

IX. SAMPLING AND CHEMICAL ANALYSIS OF VEGETATION AND SOIL
- REGULAR PROGRAM (1970-1984)

a) Program Outline

During the 1970 growing season, the Ministry of the Environment established 15 permanent vegetation and soil sampling plots in the territory potentially affected by the Sudbury area smelters and two control plots in areas remote from Sudbury. Since that time, four additional plots have been established at various locations. The following table lists the location of each plot, the year of establishment and the distance and direction of the plot from the City of Sudbury. The locations of the sampling sites are shown in Figure 9.

<u>Plot Location</u>	<u>Year Established</u>	<u>Distance and Direction from Sudbury</u>
Blind River	1970	160 km W (Control Plot)
Mattawa	1970	176 km E (Control Plot)
Sudbury	1970	0 km
Garson	1970	5 km NE
Skead	1970	26 km NE
Kukagami Lake	1970	42 km NE
Grassy Lake	1970	64 km NE
Lake Temagami	1970	80 km NE
Callum	1970	29 km E
Sturgeon Falls	1970	77 km E
St. Charles	1970	28 km SE
Burwash	1970	27 km S
Tilton Lake	1973	15 km SW
Lake Penage	1970	37 km SW
Killarney Park	1972	64 km SW
Nairn Centre	1970	48 km WSW
Fairbanks Park	1973	39 km W
Rayside Township	1970	16 km NW
Morgan Township	1970	24 km NW
Milnet	1970	37 km N
Chiniguchi Lake	1973	57 km NNE

Foliage samples of several vegetation species and soil samples (0-10 cm) were collected at each site. Initially, the samples were analyzed for sulphur, copper, nickel, iron, selenium, arsenic, cobalt and fluoride. Each year the chemical analysis data have been examined, and as a result certain modifications have been made in the program. Additional sampling sites have been established, other chemical analyses discontinued, some analyses initiated and the sampling of some plant species discontinued. In 1971, 1972 and 1973, the sampling was carried out during June, July and August. Analysis for fluoride was discontinued in 1971.

In 1974, sampling was reduced to include only trembling aspen and soil (0-10 cm) which were analyzed for total sulphur, copper, nickel, iron and arsenic, in June, July and August. In 1975, 1976, 1979 and 1987 triplicate samples of white birch foliage and triplicate soil samples were collected at each sampling site in July and August. The samples were analyzed for sulphur, copper, nickel, iron, arsenic and lead in all years.

In years prior to 1975, the analyses were performed on "washed" samples. Experience has shown that the washing procedure did not significantly alter the concentrations of elements in vegetation, and therefore, washing of samples was discontinued.

Soils were analyzed for the same elements as vegetation plus pH, total calcium content and total magnesium content.

b) Trace Metal Emissions in the Sudbury Area

On the basis of a number of emission rate studies conducted by the Ministry in co-operation with Inco Ltd. and Falconbridge Ltd. during the period 1973-1981, it was determined that iron, copper, nickel, lead and arsenic were the major elements emitted from smelting operations (27, 28). It was further determined that elements such as zinc, aluminum, chromium, cadmium, magnesium, manganese, cobalt and selenium were also present in the emissions but in considerably lower amounts.

The average emission rate of particulate emissions (and consequently of trace elements) is believed to have decreased since the 1970's, in conjunction with restrictions in SO₂ emissions. Table 31 summarizes some of the data from the Inco Ltd. tall stack (27). It should be emphasized that the data measurements are accurate to only within a factor of two; however, there appears to exist a downward trend in emissions and hence in the deposition rate of metals in the Sudbury basin, as a function of time.

c) Elemental Analysis of White Birch Foliage

i) Copper

Copper concentrations in the white birch foliage were found to fluctuate from year to year; however, there are several conclusions which can be made regarding the data. In most years, the highest copper concentrations were encountered at Garson, Skead and Sudbury (Table 32). In 1970, only samples from those sites farthest from Sudbury (Blind River, Mattawa, Grassy Lake, Sturgeon Falls, St. Charles, Nairn Centre and Morgan Township) had copper contents below the upper limits of normal concentration guideline of 20 ug Cu/g. Since 1976, the number of exceedences of the normal concentration guideline has decreased, with only samples from the Garson and Sudbury sites in 1984 exceeding the guideline.

ii) Nickel

The normal concentration guideline of 30 ug nickel/g tissue was exceeded in all years at the Sudbury, Garson, Skead and Rayside Township sites (Table 33). They were exceeded in samples collected at Milnet in 1970, and at Kukagami Lake and Burwash in all years except 1979 and 1984. Tilton Lake samples were above normal for all years except 1979. Nickel concentrations remained fairly constant at most sites from 1970 to 1973 then increased in 1975 and 1976. In later collections, the values decreased until the lowest values were measured in the 1979 or 1984 samples.

iii) Arsenic

Normal concentration guidelines (2 ug/g) for arsenic in white birch foliage were exceeded at only four sites (Skèad, Kukagami Lake, Garson and Sudbury) (Table 34). This occurred in each year from 1970 and 1975 at Skèad but only in 1970 at Kukagami Lake. The other exceedences were at Garson in 1971 and 1975 and at Sudbury in 1971. The latest collections (1979, 1984) generally showed the lowest arsenic content.

iv) Selenium

The analytical data for selenium are included in Table 35. In all samples taken in 1970, selenium values exceeded the normal concentration guideline of 0.5 ug Se/g tissue. Comparison with the control sample collected at Mattawa indicated, however, no difference between sites affected by Sudbury emissions and those unaffected. Above normal selenium content was also found in 1984 foliage samples from the Sudbury, Rayside Township, Tilton Lake and Garson sites. These 4 sites are among the closest to the Sudbury smelter complex. Although selenium concentrations were the highest in 1984 at these 4 sites, 12 of the remaining 17 sampling sites produced the lowest measured levels of selenium in foliage.

vi) Iron

The iron content of birch foliage samples are presented in Table 36. In nearly all cases, the values were below

the normal concentration guideline of 500 ug Fe/g tissue. The two exceptions were for samples collected at Temagami and Morgan Townships, both in 1975. There is no apparent relationship of iron values to proximity to the smelters in the Sudbury area based on these data. There was a large amount of variability from year to year, even at the control sites, and no conclusive trends could be derived. High variability of iron content in soil is common thus iron content in foliage uptaken from soil is expected to be variable.

vi) Lead

The lead content of all white birch foliage samples were within the normal concentrations and no samples exceeded the guideline of 30 ug/g (Table 35). The lowest values were found in 1984 in nearly all instances, indicating a decrease in lead content of foliage in recent years.

vii) Sulphur

The sulphur content of white birch foliage is presented in Table 38. All post 1971 samples were found below the normal concentration guidelines of .4% S in tissue. Generally, sulphur content of birch leaves has declined since the early 1970's. This corresponds to the declining number of potentially injurious fumigations (Table 22). Sulphur content from most Sudbury sites, with the exception of Skead and Garson (closest downwind sites), were comparable to the control values for the later collections.

viii) Summary of White Birch Foliage Analysis

The upper limits of normal concentration for copper and nickel in white birch foliage were commonly exceeded at Sudbury, Garson, Skead and, less often, at slightly greater distance from the smelter (Rayside Township, Tilton Lake, Callum and Kukagami Lake). The later collections (1979, 1984) of birch foliage had lower content of nickel and copper at most sites compared to earlier collections. Above normal arsenic content in foliage was noted in pre-1976 samplings at 4 sites (Sudbury, Garson, Skead and Kukagami Lake). The more recent collections showed a decrease in foliar arsenic content. Concentrations of selenium were found to be above normal in all samples collected in 1970, including a control sample, and at 4 sites in 1984 (Sudbury, Garson, Skead and Tilton Lake). The majority of sites had lower foliar selenium content in the latest collections (1979, 1984). All birch leaf samples collected after 1971 contained normal concentrations of sulphur. Lead and iron concentrations were within normal limits and no trend with distance from the smelter was apparent.

Particulate emissions are believed to have decreased since the 1970's in conjunction with reductions in SO₂ emission. This is reflected in foliar content of copper, nickel and arsenic.