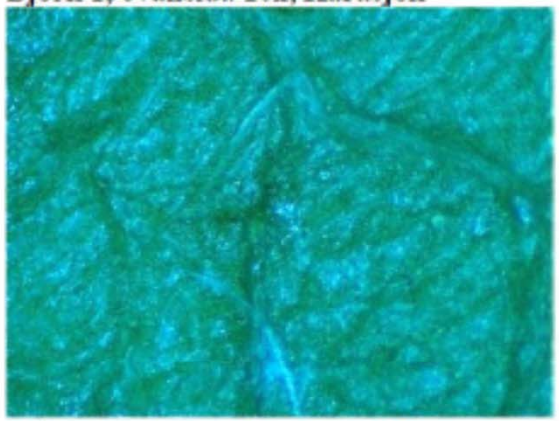


Figure 19. Rowan leaves from (July 1st. 2006) sampled in Nordreisa), enhanced 60x.

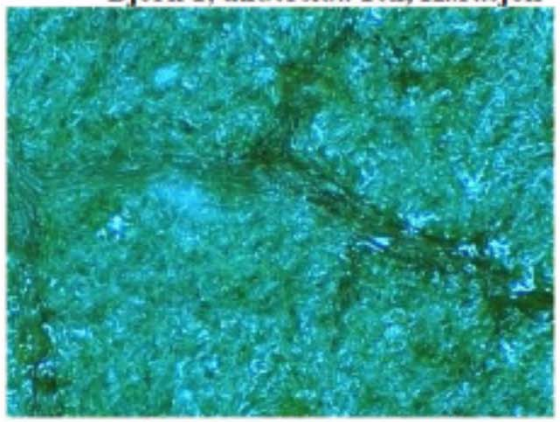
Björk 1, ovansida 10x, Karasjok



Björk 1, undersida 10x, Karasjok



Björk 1, ovansida 60x, Karasjok



Björk 1, undersida 60x, Karasjok

Figure 20. Birch leaves from Karasjok with concentric rings, injuries to the wax-layer and small brown spots.

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Karasjok Birch August 4th 2006

Karasjok pine August 4th 2006

Karasjok pine August 4th 2006

Lakselv Rowan August 4th 2006

Damage by climate or air pollution

- Hammerfest – Kvalsund August 2006
- Empetrum nigrum – crowberry -Tromsø June 2006
- Vaccinium myrtillus - Bilberry Tromsø June 2006

Fig. 2. Skråning med hovedsakelig død krekling. Kvalsund kommune, Finnmark, august 2006.

Fig. 3. Visne greiner av blåbær blant friske skudd av skrubbær. Tromsø kommune, Troms, juni 2006.

Fig. 1. Detalj av brun krekling. Tromsø kommune, Troms, juni 2006.

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