

Key note address:

^{137}Cs in reindeer forage plants 1986—1988

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The entire Swedish reindeer area was to some extent contaminated by radionuclides after the accident at Chernobyl, USSR, in 1986. As much as 10% of the total emission of ^{137}Cs + ^{134}Cs may have hit Sweden, mainly as wet deposition. This took place over eastern and northern Sweden in connection with precipitation on April 28—30. Rain fell on the major part of the area and only in northernmost Sweden was the precipitation snow. No significant differences in estimated ^{137}Cs activity concentrations in the precipitation, whether rain or snow, were, however, found (Persson, Rode and De Geer, 1987).

The fallout hit the reindeer area when most of the ground, except knolls, southfacing slopes, river banks, etc., was still covered with a more or less impenetrable layer of hard snow. Thus, arboreal lichens might have been the first forage plants with high activity concentrations of radionuclides that reindeer encountered. For example, in northern Jämtland, *Bryoria fuscescens* with 120,000 Bq $^{137}\text{Cs} \cdot \text{kg}^{-1}$ d.m. was found at Brattliden and at Torsfjärden the activity amounted to 34 000 on June 4 (Eriksson et al. 1987).

Most soils within the reindeer area have low pH, often high organic content and minor amounts of clays and minerals, which are important for binding radiocesium (Svenska Säll-

skapet för Antropologi och Geografi, 1953—1971). Thus, significant amounts of radiocesium are also found in vascular plants. At Tällvattenmon, county of Västernorrland, heather (*Calluna vulgaris*) with an activity concentration of ^{137}Cs amounting to 32 000 Bq kg^{-1} d.m. was sampled on July 1986. At Mossavattnet, county of Västerbotten, rhizomes of sedges (*Carex spp.*) were found with 12 000 Bq of $^{137}\text{Cs} \cdot \text{kg}^{-1}$ d.m. on October 10 (Eriksson et al. 1987).

The task of the Reindeer Section is to concentrate on applied research directed towards the reindeer trade. Hence, the botanical work was from the beginning focused on monitoring ^{137}Cs in plants and parts of plants of direct importance to reindeer as forage.

A basic material consisting of (*Cladina arbuscula*), heather and crowberry (*Empetrum hermaphroditum*) was sampled from almost all over the reindeer area with emphasis on the winter range. The plants were dried, ground and measured with a Ge (Li) detector by the Swedish Defence Research Establishment, Dept. of NBC Defence, Umeå (Eriksson et al. 1987).

During the fall, the Sami communities were offered a sampling scheme of their own by the National Board of Agriculture. About twenty lichen samples, mainly *Cladina arbuscula*, were sampled in most communities. Totally more

than seven hundred samples were treated and measured by the Dept. of Radioecology, Swedish Univ. of Agr. Sciences.

Only the top third of the lichens was collected, as grazing is usually concentrated to this part of the plant. Also, the tops of the lichen thalli usually store the highest concentration of cations, for example ^{137}Cs (Lidén and Gustafsson, 1966, Tuominen and Jaakola, 1973).

From vascular plants, mainly annual shoots were sampled much for the same reason as for the lichen sampling.

Since ^{137}Cs activity concentrations in reindeer lichens (*Cladina spp.*) growing close together do not differ very much (Tuominen and Jaakola, 1973), all data on ^{137}Cs activity

concentrations in reindeer lichens were processed and a map was produced, by means of floating mean values and block-kriging, showing the distributing of ^{137}Cs activity concentrations in reindeer lichens throughout the reindeer winter range (fig. 1).

The general pattern is much the same as the one found on the standard maps based on aerial surveys showing the ^{137}Cs activity deposition (SGAB, 1986, these proceedings, page 10). The peak areas, with ^{137}Cs activities in reindeer lichens well above $40 \text{ kBq} \cdot \text{kg}^{-1} \text{ DM}$, were found around Lake Vojmsjön, county of Västerbotten, in the NW corner of the county of Jämtland and in the interior part of the county of Västernorrland. It should also be noted that the whole of the county of Norrbotten is affected to some extent but, except for the SW part along the Skellefte river, not enough to bring reindeer meat above the action level.

Comparison between radiocesium activity concentration in the basic set of sampled forage plants of 1986, i.e. *Cladina arbuscula*, heather and crowberry from 130 sites revealed that the load in heather was about $40\% \pm 5$ and that of crowberry was $20\% \pm 3$ of that in *Cl. arbuscula*.

Activity concentrations of ^{137}Cs in forage plants growing on permanent plots (fig. 1) were measured in 1986–1988.

Among lichens, *Cladina arbuscula* is paid special attention. As compared to the 1986 level, status quo prevailed at three sites — Bjurholm, Rackosjön and Ullatti. A 40% decrease was noticed at one site — Kubbe. This decrease was even more pronounced in *Cl. rangiferina* (60%). The main difference between the status quo sites and Kubbe, is that Kubbe started out in 1986 with much higher ^{137}Cs activity concentrations in the ground vegetation.

At one site — Rackosjön —, several samplings of *Cl. arbuscula* were carried out during the summer of 1987. (fig 3.) They revealed considerable fluctuations in the Cs-load. The low

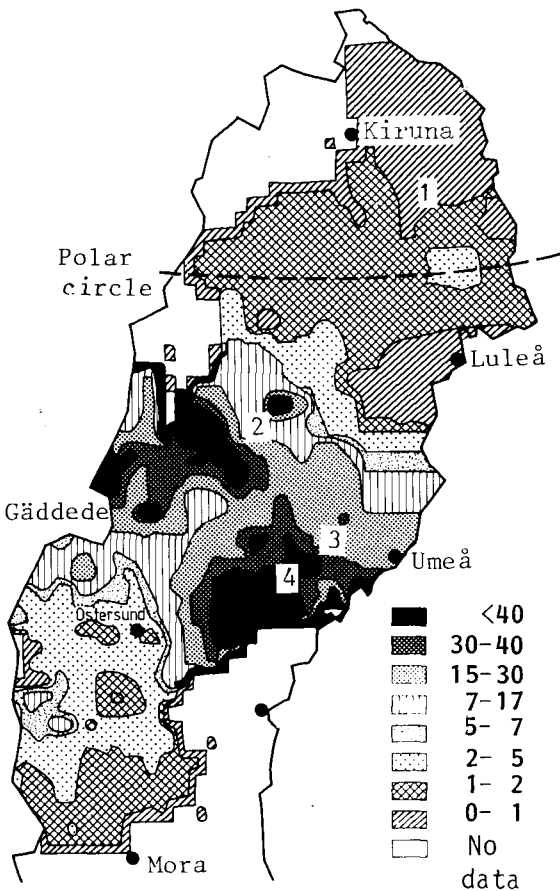


Figure 1. Cs-137 in reindeer lichens (*Cladina spp.*) kBq/kg DM. Permanent study plots: 1. Ullatti. 2. Rackosjön. 3. Bjurholm. 4. Kubbe.

value ($9304 \pm 1160 \text{ Bq } ^{137}\text{Cs/kg}$), about 65% of the peak value, was registered at the height of the summer, when the water had been rather dry for a period of time, whereas high concentrations were measured during periods of rainy weather. Uneven distribution of radiocesium within the sites, and fluctuations of radiocesium within the thalli due to precipitation may jointly be responsible for the fluctuating values. (Tuominen and Jaakola, 1973.)

Activity concentrations in bilberry (*Vaccinium myrtillus*) and crowberry were studied at the Bjurholm and Ullatti sites. On both sites there was a slight tendency towards raised levels from 1986 to 1988, bilberry having a slightly higher activity concentration of ^{137}Cs (fig. 2.)

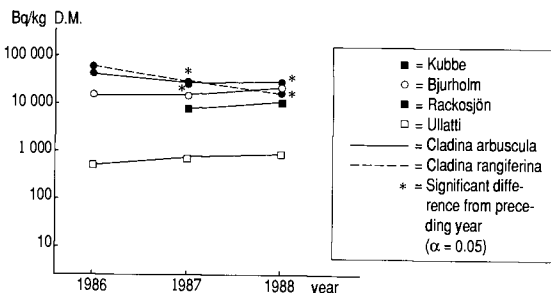


Figure 2. Cs—137 in reindeer lichens (*Cladina arbuscula* and *Cl. rangiferina*), 1986—1988

In 1986 and 1988 wavy hairgrass, (*Deschampsia flexuosa*) fire weed (*Epilobium angustifolium*) and buck—bean (*Menyanthes trifoliata*) were sampled at Rackosjön and measured for their activity concentration of ^{137}Cs . A statistically significant decrease of 57% (wavy hairgrass), 34% (fire weed) and 14% (buck—bean) was registered.

Garmo *et al.* have monitored the activity concentration of $^{134}\text{Cs} + ^{137}\text{Cs}$ in some forage plants in Griningsdalen, Norway in 1986—1988.

A comparison shows:

	Garmo <i>et al.</i>	Eriksson
Wavy hairgrass	—56%	—57%
Buck-bean	—14%	—14%
Bilberry	—79%	± 0

Notwithstanding that the Norwegian figures show ^{137}Cs plus ^{134}Cs , the figures concerning wavy hairgrass and buck—bean are fairly similar. It is quite surprising then that the reduction of the activity concentration in bilberry differs so much.

During the summer of 1987 wavy hairgrass, fire weed and buck—bean were sampled repeatedly at Rackosjön. From a peak value of $1670 \pm \text{Bq} \cdot \text{kg}^{-1} \text{ DM}$, hairgrass decreased 88% in two months. Fire weed started out at $475 \text{ Bq} \cdot \text{kg}^{-1} \text{ DM}$, and dropped to a minimum of $119 \pm 31 \text{ Bq}$ in one month. A trend towards a secondary maximum was seen in wavy hairgrass, that starts its next year's growth in late summer. This second rise in activity concentration might have been supported by heavy rains in late July—August (fig. 3).

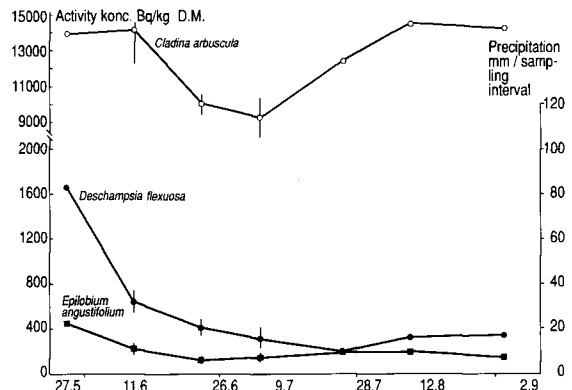


Figure 3. Temporal variations in Cs—137 activity concentration in *Cladina arbuscula*, *Deschampsia flexuosa* and *Epilobium angustifolium*.

Buck—bean was sampled on June 25 and on July 14. The rhizomes were, following Sjörs (1987), divided into annual shoots of 1985, 1986 and 1987 and measured. The shoots of 1985 and 1986 remained stable at around $1800 \pm 130 \text{ Bq} \cdot \text{kg}^{-1} \text{ DM}$, whereas there was a decrease in the 1987 shoots from $3880 \pm 490 \text{ Bq} \cdot \text{kg}^{-1} \text{ DM}$ to $1700 \pm 160 \text{ Bq} \cdot \text{kg}^{-1} \text{ DM}$, i.e. 55% (fig. 4).

According to the plan, the permanent plots will be harvested at regular intervals during

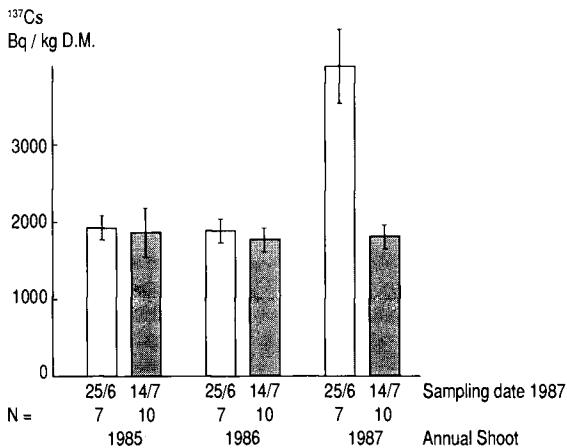


Figure 4. Cs—137 in annual shoots of buck—bean (*Menyanthes trifoliata*).

years to come, providing data on the effective half-life of ¹³⁷Cs in important forage plants. However, it is now imperative to find out the transfer factor of ¹³⁷Cs from plant to reindeer meat during different seasons. It will then be possible to plan actions aimed at minimizing radiocesium in reindeer meat.

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