A Biogeochemical Study of Bog Plants

by

Philip A. Bentley

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Department of Botany

McGill University

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CHAPTER I

INTRODUCTION

<u>Introductory statement</u> - Prospecting for ore minerals is often carried on by examining the bedrock at or very near the earth's surface. The bedrock, however, over large areas of the earth, is covered by layers of material called overburden. It has been demonstrated that under certain conditions the bedrock can be examined indirectly by chemical analyses of the soils or plants covering it. Canada, particularly in the north, has large areas covered by deposits in the form of peat bogs or muskegs. The examination of bedrock under peat bogs or muskeg by chemical analyses has not been practised in Canada, but it has been tried with some success in Finland.

The present study was organized under the name "Operation Muskeg" to be carried out by a team of geologists and a botanist from McGill University. The author was the botanist on the team. The purpose of the project was to examine the distribution of metals in peat bogs from the bedrock to the surface vegetation. Peat bogs with and without mineralization beneath them were to be sampled.

The resulting data on the distribution of metals in the peats and their underlying deposits has been reported by Gleeson (1960). The data on the distribution of metals in the peat bog vegetation is the subject of this report.

Literature Review and Definition of Terms

The history of geochemistry is reviewed very thoroughly by Hawkes (1950). Hawkes defines geochemistry as "an attempt to detect chemical patterns resulting from the dispersion of elements from the primary site of the ore".

The use of plants to detect ore bodies is known as geobotanical prospecting. The history of geobotanical methods of prospecting, including biogeochemistry is reviewed by Rankama (1947); Robinson, Lakin and Reichen (1947); Hawkes (1950); Warren and Delavault (1950 a); Marmo (1953); Vinogradov (1954); Cannon (1955, 1960). Geobotanical methods have been used in prospecting for minerals and metals probably since history began. Robinson, Lakin and Reichen (1947) record how as early as 1461 John di Castro used the presence of old world holly in prospecting for aluminum (Mellor, 1924). A plant such as old world holly, growing only on aluminum enriched soils or only on ore is an example of an "indicator plant". The use of such a plant is a purely geobotanical method.

Another aspect of geobotanical prospecting is the study in plant ecology of edaphic factors affecting whole plant associations. It has been noted many times that the chemical nature of the soils can control the plant associations existing on them. This topic is reviewed by Billings (1957, pp. 381-383). Whittaker (1954 a, 1954 b) reviews the problem of serpentine soils and the associations that occur on them. Wells (1962) also describes the plant communities associated with serpentine soils. Krucksberg (1954) and Walker (1954) report on other problems associated with serpentine soils. Plant associations over chemically altered rocks may be due to deficiencies of certain nutrients or excesses of certain elements. Excesses of such an element as zinc may produce toxicity symptoms in plants or even areas barren of vegetation (Cannon, 1955). Whittaker (1954 a) states that serpentine soils are usually sterile and unproductive, posses unusual floras with narrowly endemic species, and support vegetation of striking physionomic contrast to that on other soils. Good (1953) quotes several references, including Schimper (1903-4), Hayek (1926), and Pichi - Sermolli (1948), on the occurrence of morphological changes in plants growing on serpentine soils. The changes include glabresence, glaucesence, and nanism.

The use of characteristic plant associations in prospecting has been limited to a few researchers. Harbaugh (1950) attempted the use of this method but found it to be of little use. Lovering, Huff and Almond (1950) state that each of three rock types seemed to have its own characteristic assemblage of plants. The ore zone was clearly indicated by the plant association.

Vinogradov (1954) mentions in a general way the use of plant associations to indicate mineralized areas.

Sarosiek (1957) describes the vegetation on mining-smelter nickel heaps and concludes that the differences in vegetation are differences in stages of succession.

Beadle (1954,1962) has used the phosphate content of the soils to delimit plant communities in Australia.

Mainly since the 1930's a further development of geobotanical methods has taken place. This is known as "biogeochemistry". Biogeochemistry is the chemical analysis of plants for metallic elements taken up from the substratum. It is believed that abnormal concentrations of these elements in the substratum are reflected by above normal concentrations in the plants growing above. The advantage of using the metal contents of plants rather than the metal contents of the soils is that the plant roots sample a larger volume of the substratum at a greater depth than is possible by taking a surface soil sample (Hawkes, 1950). The ideal "accumulator plant" is one that is widely distributed and accurately reflects the soil metal content (Robinson, Lakin, and Reichen, 1947). Biogeochemistry is another method of the geochemistry defined by Hawkes (1950), and was first used by Palmqvist and Brundin (Rankama, 1947).

The methods of biogeochemistry have been described by a number of authors, including Rankama (1947); Robinson, Lakin, and Reichen (1947); Warren, Delavault, and Irish (1949); Harbaugh (1950); Hawkes (1950); Lovering, Huff, and Almond (1950);

Warren and Delavault (1950 a, 1950 b); White (1950); Riddell (1952); Warren, Delavault, and Irish (1952 a, 1952 b); Cannon (1953, 1955, 1957); Marmo (1953); Schmidt (1955, ~~1956~~); Warren and Delavault (1954, 1955 a, 1955 b); Warren, Delavault, and Fortescue (1955); Warren and Delavault (1957). The reports by Warren and his associates are particularly valuable to Canadian workers and are most specific in their details on the sampling and collection of plant materials.

Other reports on the use of biogeochemistry include those of Webb (1954); Beeson et al. (1955); Van Schoor (1957); Lovering (1958); and Yamagata and Murakami (1958).

The geochemistry of peat soils has been studied by fewer workers. Among those having done so are: Cannon (1955); (Cannon refers to Staker and Cummings (1941); Forrester (1942); Staker (1942, 1944); Goldschmidt (1944); Eckel (1949); and Salmi (1950)); Salmi (1955, 1956, 1958); Malmer (1958); Holman (1959); and Gleeson (1960). Gleeson (1960) reviews the history of peat soil geochemistry.

One of the first biogeochemical investigations of the plants on a peat bog was that of Marmo (1953) in Finland. He collected leaves of Ledum palustre on the bog at Rautio and analyzed for molybdenum and copper. The bog had been previously drilled and the depth of peat was 3 - 7 m. Good agreement was found between the molybdenum highs in the plant ash and the rocks below. A similar result was found with copper.

Cannon (1955) made an exhaustive geochemical study of a zinc - bearing peat and its vegetation. Among other things Cannon concludes that some plant species accumulate zinc if conditions are favorable and reflect zinc rich areas in the soil. Examples of satisfactory accumulator plants are willows, nettles, and trembling aspen, unsatisfactory accumulators are sumac and goldenrod. Cannon suggests that lead may be used as a tracer element in prospecting for zinc, that is, analyzing for lead may give more evidence of zinc mineralization than analyzing for zinc. Other workers (Warren and Howatson, 1947; Warren and Delavault, 1948; White, 1950; and Webb and Millman, 1951) also suggest the use of such a tracer element, or "pathfinder element", as it is sometimes called. Cannon (1955) also reviews the factors that may affect the uptake of elements by vegetation. Such factors include oxidation, reduction, base exchange capacity, pH, organic matter, clay content, colloid content, water level, and interactions between elements in the vegetation.

Salmi (1956) successfully used bog plants along with peats in biogeochemical prospecting.

Malmer (1958) studied the relationship between the chemical composition of mire plants and the peat they were growing on. Malmer used both metallic and non-metallic elements and found no close correlation between the contents of the plants and the amounts determined in the peat.

Object of the present study - The object of the present study was to gather data on the peat bog or muskeg vegetation over mineralized (positive) rocks and over non-mineralized (negative) rocks for comparative purposes. The positive or negative areas were to be selected by the geologist members of the project. It was proposed to describe plant associations over positive and negative areas to determine if there were any detectible differences which were consistent.

The plant associations were to be studied by: (1) the sampling of the vegetation with quadrats to enable the plant associations of the area to be mapped and described; (2) the collecting of plant samples for metal analysis to allow the mapping of biogeochemical areas; and (3) the collecting of plants for the benefit of plant geography as an associated side line.

FIELD AREAS

The original plan was to spend the first field season sampling bogs known to be in negative areas. Blacky Bay Bog, south of Kenora, Ontario (figure 1), was selected for sampling. The second season was to be spent sampling bogs over positive areas. Bogs over such mineralized areas could not be located and so the second season was spent sampling bogs that had interesting geophysical anomalies but no known mineralization under or near them. This bog was located near Scott Lake, 42 miles north of Amos, Quebec.

The author also accompanied Mr. C. Gleeson and sampled the vegetation over the Mattagami Lake Mines property. Here a known zinc ore body was overlain by glacial lake sediments (clays).

Thus, although the comparisons of the original object of the study have not been accomplished, valuable reference material has been collected from areas representative of those where the biogeochemical method of prospecting may be used in Canada. It is also suggested that further research on the vegetation of bogs over definitely mineralized areas would be most desirable.

CHAPTER II

FIELD AND LABORATORY METHODS AND FIELD AREAS

PART I. VEGETATIONAL ANALYSIS

Field sampling methods - Blacky Bay Bog. The vegetation of Blacky Bay Bog was sampled by means of the quadrat method, (Oosting, pp. 43ff, 1953). Trees and shrubs were sampled in 10 m. square quadrats and herbs and mosses in 2 m. square quadrats. The small quadrat was placed in the corner of the larger nearest the grid position. The large quadrat was placed in undisturbed vegetation as near the grid position as possible, either east or west of the cut survey line. Abundance and cover were estimated for all trees, shrubs, mosses and herbs by means of the following numerical scales. Abundance means the relative plentifulness of the individual species.

Abundance Value	1 - means	very sparse (very rare)
	2 - "	sparse (rare)
	3 - "	not numerous (infrequent)
	4 - "	numerous (abundant)
	5 - "	very numerous (very abundant)

Cover Value	1 - covering	less than 5% (1/20) of the ground surface
	2 - "	5 to 25% of the ground surface
	3 - "	25 to 50% " " " "
	4 - "	50 to 75% " " " "
	5 - "	75 to 100% " " " "

Each species was listed as it was met on a quadrat data sheet along with its abundance and cover values. Notes on the habitat and general notes on the vegetation were also made on each quadrat data sheet. The maximum height of all trees and shrubs was noted, as was the number of trees in each quadrat. The term "trees" here includes the size classes "insignificants" and "trees". Tree species are frequently grouped into three size classes. These are "seedlings" which are less than 1 inch in diameter and 1 foot in height; "insignificants", which are less than 1 inch in Diameter Breast Height (D.B.H. - 4.5 feet from the ground) and over 1 foot in height; and "trees" which are more than 1 inch in D.B.H. and over 1 foot in height. In the following discussions the term "insignificants" is included in the term "trees" unless it is specifically mentioned.

All sampling, both geological and botanical, on Blacky Bay Bog was done on a grid. A base line 2400 feet long was laid off from west to east along the north side of the bog. Lines intersecting the base line at right angles crossed the bog. Botanical sampling was done on three of these lines at intervals of 100 feet across the bog from north to south. The three lines sampled crossed the base line at 800 feet, 1600 feet, and 2400 feet east of the zero point. Thus botanical sampling was done at intervals of 100 feet north and south and 800 feet east and west. The open bog areas on Blacky Bay Bog were subjectively mapped in the field without the collection of quantitative data.

Traverses were made along intersecting lines 800, 1600, and 2400 east to locate association boundaries. Traverses were also made along intersecting lines 400, 1200, 2000, 2800, and 3200 east to record the plant associations present and their boundaries.

Essentially similar methods of sampling the vegetation were employed at Mattagami Lake Mines and Scott Lake Bog. However there were some differences as the emphasis was put on the collection of samples for chemical analysis.

The Scott Lake Bog was large and the vegetation was sampled while collecting analytical samples. A 10 m. square quadrat was outlined at each sampling point, the species recorded and the abundance of each species estimated. Sampling points were located at 800 foot intervals on line 862 East, line 0+00, and lines 862, 1724, and 2586 West. These lines were traversed to record the plant associations and their boundaries.

The quantitative data from Mattagami Lake Mines is based on one 10 m. quadrat and two one m. quadrats per association. The Spruce - Labrador-tea association was sampled at L 600 W, 950 N on the grid (see figure 3) and the Spruce - Fir - Alder association was sampled at L 200 E, 350 N on the grid. These samples appeared to be representative of their respective associations. The D.B.H. and height of each tree was recorded in these samples. Traverses recording plant associations and association boundaries were made on lines 800, 600, 400, and 200 East, on line 0+00, and on lines 200, 400, 600, 800, and 1000 West.

Plant collections were made of all plant species. Common species were identified in the field and less common or more difficult species collected for identification in the laboratory. These plant collections have been placed in the herbarium of the Department of Botany, McGill University.

The botanical specimens were collected in a field press with appropriate notes. The specimens were packed with ventilators and dried on a rack heated by electric light bulbs or a small Coleman heater. The specimens were checked as to identity in the laboratory, labels prepared, and doubtful or unidentified specimens sent to authorities to be identified or checked. Duplicate specimens of the vascular plants and bryophytes were sent to Drs. Scoggan and Crum, respectively, at the National Museum of Canada in return for identification and checking. The nomenclature used for the vascular plants was that of Gray's Manual (Fernald, 1950).

LABORATORY METHODS

The quadrat data sheets from Blacky Bay Bog were examined in the laboratory and the dominant tree species for each sampling point determined. The samples were grouped on this basis into five associations. A species list was compiled from the quadrat data sheets for each association. An average abundance value for each species in the samples in which it occurred was calculated from the abundance figures. An average cover value was calculated similarly. A frequency percentage was calculated for each species from the species list for each association. The frequency expresses the percentage of sample plots in which a species occurs (Oosting, p. 59, 1953). The average density of the trees present in each association was calculated from the quadrat data sheets.

The associations at each sampling point were plotted on a map of Blacky Bay Bog and the approximate association boundaries drawn. The field map of the open bog associations was added to the vegetation map.

Finally, a note on the habitat, the vegetation and the dominant species was prepared from the species list and the quadrat data sheets.

The quantitative data on the vegetation of Scott Lake Bog was analyzed similarly. The uniformity of the vegetation and the lack of data, however, best allowed a species list with average abundances and frequency percentages, with the description of plant zones rather than plant associations. These zones were mapped and a note on the characteristics of each zone prepared.

The small amount of data on the vegetation of the Mattagami Lake Mines Property allowed the preparation of species lists, the calculation of total basal areas for the tree species and the preparation of a vegetation map, with notes on each plant association.

PART II. CHEMICAL ANALYSIS

FIELD SAMPLING METHODS

Selection and location of samples - The collection of plant samples for chemical analysis was correlated with the sampling of the humus and soils. The sampling was carried out on a grid at 100 to 800 foot intervals. The plant species sampled were selected by growth form and frequency of occurrence. Thus a tree species, a shrub species, a herb species and a moss species were usually collected at each sampling point. Occasionally specimens of one species or another were not present at a sampling point and sometimes two species in one life form were collected.

Plant samples - A plant sample was required to be approximately 200 grams (live weight). Tree and shrub samples were removed with clippers and consisted of twigs showing 4 or 5 years of growth with leaves. The sample trees (25 - 40 feet tall) had to be first cut down and then the twigs were removed from different branches within 10 feet of the top of the tree. Whole plants of the herbs were ripped from the peat soil and any clinging peat shaken off. Clumps of mosses were removed whole and any clinging peat shaken off. All samples were placed in 12 lb. kraft paper bags and stapled shut.

Sample drying - The tree, shrub, non-fleshy herb, and dry moss samples were air-dried. Fleshy herb and wet moss samples were placed over a botanical plant specimen drier to speed their drying. A gas-heated oven was found to be too hazardous for drying these plant samples. The dried plant samples were then packed in cardboard cartons and shipped to the laboratory for analysis. Many of the suggestions of Warren, Delavault and Fortescue (1955) on biogeochemical sampling were followed.

LABORATORY METHODS

Preparation of samples - The samples were sorted in the laboratory. Twigs of trees and shrubs collected in 1957 contained the growth of 1957, 1956, 1955, 1954, etc. The growth of 1956 was termed second year (2 yr. old) wood and was the most desirable for chemical analysis (see Warren, Delavault, and Fortescue, 1955). This second year wood was selected for most analyses of trees and shrubs, except in some species where the year of growth was very difficult to determine. The entire needles or leaves of some trees and shrubs were also selected for analysis without regard to age. Herbaceous samples usually consisted of the entire shoot, including stem, leaves and flowers or fruit. The entire plant, including the rhizones, of one herb was analyzed. Entire moss plants were analyzed after all litter was carefully removed.

The 5 to 10 grams of plant parts selected for analysis were ground in a Wiley Mill to pass through a 20 wire mesh or were pulverized in a high speed food blender for 2 minutes. The Wiley Mill was brushed and blown clean with a compressed air jet between samples. The blender was brushed in soapy running tap water, rinsed, and dried with a clean cotton cloth between samples. The powdered plant material was placed in a code marked ½ lb. kraft paper bag until analysis.

Metal determinations - The plant samples were analyzed for the metals copper, zinc, lead and nickel. The analytical methods used were adaptations of those used for copper, zinc and lead by Bloom and Crowe (1953) and that used for total nickel by Bloom (1956).

Ashing of plant material - The powdered plant material was prepared for analysis by ashing in the following manner: The plant material was placed in weighed rose unglazed crucibles (Coors # 320) #2 - 30 ml., and the whole re-weighed. All weights were to tenths of a milligram. The crucibles with covers tipped were placed 12 at a time in the furnace at 300° Centigrade with the door partly open. The furnace door was closed and the temperature increased to 550° - 600° Centigrade after two hours. The covers were removed and the material stirred with a platinum rod at the end of three hours. The material was stirred every two hours until no black material remained, then the samples were removed, weighed, returned to the oven and re-heated until a constant weight was obtained. The process usually took 8 - 12 hours. After final cooling of the samples the methods of Bloom and Crowe (1953) and Bloom (1956) were applied. 0.1 gram of plant ash was used for the copper, zinc and lead determinations. 0.2 gram was used for the nickel determination. The smallest amount of metal detectable was 10 parts per million. Reproducibility for these tests is in the order of plus or minus 30 percent (Gleeson, 1960).

Calculations - The metal determinations yielded the metal contents of the plant samples in parts per million on the basis of the weight of ash used (ppm - ash). The percentage ash of each plant sample was known and using this, the metal content in parts per million on the basis of the air-dried weight (ppm - dry wt.) used was calculated.

The copper:zinc ratio was determined by dividing the zinc content of a sample into its copper content.

The Blacky Bay Bog analytical samples were analyzed by the Geochemical Laboratory of the McGill University Geology Department. The percentage ash was not recorded and thus the metal contents are expressed only in ppm - dry wt.

The Scott Lake Bog and Mattagami Lake Mines Property analytical samples were analyzed by the author in the Geochemical Laboratory of McGill University Geology Department. The metal contents are expressed in ppm - dry wt. and ppm - ash.

Methods of Presenting Analytical Data - The metal contents of the analyzed plant samples were listed on work sheets according to plant species, plant organ, grid position, and collecting area.

The metal contents of each species were plotted on plant association maps of the collecting area. They were also plotted on blank area maps and contoured at appropriate intervals.

Profile graphs were constructed showing the content of the same metal in each species at the same collecting point.

Bar graphs or histograms were made showing the frequency of metal content intervals in each species in each area.

The metal contents of any one species in any one area were averaged. Tables were compiled for each metal showing the species, the plant organ, the number of samples, the range in metal contents, the mode, the mean, and the maximum percentage variation above the average value.

PART III. FIELD AREAS

NUMBER 1 - BLACKY BAY BOG

Location - Blacky Bay is on the south shore of Kakagi (Crow) Lake, 70 miles southeast of Kenora, Ontario, and 6 miles east of Lake of the Woods. The bog lies at the east end of the bay at latitude 49°10' N., and longitude 93°49' W. (see figure 1).

Topography - Kakagi Lake lies at an altitude of 1070 feet. The topography of the area is rolling and the bog is bordered on the north and south by rocky hills rising 100 feet above the bog (Plate 1). Most of the lake basins of the area are the result of glacial gouging.

General geology - The geology of the general area was recorded by Burwash (1953). The detailed geology of the Blacky Bay area was recorded by G. Pajari and C. Gleeson (see Gleeson, 1960). Gleeson reports that the bog lies on a bedrock of diorite and interbedded tuff, greywacke and slate.

Gleeson also reports on the surficial deposits of the area. The area was part of glacial Lake Agassiz and sand and gravel deposits are attributed to beaches and shallow bays of this lake. Overlying the coarse deposits are layers of silt and glacial clay. Peat has formed in shallow basins of Kakagi Lake and in many similar areas. The age of the most recent deposits (peat) is said to be 8020±100 years (Elson, 1957, p. 24; Gleeson, 1960). The Blacky Bay Bog was first examined because

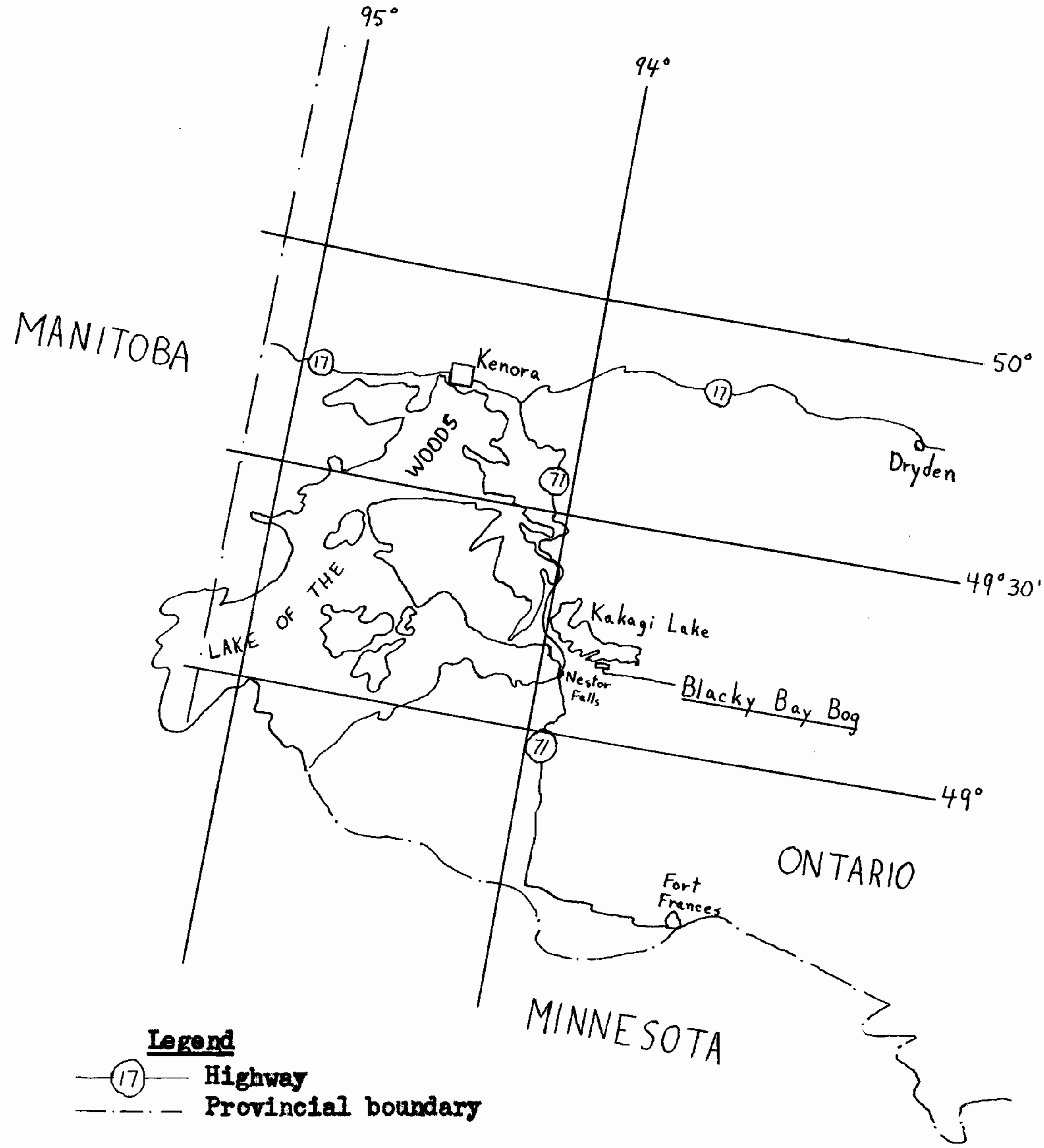


Figure 1 - Map of Western Ontario showing location of Blacky Bay Bog.

Scale: 1 inch = 28 miles

of a geophysical anomally over it. Later, the bog was diamond drilled in two places without finding ore. Gleeson (1960) also obtained rock cores from beneath the bog. Gleeson found no evidence of metallization under or near the bog and considered it to be a normal type of bog without sulphide mineralization.

Inorganic deposits - Gleeson (1960) reported that the peat deposit was underlain by 1 - 5 feet of bluish grey clay, 5 - 20 feet of watery grey clay, 5 - 20 feet of compact grey clay, 1 - 5 feet of compact red clay, and 6 - 30 feet of compact grey clay. These clays were above 5 - 20 feet of silty and sandy fractions; which rested on a glacial till of coarse sand and boulders above the bedrock.

Organic deposits - The organic deposits consisted of peat which had a maximum thickness of about 28 feet and an average depth of 15 feet. The peat of the deposit was of five types: (1) calcareous gyttja (marly), (2) gyttja, (3) fibrous carex (sedge) peat, (4) fibrous sphagnum (moss) peat, and (5) woody peat. Types 1 and 2 were deep, underlying peats. Types 3, 4 and 5 occurred near the surface. Type 3 occurred near the lake and stream, type 4 mostly east of L 800 E (see figure 3) and type 5 along the eastern margins of the bog (Gleeson, 1960). The average pH of the peats of Blacky Bay Bog was very close to 6 within a narrow range (Gleeson, p. 64, 1960).

Surface description and drainage - The bog measured approximately 3,000 feet long and 1,000 feet wide. The northern edge of the bog was bordered by gently sloping glacial till which was covered by upland forest. The southern edge of the bog was bordered by a steep rock cliff on which a broken coniferous forest occurred,(see figure 3).

The bog surface sloped very gently towards the lake. The bog was drained by a stream which entered the east end, flowed along the north side for one-half its length, then flowed through the centre of the bog to the lake. The bog was relatively dry except for the entire northern margin, and the central portion about the stream and the lake.

NUMBER 2 - SCOTT LAKE BOG

Location - Scott Lake and the bog just east of it are located 42 miles north northeast of Amos, Quebec, in the southwest corner of Soissons township, at longitude 77°57'W., latitude 49°11'N.(figure 2).

General geology - Gleeson (1960) reports that geophysical results suggest the presence of a band of basic rocks striking about northwest, and that the bog is underlain by an ultrabasic plug. The depth of overburden is probably over 100 feet. The Scott Lake Bog was examined because of the geophysical anomally occurring over it. Gleeson found no evidence of mineralization in the peats of the bog and considered it to be

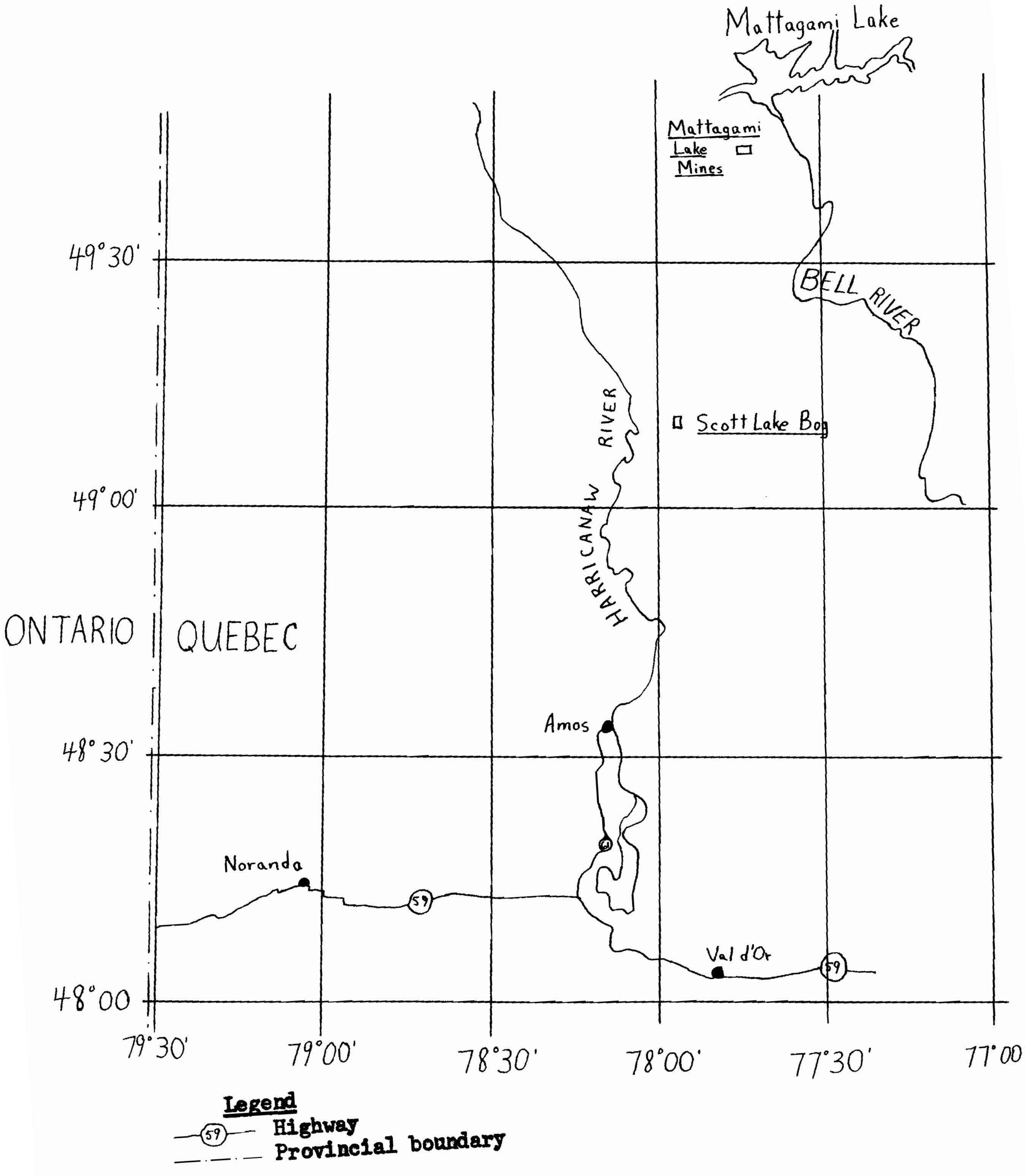


Figure 2 - Map of Western Quebec showing location of Scott Lake Bog and Mattagami Lake mines property.

Scale: 1 inch = 20 miles

a normal type of bog without sulphide mineralization.

Organic and inorganic deposits - The dominant type of peat was the sedge (Carex) type. Near the surface it was intermixed with sphagnum (moss) peat. These organic layers varied from 5 to 10 feet thick and were underlain by a blue-grey clay. The top three feet of peat were acid (pH 3.3 - 4) while the peat just above the clay was less acid (pH 4.2 - 4.9). The underlying clays were still less acid (pH 4.7 - 6.1) (Gleeson, 1960).

Surface description and drainage - The bog was about 1¼ miles long and ¾ of a mile wide. It resulted from the partial filling of a shallow lake basin. A small pond remained in the southwest part of the bog and this pond was drained by a stream flowing to the northeast (see figure 4). Most of the bog was very poorly drained.

NUMBER 3 - MATTAGAMI LAKE MINES

Location - This mining property is located 6 miles south of Mattagami Lake and 2 miles east of Watson Lake, Quebec, It is about 80 miles northeast of Amos and is at latitude 49°43' N., and longitude 77°43' W.,(see figure 2).

Relief and drainage - The geology and relief of the area are described by Longley (1943) and Beland (1953) in reports published by the Quebec Department of Mines. The whole area is of very low relief. The central part of the sample area was low, flat and somewhat swampy, while the eastern and western parts were slightly higher and drier. The area was drained from south to north by two streams. A very shallow stream drained the central portion and a deeply incised (20 to 30 feet) stream drained the western portion of the sample area. The streams went north and east and eventually into the Bell River, (see figure 5).

Geology and mineralization - Gleeson (1960) describes the geology and mineralization. The general area is underlain by altered volcanic rocks which are made up of acid and basic flows interbedded with pyroclastic rocks. The ore bodies are shown in figure 5. Since the time of fieldwork, No. 1 ore body has been outlined another 1,000 feet to the northwest. No. 2 ore body, 800 feet to the southeast was not known at the time. The ore contains approximately 13 percent zinc and small amounts of copper, gold, and silver. No less than 20 million tons of ore are present.

Soils and pH - There was no peat deposit on this property, even though Sphagnum moss in various stages of decomposition varied from 6 to 24 inches in thickness. Gleeson (1960) sampled the soils of the area. An Ao (humus or decomposed moss) horizon rests on the B horizon (brown clay) and only occasionally does a thin leached (A_2) layer occur. A thin humus layer occurs in the old burn area to the south.

The average pH of the humus was 4.2; that of the brown clay was 5.1; and that of the grey clay was 7.4.

The clays varied in thickness from 20 to 100 feet. They were normally coarser and wetter at depth and they were usually underlain by a layer of boulder till.

CHAPTER III

PLANT ASSOCIATIONS OF THE SAMPLE AREAS

PART I. BLACKY BAY BOG VEGETATION

Introduction - The major part of Blacky Bay Bog was covered in a coniferous forest. A deciduous forest occurred in the northeast corner, and an open or shrub-covered area bordered the stream and the lake (Plate I).

The bog was bordered on three sides by a variable upland forest in which Balsam-Fir (*Abies balsamea* (L.) Mill.), Aspens (*Populus* spp.), Paper-Birch (*Betula papyrifera* Marsh.), Black Spruce (*Picea mariana* (Mill.) BSP.) and White Cedar (*Thuja occidentalis* L.) were important trees. A large number of upland shrubs and herbs were also characteristic of this forest.

Marginal forest association - A transition zone 25 to 75 meters wide occurred at the bog margin as the upland forest gave way to the bog forest in which Black Spruce was the dominant, (see figure 3).

This marginal forest often appeared to be a White Cedar swamp. It was in a poorly drained area of one foot high hummocks between wet depressions or pools of water (Plate IIA). Balsam-Fir, Black Spruce, and White Cedar were always present. Their average densities were 20, 16, and 12 trees per $100m^2$,

PLATE I

View of Blacky Bay Bog from hill to the north. Note open bog along lake at right, Black Spruce forest in centre of bog and Black Ash forest (light band) on left.

TABLE I

BLACKY BAY - MARGINAL FOREST ASSOCIATION SPECIES LIST

Species list	Abundance (average)	Cover (average)	Frequency (percent)	Density (trees per 100 m^2)
Abies balsamea	4	2	100	20
Picea mariana	3	2	100	16
Thuja occidentalis	3	2	100	12
Populus balsamifera	2	1	44	
P. tremuloides	1	1	22	
Fraxinus nigra	1	1	22	
Betula papyrifera	1	1	22	
Larix laricina	1	1	11	0.5
Acer spicatum	1	1	11	
Alnus rugosa var. americana	2	1	66	
Amelanchier ? alnifolia	1	1	11	
Chamaedaphne calyculata var. latifolia	2	1	22	
Cornus stolonifera	1	1	33	
Corylus americana	1	1	44	
Juniperus communis var. depressa	1	1	11	
Kalmia polifolia	1	1	11	
Ledum groenlandicum	4	2	77	
Lonicera canadensis	2	1	44	
L. hirsuta	1	1	11	
Myrica Gale	2	1	11	
Rhamnus alnifolia	1	1	22	
Ribes triste	1	1	22	
Rosa sp.	1	1	11	
Salix sp.	1	1	11	
Taxus canadensis	3	1	11	
Vaccinium angustifolium	1	1	33	
V. myrtilloides	1	1	33	

TABLE I - CONTINUED

Species list	A	C	F
Actaea rubra	1	1	11
Anemone sp.	1	1	11
Aquilegia canadensis	1	1	11
Aster macrophyllus	1	1	11
Aster sp.	1	1	11
Botrychium virginianum	1	1	11
Cardamine pensylvanica	1	1	11
Carex disperma	2	1	44
Carex gynocrates	1	1	11
C. leptalea	5	2	11
C. sp.	1	1	11
C. sp.	2	2	11
C. sp.	1	1	11
C. sp.	4	1	11
C. sp.	1	2	11
C. sp.	1	1	11
C. sp.	3	1	11
C. spp.	1	1	11
Cinna latifolia	1	1	11
Circaea sp.	1	1	11
Clintonia borealis	1	1	22
Coptis groenlandica	3	2	66
Cornus canadensis	2	1	66
Dryopteris sp.	1	1	11
Equisetum arvense	1	1	11
E. litorale	5	4	11
E. sylvaticum	2	1	11
E. sp.	1	1	11
Fragaria virginiana	2	1	22
Galium triflorum var. asprelliforme	2	1	33
Gaultheria hispidula	2	1	55
Geranium Bicknellii	1	1	22
Glyceria striata	1	1	11
Goodyera repens var. ophiodes	1	1	11
Halenia deflexa	1	1	11
Lathyrus palustris	1	1	22

respectively. Fir was usually the dominant tree along the north side of the bog and Black Spruce was the dominant along the south side. The maximum height of the Fir ranged from 25 to 50 feet, that of the Spruce from 40 to 60 feet, and that of the Cedar from 30 to 40 feet. The tree canopy varied from 50 to 75 percent closed. All size classes of each tree species were noted in most samples. In Table 1 some upland tree species will be noted from samples on or very near the upland.

The shrubs varied in abundance from very sparse under a closed canopy to very numerous under openings. Speckled Alder (Alnus rugosa (DuRoi) Spreng. var. americana (Regel) Fern.) was the only tall shrub in the zone and it was sparse in average abundance. Labrador-tea (Ledum groenlandicum Oeder) was the most important shrub with a frequency of 77 percent and an average abundance of numerous. This shrub thus formed the characteristic shrub association.

Herbs varied from very sparse to numerous in abundance. Most samples had a scattered layer of herbs with occasional colonies of sedge or grasses under openings in the tree canopy. The most frequent herbs were the Sedges (Carex spp.) taken as a group. Next in frequency were Goldthread (Coptis groenlandica (Oeder) Fern.), Miterwort (Mitella nuda L.), Bunchberry (Cornus canadensis L.), False Solomon's-seal (Smilacina trifolia (L.) Desf.), Rock-Cranberry (Vaccinium Vitus-Idaea L. var. minus Lodd.),

TABLE I - CONTINUED

Species list	A	C	F
Linnaea borealis var. americana	4	1	22
Listera cordata	1	1	11
Maianthemum canadense	2	1	44
Mitella nuda	3	1	66
Moneses uniflora	2	1	33
Pyrola secunda	2	1	44
Rubus pubescens	2	1	44
Schizachne purpurascens	3	2	11
Smilacina trifolia	2	1	55
Solidage sp.	1	1	11
Streptopus roseus var. longipes	1	1	11
Trientalis borealis	1	1	44
Vaccinium macrocarpon	1	1	44
V. Vitus-Idaea var. minus	2	1	55
Viola conspersa	1	1	11
V. pallens	4	1	11
V. sp.	4	1	11
V. sp.	1	1	11
Aulacomnium palustre	2	1	66
Brachythecium sp.	2	1	66
Calliergon cordifolium	2	2	11
C. giganteum	3	1	22
Calypogeia meylanii	2	1	11
Campylium chrysophyllum	5	1	22
C. sp.	2	1	33
Climacium dendroides	3	1	11
Dicranum drummondii	2	1	55
D. flagellare	1	1	11
D. rugosum	2	1	44
D. scoparium	3	1	11
Eurhynchium pulchellum	2	1	33
Geocalyx graveolens	1	1	11
Hylocomium splendens	3	2	66
Leptobryum pyreforme	1	1	11
Mnium affine	3	1	33

TABLE I - CONTINUED

Species list	A	C	F
M. pseudopunctatum	2	1	11
M. punctatum	1	1	11
M. sp.	3	1	22
M. spinulosum	3	1	11
Pleurozium schreberi	5	3	100
Polytrichum juniperinum	1	1	11
Polytrichum juniperinum var. alpestre	1	1	33
Ptilium crista-castrensis	1	1	11
Rhytidiadelphus triquetrus	3	2	44
Sphagnum capillaceum	4	2	44
S. magellanicum	2	1	44
S. robustum	5	4	11
S. warnstorfianum	5	3	22
S. wulfianum	1	1	11
Tetraphis pellucida	1	1	11
Thuidium delicatulum	4	1	33
Thuidium recognitum	3	1	22

and Creeping Snowberry (Gaultheria hispidula (L.) Bigel.).

The mosses covered from 90 to 98 percent of the forest floor in dense mats. Pleurozium schreberi (Brid.) Mitt. was always present and very numerous. The Sphagnum (Sphagnum spp.) mosses although not always present were numerous and sometimes dominant. Other mosses such as Hylocomium splendens (Hedw.) Schw., Brachythecium spp., and Dicranum drummondii C.M. were often present. Mosses of the genera Calliergon and Campylium were often in the pools of the forest floor.

Spruce - Cedar forest association - This association occurred on the poorly drained edge of the peat bog (see figure 3). The mossy hummocks of the forest floor were up to two feet high with pools of water or wet depressions between them.

The stand was dominated by Black Spruce in association with White Cedar (see Table II). The average density of the Spruce was 39 trees per $100m^2$, and that of the Cedar was 8 trees per $100m^2$. Spruce of all sizes was always present. Large trees of Cedar were sometimes sparse. Vegetative reproduction by the Cedar occurred in one-half of the samples. The maximum height of the Spruce ranged from 35 to 50 feet and that of the Cedar from 25 to 30 feet. The tree canopy was broken ranging from 50 to 75 percent closed. Balsam-Fir seedlings and trees of insignificant size occurred with a frequency of 50 percent.

TABLE II

BLACKY BAY - SPRUCE - CEDAR FOREST ASSOCIATION SPECIES LIST

Species list	Abundance (average)	Cover (average)	Frequency (percent)	Density (trees per 100m.^{2})
Picea mariana	4	3	100	39
Thuja occidentalis	2	2	100	8
Abies balsamea	1	1	50	3
Alnus rugosa var. americana	1	1	100	
Chamaedaphne calyculata var. latifolia	3	1	50	
Corylus americana	1	1	50	
Ledum groenlandicum	4	3	100	
Myrica Gale	2	1	25	
Vaccinium angustifolium	1	1	50	
V. myrtilloides	1	1	50	
Calamagrostis canadensis	1	1	50	
Carex disperma	1	1	25	
Carex sp.	1	1	25	
C. sp.	1	1	25	
Cornus canadensis	2	1	75	
Drosera rotundifolia	1	1	25	
Gaultheria hispidula	2	1	100	
Linnaea borealis var. americana	2	1	50	
Listera cordata	1	1	25	
Maianthemum canadense	1	1	25	
Mitella nuda	2	1	25	
Moneses uniflora	1	1	25	
Pyrola secunda	1	1	75	

TABLE II - CONTINUED

Species list	A	C	F
Smilacine trifolia	1	1	100
Trientalis borealis	1	1	25
Vaccinium macrocarpon	2	1	50
V. Vitus-Idaea var. minus	2	1	100
Aulacomnium palustre	2	1	50
Brachythecium sp.	2	1	50
Calliergon giganteum	2	1	25
Campylium chrysophyllum	5	1	25
Campylium sp.	1	1	25
Dicranum drummondii	3	1	75
D. rugosum	2	1	75
Hylocomium splendens	3	1	50
Hypnum pratense	1	1	25
Mnium affine	2	1	25
M. punctatum	5	1	25
M. pseudopunctatum	1	1	25
Pleurozium schreberi	4	2	100
Polytrichum juniperinum var. alpestre	1	1	50
Sphagnum capillaceum	5	4	75
S. capillaceum var. tenellum	5	3	25
S. fuscum	1	1	25
S. magellanicum	1	1	25
S. quinquefarium	5	1	25
S. robustum	4	3	75
S. tenerum	3	1	25
S. warnstorfianum	4	1	25

Labrador-tea dominated the shrub layer in this association with the Alder ever present in scattered clumps (Plate II B). The shrub layer was very dense under an opening in the tree canopy but was very sparse or absent under a closed canopy.

The moss mat covered 95 to 99 percent of the forest floor. Sphagnum spp., with a Cover Value of 4 or 5, dominated the mosses. Pleurozium scherberi, and the genus Dicranum was always present. The genera Calliergon and Campylium occurred in pools of water or very wet depressions.

Spruce forest association - This was the driest and best-drained association on the bog with dry hummocks, and depressions that were usually no more than damp (see figure 3). The relief of the bog surface was no more than two feet and the hummocks varied in area from 1 to 3 m^2. The dominant tree was Black Spruce (see Table III) whose density varied from 33 to 105 trees per 100 m^2. Black Spruce of all ages were present. Occasionally vegetative reproduction from moss covered lower branches was noted. The tree canopy varied from open and park-like (20% cover) to 90 percent closed. Most Black Spruce were less than 8 inches in D.B.H, while maximum heights ranged from 35 to 55 feet. One tree cut for sampling measured 7.5 inches in diameter at the butt, was 46 feet tall, and had 250 ± 5 annual rings.

TABIE III

BLACKY BAY - SPRUCE FOREST ASSOCIATION SPECIES LIST

Species list	Abundance (average)	Cover (average)	Frequency (percent)	Density (trees per 100 m.2)
Picea mariana	5	4	100	55
Abies balsamea	1	1	25	2
Thuja occidentalis	2	2	13	10
Ledum groenlandicum	4	2	100	
Chamaedaphne calyculata var. latifolia	3	1	100	
Myrica Gale	3	1	100	
Alnus rugosa var. americana	2	2	25	
Betula pumila var. glandulifera	1	1	50	
Kalmia polifolia	1	1	25	
Corylus americana	1	1	13	
Salix discolor	1	1	13	
Vaccinium angustifolium	2	1	13	
Calamagrostis canadensis	1	1	25	
Carex disperma	1	1	13	
Carex sp.	1	1	13	
C. sp.	3	2	13	
C. sp.	1	1	13	
Clintonia borealis	1	1	13	
Cornus canadensis	4	2	13	
Gaultheria hispidula	2	1	75	
Glyceria striata var. stricta	1	1	50	
Graminae	1	1	13	

TABLE III - CONTINUED

Species list	A	C	F
Linnaea borealis var. americana	2	1	25
Listera cordata	1	1	25
Maianthemum canadense	1	1	13
Pyrola secunda	1	1	25
Sarracenia purpurea	1	1	13
Smilacina trifolia	1	1	75
Spiranthes sp.	1	1	25
Vaccinium macrocarpon	1	1	100
V. Vitus-Idaea var. minus	2	1	100
Aulacomnium palustre	1	1	25
Brachythecium sp.	1	1	25
Calliergon giganteum	1	1	13
Dicranum drummondii	4	2	75
D. rugosum	3	1	63
Drepanocladus uncinatus	1	1	13
Mnium affine	1	1	13
M. pseudopunctatum	1	1	13
Pleurozium schreberi	5	4	100
Polytrichum juniperinum var. alpestre	1	1	25
Ptilium ciliare	1	1	13
Sphagnum capillaceum	4	1	88
S. capillaceum var. tenellum	5	2	38
S. fuscum	5	2	25
S. magellanicum	2	2	63
S. recurvum	4	1	38
S. robustum	5	3	50
S. tenerum	3	1	13

Shrubs, which were very sparse or absent under a closed canopy, were numerous under scattered openings in the tree canopy (Plate III A & B). They formed a dense layer two feet high under open, park-like conditions. The mixed shrub associations were dominated by Labrador-tea with Leather-leaf (Chamaedaphne calyculata (L.) Moench, var. latifolia (Ait.) Fern.) and Sweet Gale (Myrica Gale L.) always present in varying proportions.

Herbs were very sparse in this association, the ground often being shaded by a closed canopy of trees or shrubs. However, herbs such as Large Cranberry (Vaccinium macrocarpon Ait.), Rock-Cranberry, Creeping Snowberry and False Solomon's-seal were nearly always present. Grass-Sedge expanses formed by Carex spp. and Blue-joint (Calamagrostis canadensis (Michx.) Nutt.) or Fowl-meadow Grass (Glyceria striata (Lam.) Hitchc., var. stricta (Scribn.) Fern.) did occur on Sphagnum spp. in some forest openings.

Mosses formed a mat covering 90 to 100 percent of the bog surface. Hummocks were covered in a mat of Pleurozium Schreberi (Brid.) Mitt. or Sphagnum spp. The latter often formed a mat in the moist depressions as well. Other mosses occurred but were of much less importance than those named.

Spruce - Larch forest association - This Spruce - Larch association occurred in a narrow band adjoining the more

PLATE III

Blacky Bay Bog

A. Spruce forest association near L 1600 E, 900 S. Note moss mat with few herbs or shrubs under the nearly closed canopy.

B. Spruce forest association near L 1600 E, 800 S. Note the dense growth of Labrador-tea under an open canopy.

open central portion of the bog (see figure 3). The bog surface under this association was characterized by mossy hummocks two feet high with wet depressions or pools of water between the hummocks.

The dominant tree was Black Spruce with an average density of 41 trees per 100 m^2 (see Table IV) and a maximum height of 30 to 40 feet. Black Spruce of all size classes were usually numerous. The maximum D.B.H. of mature trees was less than six inches. The trees were widely spaced forming an open type of canopy. American Larch (Larix laricina (DuRoi) K. Koch) occurred with the Black Spruce with an average density of six trees per 100 m^2 The Larch were small in stature having maximum heights of 20 to 30 feet and a maximum D.B.H. of 4 inches. Dead Larch trees were noted in each sample and on the open bog all Larch trees were dead. An examination of living trees of Larch and Spruce revealed a smaller annual increment since about 1940. Larch in the seedling and insignificant size classes were rare in occurrence.

The open type of tree canopy and a dense shrub layer occurred together (Plate IV A & B). Speckled Alder, a shrub to 10 feet high, occurred in a low shrub blanket formed mainly by Labrador-tea. The Labrador-tea was in association with Leather-leaf, Sweet Gale, and Juneberry (Amelanchier ? alnifolia Nutt.).

PLATE IV

Blacky Bay Bog

A. Spruce - Larch forest association near L 800 E, 800 S. Note the dense shrub layer of Speckled Alder and Labrador-tea.

B. Spruce - Larch forest association near L 800 E, 500 S. Note dense shrub layer dominated by Labrador-tea.

IV

TABLE IV

BLACKY BAY - SPRUCE - LARCH FOREST ASSOCIATION SPECIES LIST

Species list	Abundance (average)	Cover (average)	Frequency (percent)	Density (trees per $100m.^2$)
Picea mariana	4	4	100	41
Larix laricina	1	1	100	6
Thuja occidentalis	1	1	20	1
Alnus rugosa var. americana	4	2	80	
Amelanchier ? alnifolia	1	1	80	
Andromeda glaucophylla	1	1	20	
Betula pumila var. glandulifera	2	1	60	
Chamaedaphne calyculata var. latifolia	2	1	100	
Cornus stolonifera	2	1	20	
Corylus americana	1	1	20	
Juniperus communis var. depressa	1	1	20	
Ledum groenlandicum	5	4	100	
Lonicera canadensis	1	1	20	
Myrica Gale	2	1	80	
Rhamnus alnifolia	1	1	20	
Ribes triste	1	1	40	
Rosa acicularis	1	1	20	
Rubus Idaeus	1	1	40	
Salix bebbiana	1	1	20	
S. candida	1	1	20	
S. discolor	1	1	40	
S. sp.	1	1	20	
Vaccinium angustifolium	2	1	20	

TABLE IV - CONTINUED

Species list	A	C	F
V. myrtilloides	2	1	20
Aster sp.	1	1	20
Athyrium Filix-femina var. Michauxii	1	1	20
Calamagrostis canadensis	1	1	40
Carex disperma	1	1	60
C. gynocrates	1	1	20
C. sp.	1	1	20
C. sp.	1	1	20
C. sp.	1	1	20
C. sp.	3	2	20
C. sp.	1	1	20
C. sp.	5	4	20
C. sp.	4	2	20
C. sp.	1	1	20
Circaea sp.	1	1	20
Coptis groenlandica	4	2	20
Corallorhiza trifida var. verna	1	1	20
Cornus canadensis	4	2	20
Drosera rotundifolia	1	1	20
Epilobium angustifolium	1	1	20
Equisetum arvense	2	1	20
Fragaria virginiana	1	1	20
Galium sp.	1	1	20
Gaultheria hispidula	2	1	20
Glyceria striata var. stricta	1	1	20
Lycopus uniflorus	2	1	20
Maianthemum canadense	1	1	20
Mitella nuda	3	1	40
Potentilla palustris	1	1	20
Pyrola rotundifolia	3	1	40
P. secunda	2	1	40
Rubus pubescens	3	2	20
R. Idaeus	1	1	20
Smilacina trifolia	1	1	80

TABLE IV - CONTINUED

Species list	A	C	F
Trientalis borealis	1	1	40
Vaccinium macrocarpon	1	1	60
V. Vitus-Idaea var. minus	2	1	80
Viola sp.	1	1	100
Aulacomnium palustre	2	1	80
Blepharostoma trichophyllum	1	1	20
Brachythecium sp.	3	1	100
Bryum pseudotriquetrum	1	1	20
Campylium chrysophyllum	1	1	40
C. hispidulum	3	1	20
Climacium dendroides	1	1	40
Dicranum drummondii	1	1	60
D. rugosum	2	1	40
Fissidens osmundoides	1	1	20
Hylocomium splendens	2	1	40
Hypnum pallescens	1	1	20
Mnium affine	1	1	20
M. pseudopunctatum	1	1	20
Plagiothecium denticulatum	1	1	20
Pleurozium schreberi	4	2	80
Polytrichum juniperinum var. alpestre	1	1	40
Ptilium crista-castrensis	1	1	20
Rhytidiadelphus triquetrus	1	1	20
Sphagnum capillaceum	5	2	40
S. capillaceum var. tenellum	3	2	60
S. fusdum	1	1	20
S. magellanicum	3	2	40
S. recurvum	3	3	40
S. robustum	5	3	20
S. warnstorfianum	1	1	20
Thuidium recognitum	2	1	40
Tomenthypnum nitens	1	1	20

Herbs were generally sparse in abundance and low in cover under the heavy shrub blanket. Violets (Viola spp.), Rock-Cranberry, and False Solomon's-seal were often present. Sedges (Carex spp.) were sometimes numerous (Plate V A), especially near the Sedge-covered, open, central portion of the bog.

The moss cover was from 95 to 100 percent complete. Sphagnum spp. were the dominant mosses, although Pleurozium schreberi did form mats on the dryer sites, and Brachythecium sp. and Aulacomnium palustre were usually present.

Ash forest association - This association along the northeast corner of the peat bog (see figure 3) was very wet with numerous hummocks one foot high and some three feet high. The pools or wet areas between hummocks occupied 40 to 70 percent of the forest floor.

This stand was dominated by Black Ash (Fraxinus nigra Marsh.) (see Table V). Associated with it were Balsam-Fir, White Cedar, and Black Spruce. The densities of these four species were 35, 24, 8, and 2 trees per 100 m^2, respectively. Ash and Fir were present in all size classes in all samples, however the number of large Fir trees was small, most of the Fir being in the insignificant size class. Ash of insignificant size did occur locally in dense stands at the rate of 8 per m^2. This number was not included in the Ash tree density figure given

PLATE V

Blacky Bay Bog

A. Spruce - Larch forest association near L 800 E, 500 S. Note the Sedge hummock in the foreground with Labrador-tea and Leather-leaf at the sides.

B. Ash forest association near 2300 E on the baseline. Note the many young trees, the open canopy and the domination of the forest floor by grasses and sedges.

above. The Cedar in this stand were mostly large trees, but seedlings were common. The Spruce were nearly all large trees. The tree canopy was about 70 percent closed but the Ash allowed a large amount of light to reach the forest floor.

Shrubs under the Ash association were very sparse to sparse in abundance and always less than 5 percent in cover. Mountain - Maple (Acer spicatum Lam.), Speckled Alder and Fly-Honeysuckle (Lonicera canadensis Bartr.) were present in all samples.

Herbs were very abundant and dominated by grasses and sedges which gave the forest floor its characteristic appearance (Plates V B & VI A). The Sedges (Carex spp.) as a group were always present and had an average Cover Value of 4. Carex leptalea Wahlenb., was one of the commonest species. Among the Grasses Glyceria spp. were locally abundant. Goldthread, Dwarf Raspberry (Rubus pubescens Raf.) and Marsh-Marigold (Caltha palustris L.) were always present.

The moss cover under this dense herb layer ranged from 95 percent cover to scattered moss plants giving 50 percent cover. Climacium dendroides (Hedw.) Web. & Mohr, and Rhytidiadelphus triquetrus (Hedw.) Warnst., were always present. Sphagnum warnstorfianum DuRietz, was the only species of this genus found in the Ash association.

Open bog associations - The open bog at Blacky Bay

PLATE VI

Blacky Bay Bog

A. Ash forest association near L 2400 E, 100 S. Note the pools of water, the Cedar and Fir trees and the domination of the sedges.

B. Open bog associations from L 400 E. Note the Sweet Gale, Leather-leaf, Swamp-Birch, and sedges in the foreground. Cat-tails occur in the middle and a band of Speckled Alder at the forest margin.

TABLE V

BLACKY BAY - ASH FOREST ASSOCIATION SPECIES LIST

Species list	Abundance (average)	Cover (average)	Frequency (percent)	Density (trees per 100m.^{2})
Fraxinus nigra	4	4	100	35
Abies balsamea	4	1	100	24
Thuja occidentalis	2	2	100	8
Picea mariana	1	1	80	2
Populus balsamea	3	1	20	
Acer spicatum	2	1	100	
Alnus rugosa var. americana	2	1	100	
Cornus stolonifera	2	1	40	
Corylus americana	1	1	20	
Ledum groenlandicum	2	1	20	
Lonicera canadensis	2	1	100	
Rhamnus alnifolia	1	1	60	
Taxus canadensis	2	1	20	
Viburnum cassinoides	1	1	20	
V. triloba	1	1	20	
Aralia nudicaulis	1	1	40	
Aster sp.	1	1	20	
Calamagrostis canadensis	2	1	40	
Caltha palustris	1	1	100	
Carex disperma	4	3	60	
C. leptalea	3	2	80	
C. sp.	3	1	20	
C. sp.	1	1	40	
C. sp.	2	1	40	
C. sp.	1	1	60	

TABLE V - CONTINUED

Species list	A	C	F
Carex sp.	2	1	20
C. sp.	3	1	40
C. sp.	3	3	40
C. sp.	1	1	20
C. sp.	1	1	20
Cinna latifolia	3	1	20
Coptis groenlandica	3	1	100
Cornus canadensis	3	1	60
Dryopteris disjuncta	1	1	20
D. sp.	2	1	20
Equisetum sp.	2	1	20
Fragaria virginiana	1	1	20
Galium triflorum ? var. asprelliforme	2	1	80
Gaultheria hispidula	1	1	20
Glyceria canadensis	3	1	20
G. striata var. stricta	5	3	40
Hydrocotyle americana	2	1	20
Linnaea borealis var. americana	1	1	20
Lycopus uniflorus	1	1	80
Lysimachia thyrsiflora	1	1	20
Maianthemum canadense	1	1	40
Mitella nuda	2	1	80
Pyrola secunda	2	1	40
Ribes triste	1	1	40
Rubus pubescens	3	1	100
Schizachne purpurascens	3	1	20
Solidago sp.	1	1	20
S. sp.	2	1	20
Smilacina trifolia	1	1	20
Trientalis borealis	1	1	40
Viola pallens	1	1	20
V. sp.	1	1	20

TABLE V - CONTINUED

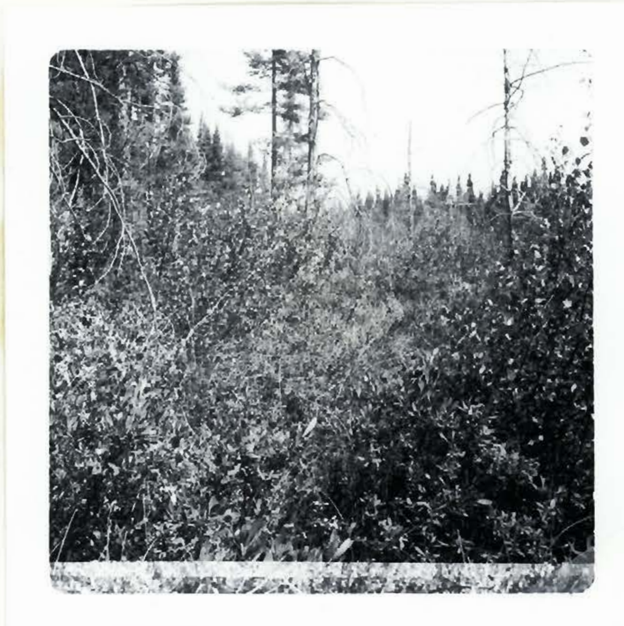
Species list	A	C	F
Aulacomnium palustre	3	1	40
Brachythecium sp.	5	1	40
Calliergon cordifolium	5	2	40
C. giganteum	5	1	20
C. richardsonii	5	3	40
Campylium sp.	5	2	20
Climacium dendroides	3	1	100
Hylocomium splendens	1	1	20
Hypnum linbergii	3	1	60
H. pratense	5	1	20
Mnium affine	5	2	80
M. punctatum	5	1	40
M. sp.	5	2	20
Pleurozium schreberi	3	1	20
Polytrichum juniperinum	2	1	20
Rhytidiadelphus triquetrus	3	1	100
Sphagnum warnstorfianum	5	3	80
Thuidium delicatulum	5	1	40
T. recognitum	5	2	80

PLATE VII

Blacky Bay Bog

A. Margin of bog forest and open bog with shrubs near L 800 E, 600 S. Note the dead Larch stubs among Speckled Alder, Swamp-Birch, Sweet Gale and Leather-leaf.

B. Shrub zone of open bog near L 800 E, 600 S. Note the Swamp-Birch, Speckled Alder and Sweet Gale.



was subjectively mapped but not quantitatively sampled. The open bog occurred along the margins of the lake and stream and was bordered on the north and south by the Spruce - Larch association (Plate VI B). The vegetation zones of the open bog ran roughly parallel to the stream (see figure 3).

The zone next to the Spruce - Larch bog forest was usually dominated by Speckled Alder with other tall shrubs such as Willows (Salix spp.) and Swamp-Birch (Betula pumila L., var. glandulifera Regel) (Plate VII A). Sedges, (Carex spp.) usually dominated the ground cover, forming hummocks, with only scattered mosses.

Nearer the stream was a zone dominated by smaller shrubs, either Swamp-Birch (Plate VII B) or Leather-leaf, with some Willows, Bog-Rosemary (Andromeda glaucophylla Link) and Sweet Gale. Some Sedges were also present, and mosses often formed a mat (Plate VIII B). Near the lake was a very wet zone dominated by Cat-tail (Typha latifolia L.) with Sedges on a floating mat. Another zone further upstream was dominated by Sedges with Cat-tail present (Plate VIII A). The edges of the stream were bordered by a narrow band of Sweet Gale and Sedge growing together on a floating mat.

PLATE VIII

Blacky Bay Bog

A. Cat-tail zone near L 400 E, 500 S. Note stream in middle, low shrubs, and band of Speckled Alder in the background.

B. Open bog near L 400 E, 400 S. Note moss mat, sedges, and Sweet Gale in background.

VIII

PART II - VEGETATION OF SCOTT LAKE BOG

The vegetation of Scott Lake Bog was quite uniform in the species of plants present as may be seen by the frequency percentages in Table VI. The two tree species, three of the shrub species and two of the herb species were almost always present. The Sphagna as a group covered almost the entire bog surface and were responsible for the ever-present hummocks on the bog. However, within this uniformity of the vegetation, different relative abundances and growth forms gave rise to several zones of vegetation.

The first zone was a marginal zone in which the Black Spruce association of the upland changed to the Black Spruce association of the bog (figure 4). The zone was usually wet (water entered a man's footprints) with pools of water and hummocks. The Black Spruce formed a 75 percent closed canopy beneath which was an association of Speckled Alder, Labrador-tea, Sedges (*Carex* spp.) and *Sphagnum* spp. (Plate IX, A & B).

The second zone was next to the first but while wet did not have pools of water or Speckled Alder. The trees were low (15 - 25 feet) Black Spruce and occasionally a few Larch. The nearly continuous shrub layer was formed mainly by Leather-leaf, Labrador-tea, Lambkill (*Kalmia angustifolia* L.)

PLATE IX

Scott Lake Bog

A. Marginal zone from bog near 2800 W on the baseline. Note the Black Spruce, Speckled Alder, with Lambkill, Leather-leaf and Labrador-tea in the foreground.

B. Marginal zone near 3000 W on the base line. Note the Speckled Alder and Labrador-tea, with Sedge (Carex disperma) on the Sphagnum moss hummocks over a pool of water.

Figure 3 – BLACKY BAY BOG
Plant Association Map
Scale: 1 inch = 127 feet

Legend
- - - Bog margin
—— Plant Association boundary
═══ Stream
L1200E Grid position

IX

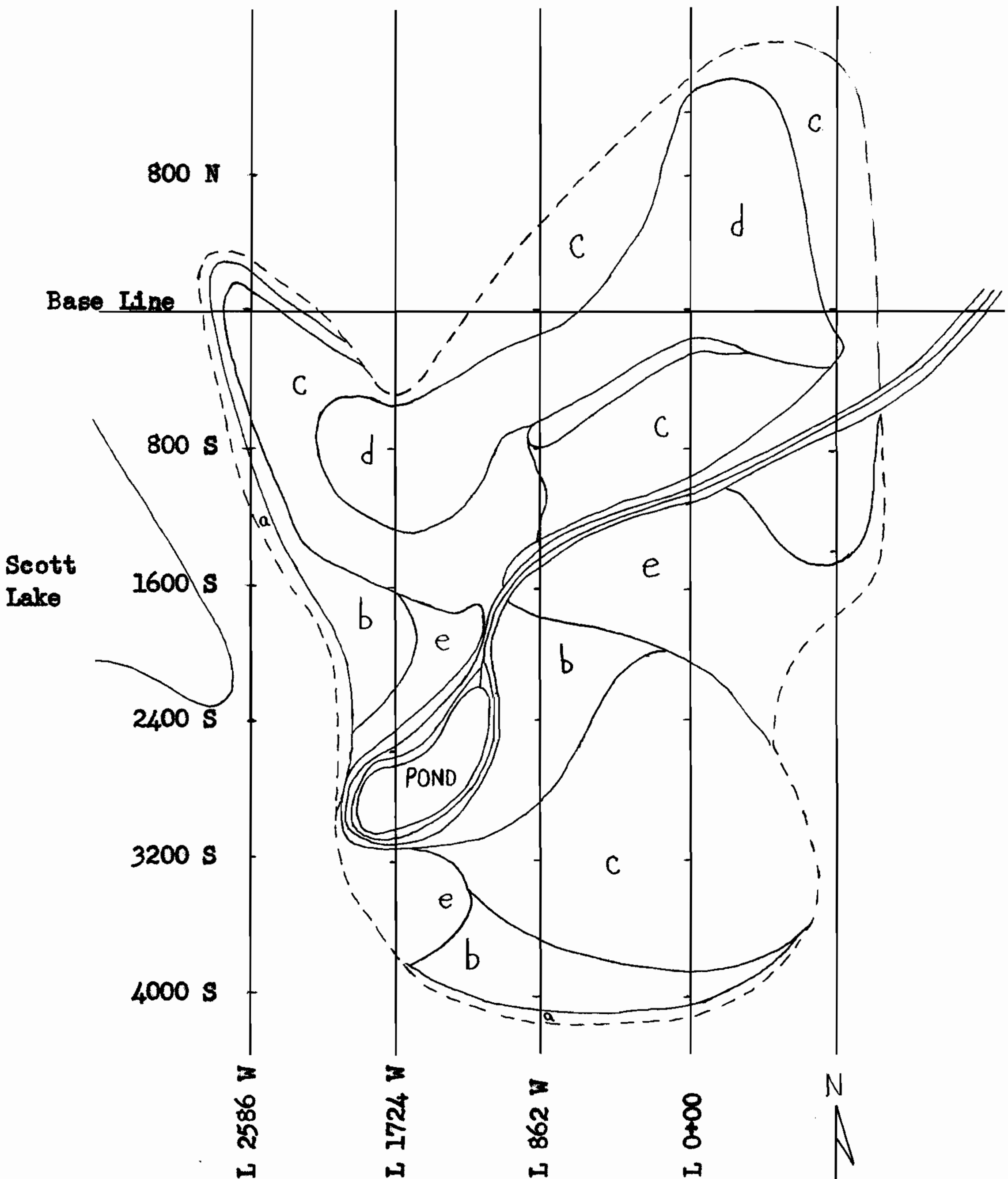


Figure 4 - Plant Association Map

SCOTT LAKE BOG
Scale: 1 inch = 1000 feet

Legend

a Zone 1 - Marginal	--- Bog margin
b Zone 2 - Spruce-Larch	── Zone boundaries
c Zone 3 - " "	├800S Grid position
d Zone 4 - Open Spruce-Larch	┤ Sample point
e Zone 5 - Dry Spruce forest	

TABLE VI

SCOTT LAKE BOG SPECIES LIST

Species list	Abundance (average)	Frequency (percent)
Picea mariana	4	100
Larix laricina	2	89
Chamaedaphne calyculata var. latifolia	4	100
Kalmia polifolia	3	100
K. angustifolia	3	89
Ledum groenlandicum	2	78
Betula pumila var. glandulifera	2	72
Andromeda glaucophylla	3	67
Salix sp.	1	28
Pyrus melanocarpa	2	22
Vaccinium myrtilloides	1	17
Vaccinium Oxycoccus	2	100
Smilacina trifolia	2	94
Carex oligosperma	3	72
C. paupercula	2	72
C. exilis	3	56
C. pauciflora	1	50
Eriphorum spissum	1	33
Equisetum fluviatile	1	28
Carex trisperma	1	22
Gaulteria hispidula	1	22
Aster sp.	2	17
Menyanthes trifoliata var. minor	2	11
Carex gynocrates	1	11
Iris versicolor	4	6
Rubus Chamaemorus	2	6

TABLE VI - CONTINUED

SCOTT LAKE BOG SPECIES LIST

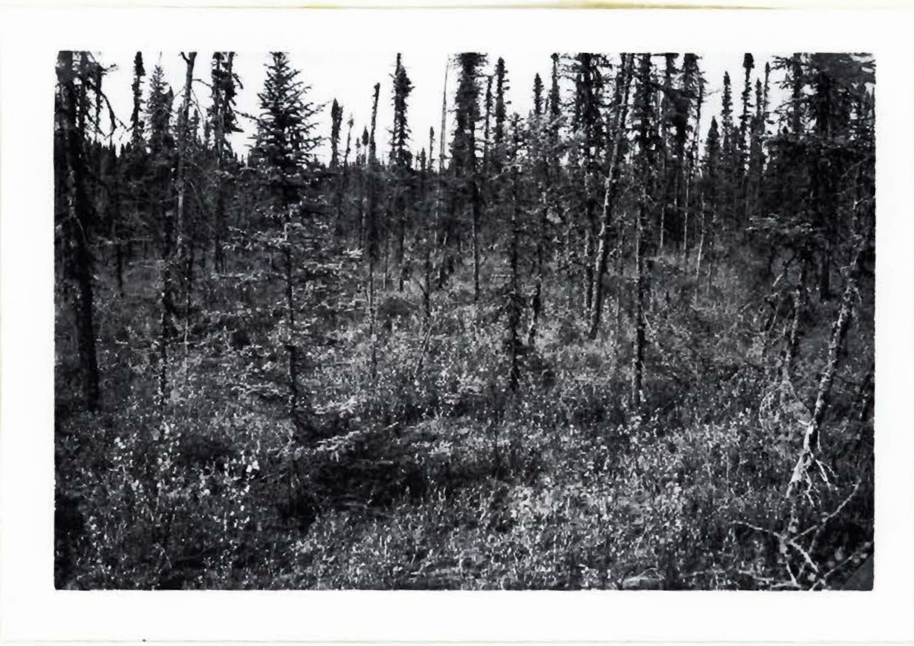
Species list	A	F
Carex ? limosa	1	6
Drosera rotundifolia	1	6
Equilobium sp.	1	6
Sarracenia purpurea	1	6
Scirpus hudsonianus	1	6
Sphagnum recurvum	4	94
S. fuscum	3	56
S. magellanicum	2	39
S. capillaceum var. tenellum	5	6
Polytrichum commune	2	44
Pleurozium schreberi	3	11

PLATE X

Scott Lake Bog

A. Low, open Black Spruce-Larch bog forest near 862 W on the base line. Note Swamp-Birch, Leather-leaf and sedges on the Sphagnum moss mat.

B. Low, open Black Spruce-Larch bog forest near 2700 W on the base line. Note the dense shrub layer with Leather-leaf, Labrador-tea and Swamp-Birch.



and Bog-Lambkill (K. polifolia Wang.). Among the herbs were Small Cranberry (Vaccinium Oxycoccus L.), Creeping Snowberry, and some Sedges. The Sphagna formed a mat with hummocks.

The third zone was near the central portions of the bog (figure 4). It was wet bog with a stunted low (to 20 feet) open forest of Black Spruce and Larch. The shrub layer contained Leather-leaf, Bog-Rosemary, Bog-Lambkill, and Swamp-Birch (Plate X, A & B). Herbs were the Small Cranberry, Creeping Snowberry, and Sedges (Plate XI A).

The fourth zone in the central part (figure 4) of the bog was wet and open with scattered clumps of stunted (to 10 feet) Black Spruce and Larch (Plates XI B & XII A). The bog surface usually had a mat formed by Sphagna. Some areas had no shrubs or herbs. Many areas had scattered Leather-leaf, Bog-Rosemary, and Sedges (Carex spp.). Large areas of the northeast part of the bog were dominated by Sedges with few shrubs and an incomplete moss mat (Plate XII A & B).

A fifth zone occurred on the bog on the central east side, and north and south of the pond (figure 4). This zone was dry and supported a tall (50 feet), 85 percent closed canopy Black Spruce bog forest. The trees were of good growth form and all size classes were present. Labrador-tea dominated the continuous shrub layer. Among the sparse herbs present were Creeping Snowberry, False Solomon's-seal, and some Sedges.

PLATE XI

Scott Lake Bog

A. Bog surface near 862 W on the base line in low, open Black Spruce - Larch bog forest. Note the Sphagnum moss mat with Swamp-Birch, Bog-Rosemary, sedges and False Solomon's-seal.

B. Very open, low Larch bog forest with the Sedge (Carex oligosperma Michx.) on a Sphagnum moss mat, near 500 E on the base line. Bog margin in the background.

PLATE XII

Scott Lake Bog

A. Very open, low Larch bog forest, near 500 E on the base line. Note the Sedge (Carex oligosperma) on the Sphagnum moss mat.

B. Bog surface in very open Larch bog forest near 862 E on the base line. Note the Sedge (Carex oligosperma) on the Sphagnum moss mat. Aster sp., and Horsetail (Equisetum fluviatile L.) are also present.

The moss cover was 75 percent Sphagnum spp. with scattered areas of Pleurozium schreberi. This zone was quite similar to the dry Black Spruce association described at Blacky Bay. This zone at Scott Lake bog was underlain, at least in part, by clay rather than peat.

The pond on Scott Lake bog had its own zones of vegetation. These included a very narrow band of Leather-leaf at the water's edge, a band (30 feet) of Sedges (Carex spp.) in water, then a band (30 feet) of Leather-leaf and Sedge, and finally a band of small Black Spruce with a Leather-leaf blanket on a Sphagna moss mat. The drainage channel from the lake was bordered by a 50 foot band of Speckled Alder along its entire length.

PART III - VEGETATION OF MATTAGAMI LAKE MINES

Spruce - Labrador-tea association - This association occurred on dryer, well-drained areas of the property (figure 5). Black Spruce was the dominant tree (See Table VII). Larch was very rarely seen. The Spruce trees had a density of 35 living and 4 dead trees per 100 m^2. The trees ranged in height from 7 to 30 feet, but only 9 trees were over 21 feet high. They ranged in D.B.H. from 12. to 5.4 inches with a total basal area of 227 in^2 per 100 m^2. The dead trees included the largest and tallest trees. The forest was very open as the trees were tall and narrow in form and the insignificants

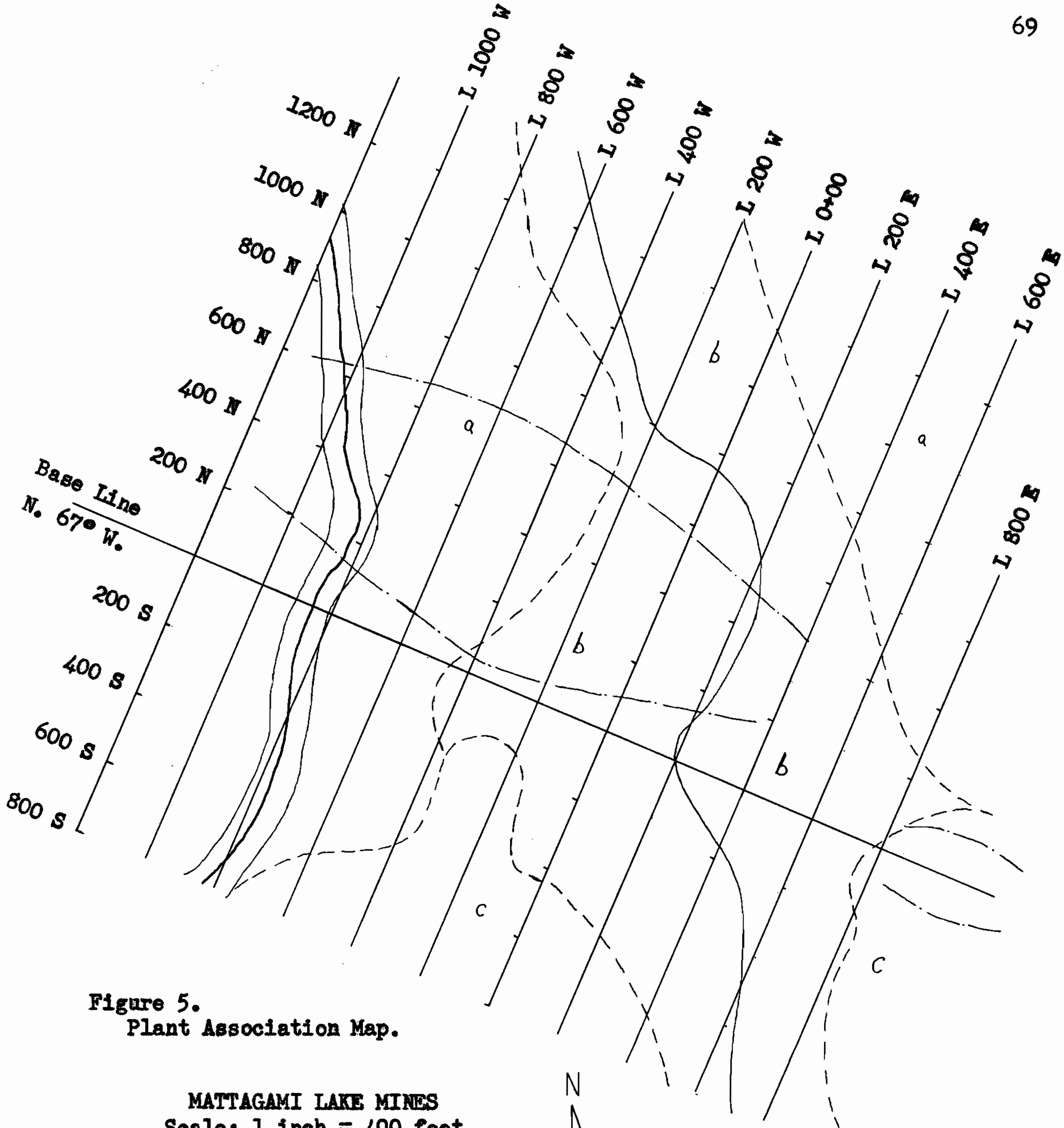


Figure 5.
Plant Association Map.

MATTAGAMI LAKE MINES
Scale: 1 inch = 400 feet

Legend

- a — Dry Spruce - Labrador-tea
- b — Wet Spruce - Fir - Alder
- c — Old burn area
- - - - — Plant association boundary
- ≡ — Stream - deeply incised
- 600S+ — Grid position
- + — Sample point
- ·—·— — Outline of ore bodies

were small. Spruce seedlings were numerous. Vegetative propagation by the rooting of lower branches in moss was common.

Labrador-tea in this open forest formed a dense shrub layer which gave a characteristic appearance to the ground cover (Plate XIII A). The Labrador-tea was rooted mainly in the hummocks but the shoots filled in the hollows as well.

Herbs were sparse and scattered mostly in very open areas. Wood-Horsetail (Equisetum sylvaticum L.) was the most abundant large herb, while the small herbs, Creeping Snowberry and Small Cranberry were usually trailing over the moss mat. This moss mat covered the entire forest floor. This mat consisted mainly of Sphagnum fuscum (Schimp.) H. Klinggr, in the form of hummocks as much as two feet high (Plate XIII B). Sphagnum capillaceum var. tenellum (Schimp.) Andrews and S. girgensohnii Russ occurred in the depressions.

Spruce - Fir - Alder Association - This association occurred in and about the shallow local drainage basins of the area (figure 5). The habitat was always damp and near the tiny streams it was very wet.

The dominant tree was Black Spruce (see Table VII). It was tall (40 to 60 feet high) and of good growth form (Plate XIV A) with a density of 8 large trees per 100 m^2. There were few dead trees but rotting windfalls were common. Spruce reproduction was rare, with one insignificant per 100 m^2. The Spruce ranged in D.B.H. from 7.6 to 11.1 inches with a total

TABLE VII

SPECIES LISTS FOR MATTAGAMI LAKE MINES

Species lists	Spruce-Fir-Alder Association: Abundance class	Spruce-Fir-Alder Association: Cover class	Spruce - Labrador-tea Association: Abundance class	Spruce - Labrador-tea Association: Cover class
Picea mariana	4	3	5	4
Larix laricina			1	1
Abies balsamea	4	3		
Alnus rugosa var. americana	5	4		
Ledum groenlandicum	4	1	5	5
Kalmia angustifolia			2	1
K. polifolia			2	1
Vaccinium myrtilloides	1	1	4	1
Viburnum edule	1	1		
Anemone sp.	1	1		
Carex trisperma	3	1	2	1
Coptis groenlandica	1	1		
Cornus canadensis	1	1	1	1
Equisetum sylvaticum	1	1	2	1
Gaultheria hispidula	5	3	5	2
Listera cordata	1	1		
Lycopodium ? annotinum	5	2		
Rubus Chamaemorus	2	1	2	1
Smilacina trifolia	1	1	2	1
Vaccinium Oxycoccus	1	1	5	2
Hylocomium splendens	1	1		
Pleurozium schreberi	3	1	4	1
Polytrichum commune			1	1
Ptilium crista-castrensis			4	1
Sphagnum capillaceum var. tenellum	4	1	5	3
S. fuscum			5	3
S. magellanicum			1	1
S. girgensohnii	5	5		
S. robustum	4	2		

basal area of 513 $in.^2$ per 100 $m.^2$ The number of Balsam-Fir trees was greater than that of Spruce but the Fir trees were much smaller and appeared to be entering openings in the canopy left by old Spruce windfalls. The Fir had a density of 10 large trees per 100 $m.^2$ They ranged in height from 15 to 40 feet, and in D.B.H. from 2.5 to 8.0 inches, with a total basal area of 20.5 $in.^2$ per 100 $m.^2$ Fir reproduction was more frequent than that of Spruce with 10 insignificants per 100 $m.^2$

Speckled Alder and Labrador-tea were scattered under the tree canopy, but under openings in the canopy the Alder formed a layer 3 to 12 feet high and the Labrador-tea was rare.

Herbs were scattered over the forest floor, but only Creeping Snowberry and Bristly Club-moss (Lycopodium annotinum L.) were very abundant.

The thick moss mat covered all litter and in many areas was the characteristic ground cover (Plate XIV B). This mat was formed mainly by Sphagnum girgensohnii with other mosses only about the driest tree trunks and hummocks.

PART IV - DISCUSSION OF VEGETATION

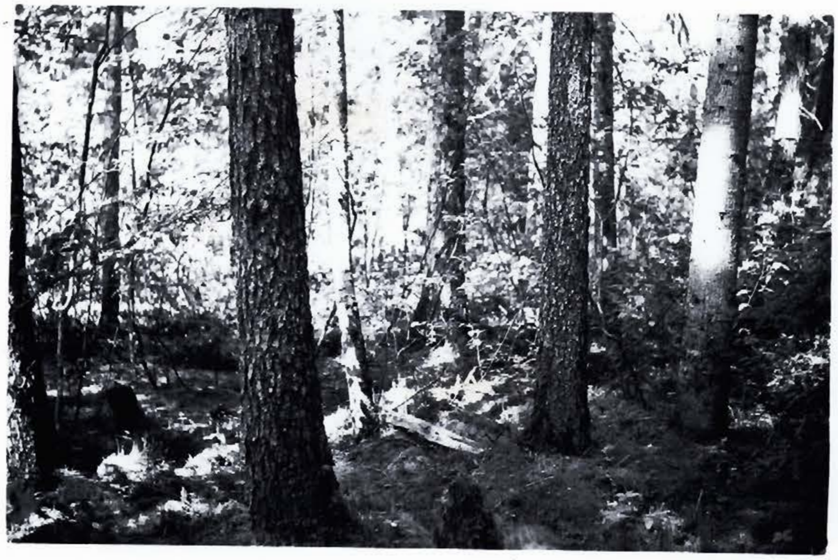
The sample areas lie in or near the Boreal Forest or "taiga" outlined by Oosting (1953) and many other workers. The Blacky Bay area lies near the southern edge of this forest

PLATE XIV

Mattagami Lake Mines

A. Spruce - Fir - Alder association. Note large Black Spruce and Balsam-Fir trees with the shrub, Speckled Alder.

B. Spruce - Fir - Alder association. Shaded forest floor with the herbs, Baked-apple (Rubus Chamaemorus L.), Wood-Horsetail, and Bristly Club-moss on the Sphagnum moss mat.



while the other two areas are well within its boundaries.

The vegetation described on Blacky Bay Bog fits into the pattern described by Dansereau and Segadas-Vianna (1952) as the succession occurring on peat bogs in Northern Quebec and Ontario where the Canadian or Spruce - Fir forest is climax. The forest associations of Blacky Bay and Scott Lake Bogs are given below with Dansereau and Segadas-Vianna's corresponding associations.

Blacky Bay	Dansereau and Segadas-Vianna	Successional stage
Marginal forest	Abietetum balsameae	(Quasi-climax)
Spruce-Cedar forest	Thujetum occidentalis	(Sub-climax)
Spruce forest	Picetum marianae	(Climax)
Spruce - Larch forest	Laricetum laricinae	(Consolidation)
Ash forest	not described	
Open bog		
Alder zone	Alnetum rugosa	(Consolidation)
Leather-leaf zone	Chamaedaphnetum calyculatae	(Consolidation)
Bog-Rosemary	Andromedetum glaucophyllae	(Pioneer)
Sweet Gale zone	Myricetum galeae	(Pioneer)
Sedge	Caricetum rostratae	(Pioneer)
Grass	Calamagrostetum canadensis	(Pioneer)
Scott Lake		
First (Marginal) zone	? Alnetum rugosa	(Consolidation)
Second (Spruce-Larch) zone	Picetum ericaceum	(Consolidation)
Third (Spruce-Larch) zone	Laricetum laricina	(Consolidation)
	Chamaedaphnetum calyculatae	(Consolidation)
	Kalmietum angustifoliae	(Consolidation)
	Andromedetum glaucophyllae	(Pioneer)
Fourth (open) zone	Chamaedaphnetum calyculatae	(Consolidation)
	Andromedetum glaucophyllae	(Pioneer)
	Caricetum rostratae	(Pioneer)
Fifth (Spruce forest) zone	Picetum marianae	(Climax)

The vegetation of the Mattagami Lake Mines property falls into the category known as "taiga" to many authors, including

Oosting. It is also similar in part to what Hustich (1949, p. 12 and 22) terms "muskeg" that is, a bog forest which has a single tree stratum of Picea mariana, and a hummocked ground vegetation of mosses - chiefly species of Sphagnum which bears a varied shrub and herb community dominated by Ledum groenlandicum. Of course, the Mattagami site did not have a peat bog, but the sites at Blacky Bay and Scott Lake were on peat bogs and the term "muskeg" of Hustich does fit the dry Spruce forest associations found on these bogs.

Moss (1953) describes a succession of Sphagnum spp. and their associated plants in relation to the moisture factor on peat bogs. The author noted this succession of Sphagnum spp. only at Mattagami site where it is recorded that S. fuscum occurred on top of the hummocks and S. capillaceum var. tenellum and S. girgensohnii occurred in the depressions. Again this was not on a peat bog but in the "tiaga" with a deep moss mat. Moss notes that similar successions on peat bogs have been noted by Nichols (1918), Moss (1949), and by certain European workers.

The results of the plant collections are not presented in this report.

The decrease in the growth rate of Larch at Blacky Bay since about 1940 has also been noted in Minnesota bogs by Isaak, Marshall, and Buell (1959). These authors refer to it as reverse plant succession caused by an increased precipitation rate since the early 1940's.

CHAPTER IV

BIOGEOCHEMICAL DATA

<u>General introduction</u> - The methods of collecting and analyzing the plant material from which this biogeochemical data has been obtained were described, as well as the specific location, topography, soils and geology of each sample area, and was recorded in Chapter II of this thesis.

<u>Presentation of biogeochemical data</u> - The biogeochemical data have been arranged on distribution maps of the areas sampled, on profile graphs, and in histograms.

The distribution maps are of two types, one is a map of the plant associations with metal contents of one plant species placed on it, and the other is a map of the sample area with the metal contents of one species contoured. The purpose of the first type of distribution map is to show correlations between metal content and plant association. The purpose of the second type is to show areas of high and low metal contents. These areas can be compared between different species or they can be compared to plant associations of the first type.

The profile graph shows the metal content of each species along one line of the sampling grid. The purpose of the profile graph is to compare the metal content of different species at the same sampling point. It also shows areas of high metal contents.

The histogram or bar graph plots the frequency of metal content intervals. The histogram shows the frequency of metal values, the modal values, and the range of metal values. The frequency and magnitude of high metal values are of use in determining metal enriched areas.

Interpretation of biogeochemical data - The interpretation of the results obtained by the analysis of plant materials for metals is difficult. H. V. Warren of the University of British Columbia has published several reports of a biogeochemical nature and included in these reports are a number of suggestions on the interpretation of biogeochemical data.

Warren, Delavault and Irish (1952,b) use average values in interpreting results. Harbaugh (1950) also stresses the importance of using average values.

Warren, Delavault, and Irish (1952,b) and other workers have calculated average metal contents for several plant species from hundreds of analyses. Where these plant samples are thought to have come from unmineralized areas the averages are called "normal" or "negative" values. When higher averages are obtained for samples from mineralized areas, the values are called "anomalous" or "positive" values. These workers suggest that when 50 or more samples of one species from one area are analyzed the results can be treated independently of any previous data. They also suggest the use of histograms to determine anomalous values. Anomalous values can be determined by the percentage variation of the values in question from normal values. With the metal copper, values 50 to 100 percent above normal are possibly anomalous, and values 100 percent or more above normal are probably anomalous. With zinc, values 30 to 50 percent above normal are possibly anomalous, and values 50 percent or more above normal are probably anomalous. The histogram of normal values is compact and has a slightly bell-shaped curve. Warren and Delavault (1955,a) state that a histogram of the content of an element more or less equally distributed in an area cuts off abruptly on the side of the high values. A histogram over a weakly anomalous area has a bell-shaped curve but is extended on the high side. A histogram ending abruptly in a high interval indicates a strong anomalous area. (Warren, Delavault and Irish, 1949).

BLACKY BAY BOG

Introduction

Sampling points - The collection of plant samples for metal analysis on Blacky Bay Bog took place at a total of 29 points on the grid. The sampling points occurred at 100 foot intervals along lines 800, 1600 and 2400 east, which were 800 feet apart. The sampling points are marked on figure 6. Some sample species were not present at all points.

Species collected and parts analyzed.- Black Spruce (Picea mariana (Mill.) BSP) was of widespread occurrence on the bog and its twigs were collected. The needles and second year-old (2 yr. old) stems were analyzed. Sweet Gale (Myrica Gale L.) was collected when present. Its leaves and stems of 2 - 4 years growth were analyzed. The metal contents of the leaves of Black Spruce and Sweet Gale appear only in the average tables (Tables IX to XII). A few samples of Labrador-tea (Ledum groenlandicum Oeder) and of Swamp-Birch (Betula pumila L. var. glandulifera Regel) were collected. The leaves and 2 yr.-old stems were analyzed but the data appear only in the average tables. Two herbs, False Solomon's-seal (Smilacina trifolia (L.) Desf.) and Sedge (Carex disperma Dew. or C. trisperma Dew.)were collected and the whole plants (roots,or rhizones, stems, leaves, and flowers or fruits) analyzed. Two moss species,(Pleurozium schreberi (Brid.) Mitt.) and Sphagnum (Sphagnum spp.) were collected and the whole plants analyzed.

All plant samples were analyzed for copper, zinc, lead and nickel and the results tabulated in parts per million on an air-dry weight basis (ppm - dry wt.)

Discussion

Zinc - The zinc contents of the surface peats, adapted from Gleeson (1960) are given in figure 6. The zinc content of each species is plotted on plant association maps in figures 7 to 12. The peat under the Black Spruce forest association does contain several of the lowest values. There is no correlation between plant associations and plant zinc contents.

The zinc contents of each species are contoured in figures 14 to 19. The contours are not correlated with the vegetation zones mapped above. The contours do show several species in which an area of higher values occurs on each side of the central drainage channel. These species are Black Spruce, False Solomon's-seal, Sedge, Sphagnum moss and Pleurozium moss.

The profile graphs of figures 20 to 22 show a varying zinc content for each species at each point. The profiles of line 800 east (L 800 E) and L 1600 E show the same tendency as the contour maps (figures 14 to 19) with higher values at the ends of the lines than in the central portion. The point 300 south (300 S) on L 1600 E shows low values for nearly all species.

The zinc contents of each species are shown in a histogram and all are more or less symmetrical and of the normal type, (see figure 23).

<u>Copper</u> - The copper contents of each species are plotted on plant association maps in figures 25 to 30. The only high values in the surface peats (figure 24) are on the north side of the bog.

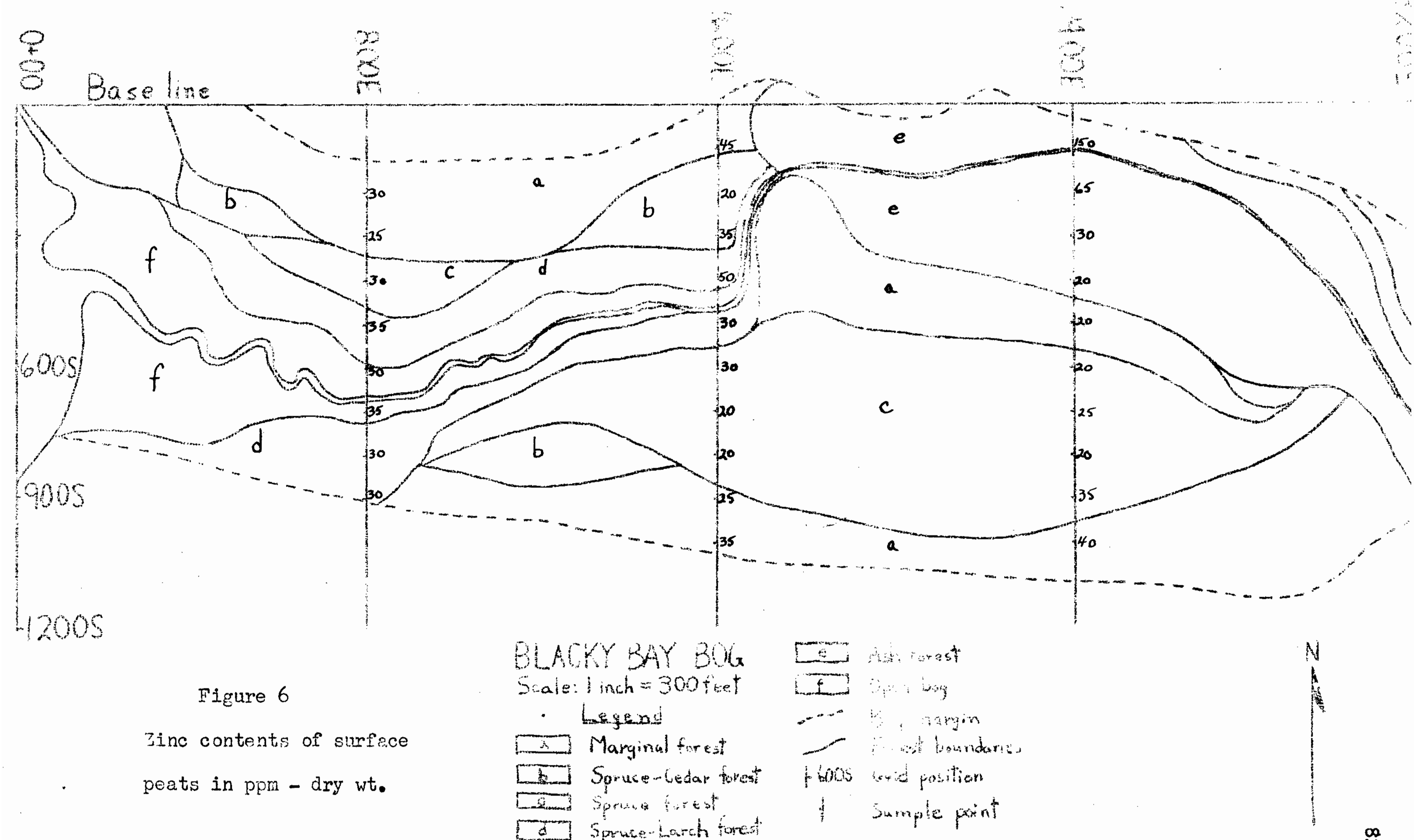


Figure 6

Zinc contents of surface peats in ppm - dry wt.

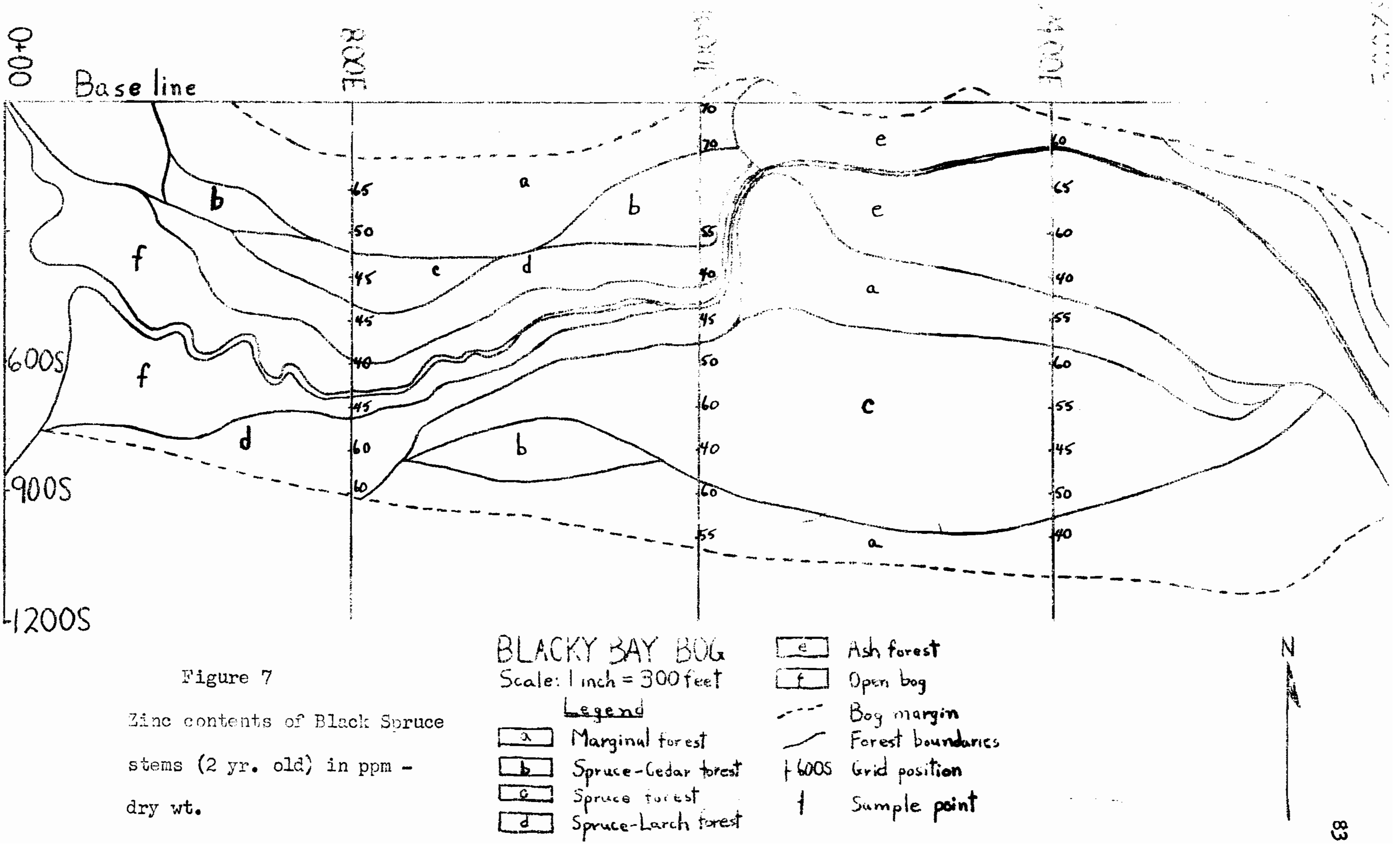


Figure 7

Zinc contents of Black Spruce stems (2 yr. old) in ppm - dry wt.

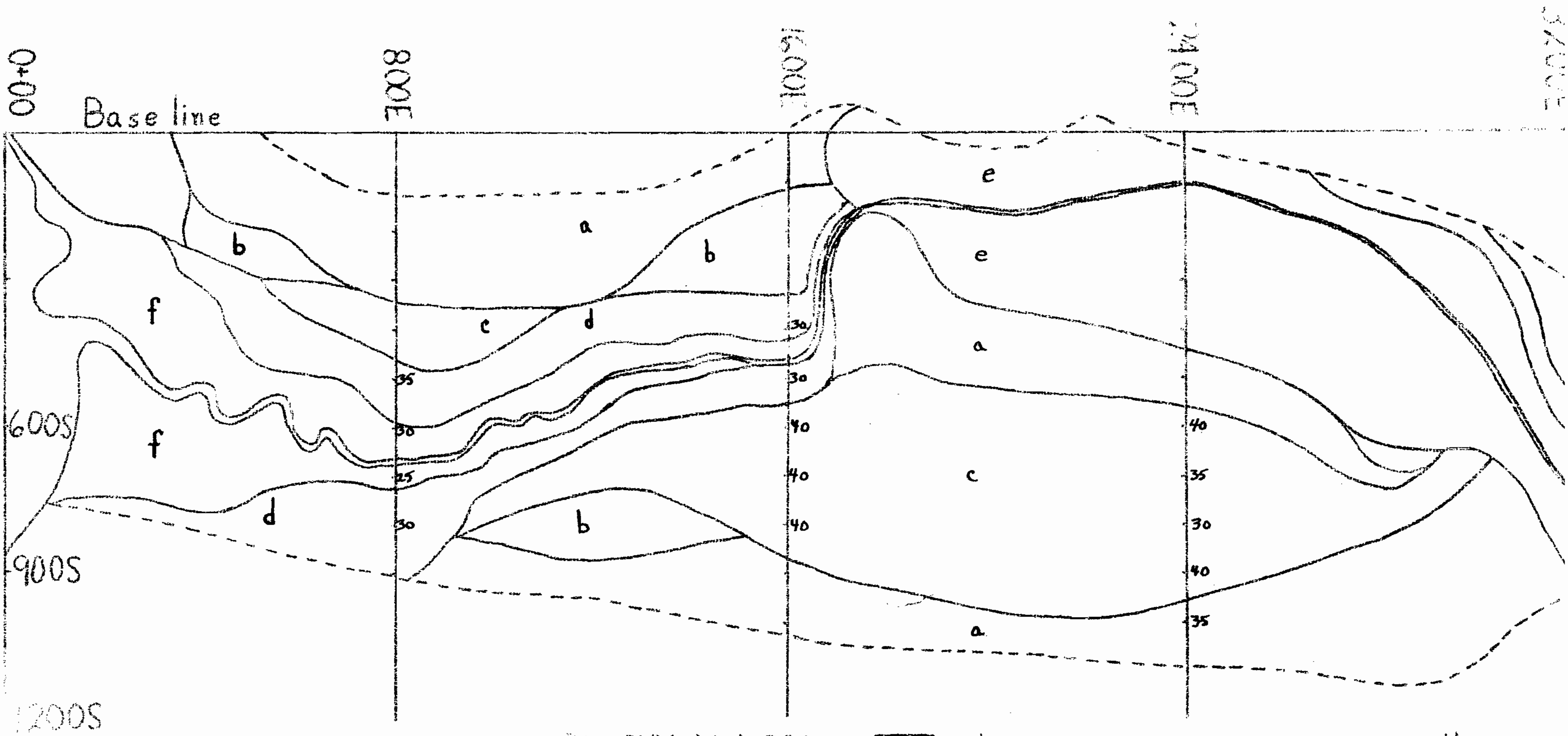


Figure 8

Zinc contents of Sweet Gale stems (2 yr. old) in ppm - dry wt.

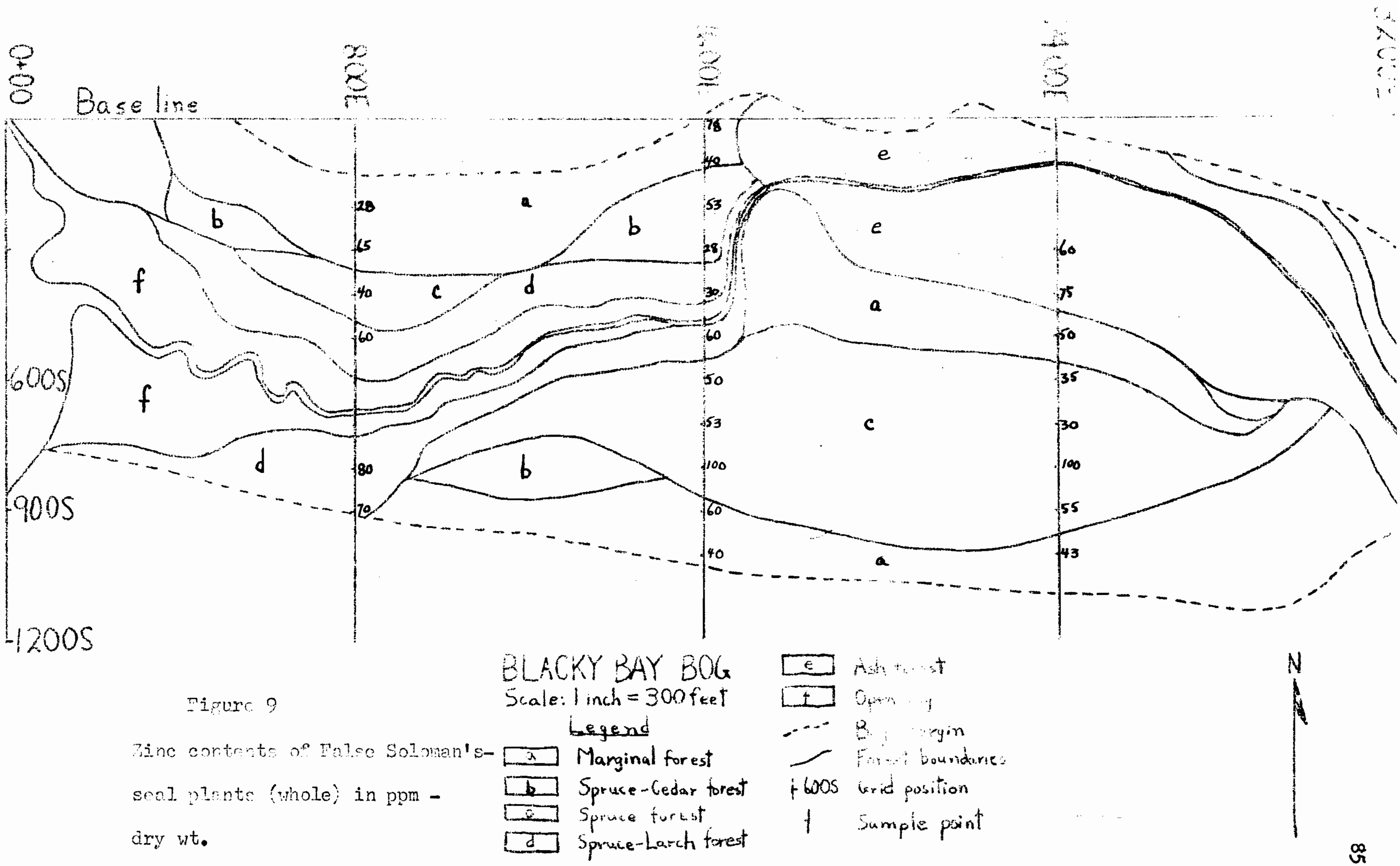


Figure 9

Zinc contents of False Soloman's-seal plants (whole) in ppm - dry wt.

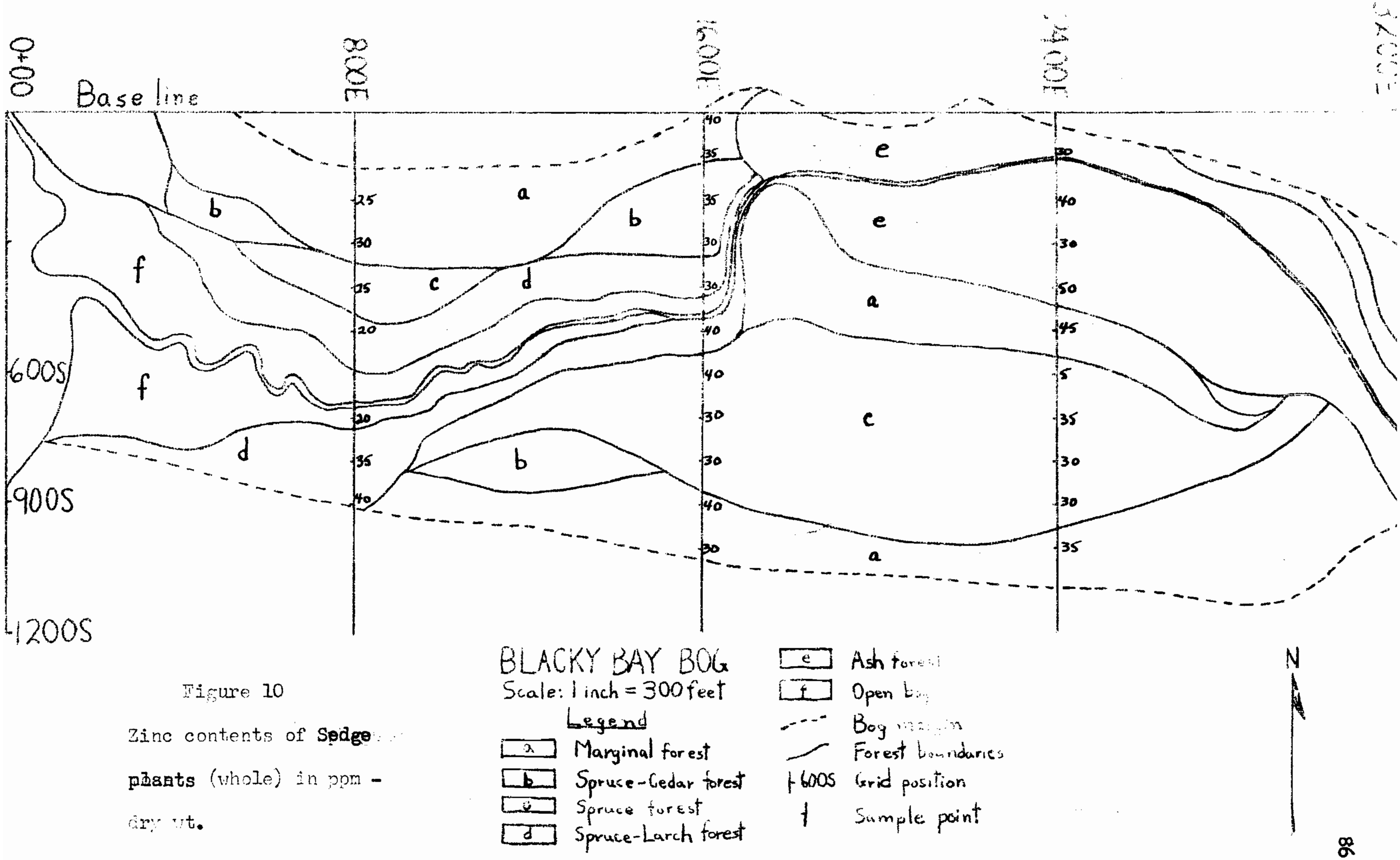


Figure 10

Zinc contents of Sedge plants (whole) in ppm - dry wt.

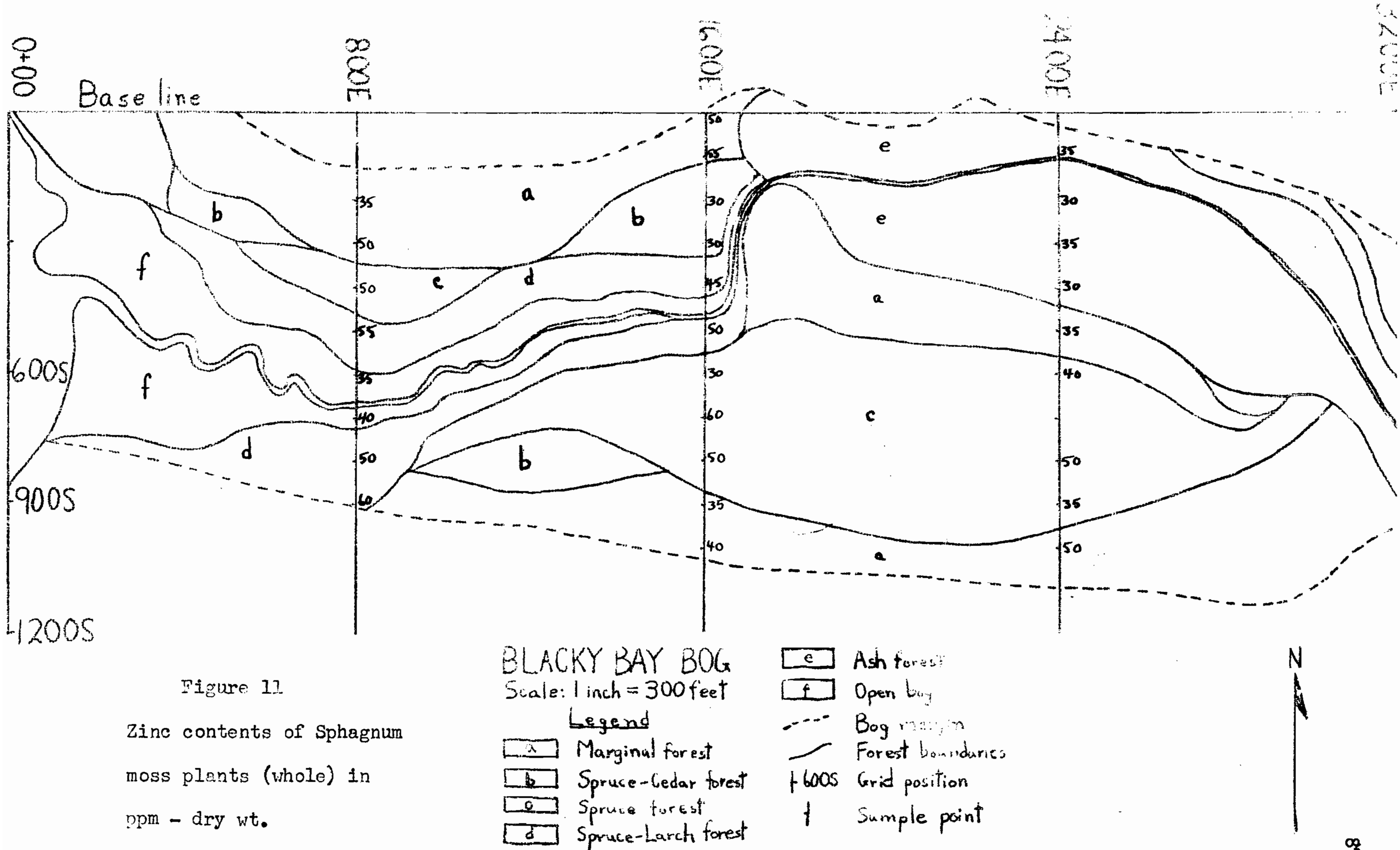


Figure 11

Zinc contents of Sphagnum moss plants (whole) in ppm - dry wt.

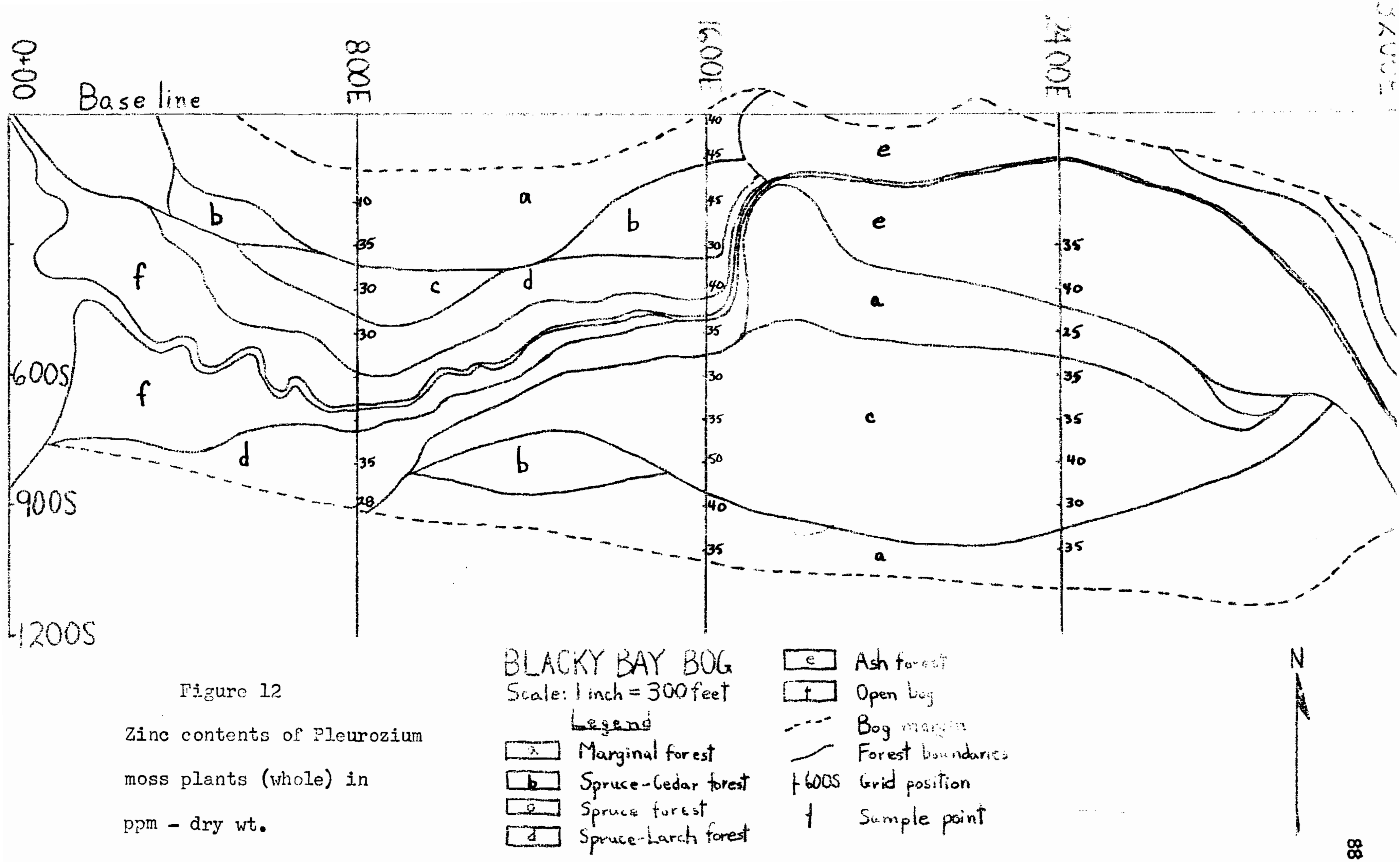


Figure 12

Zinc contents of Pleurozium moss plants (whole) in ppm - dry wt.

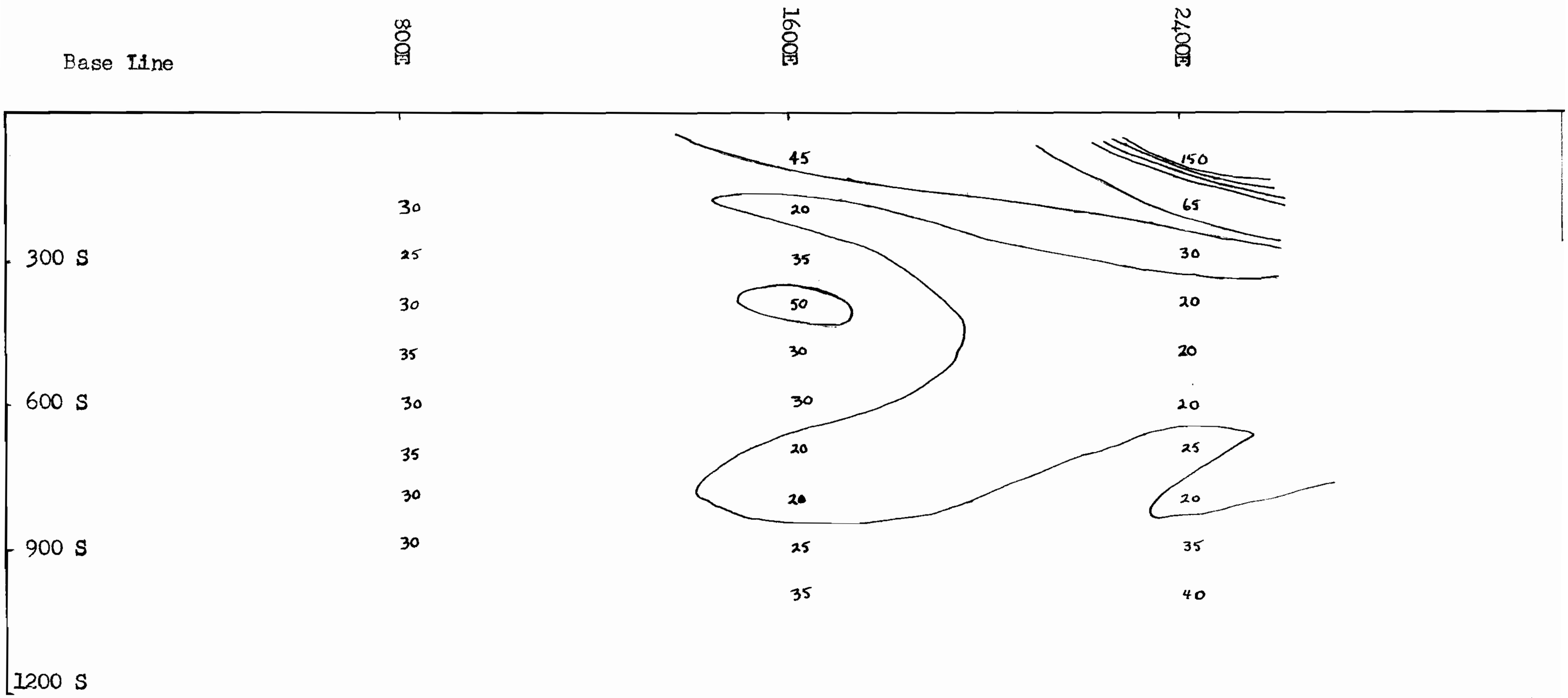


Figure 13. BLACKY BAY BOG - Contour map

Contour interval - 20 ppm (21 - 40)

Zinc contents of surface peats in ppm - dry wt.

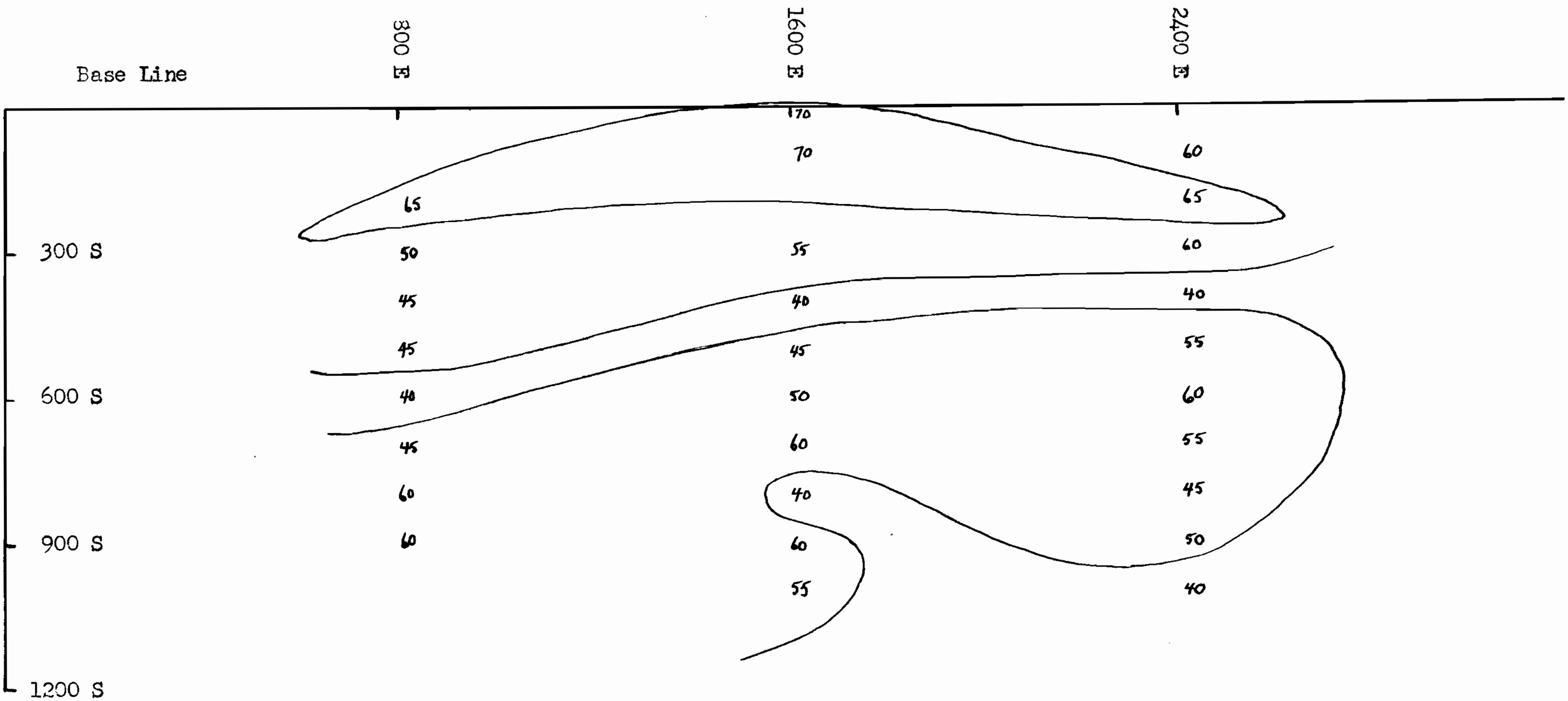


Figure 14. BLACKY BAY BOG.- Contour map

Contour interval - 20 ppm - (21 - 40)

Zinc contents of Black Spruce stems (2 yr. old) in ppm - dry wt.

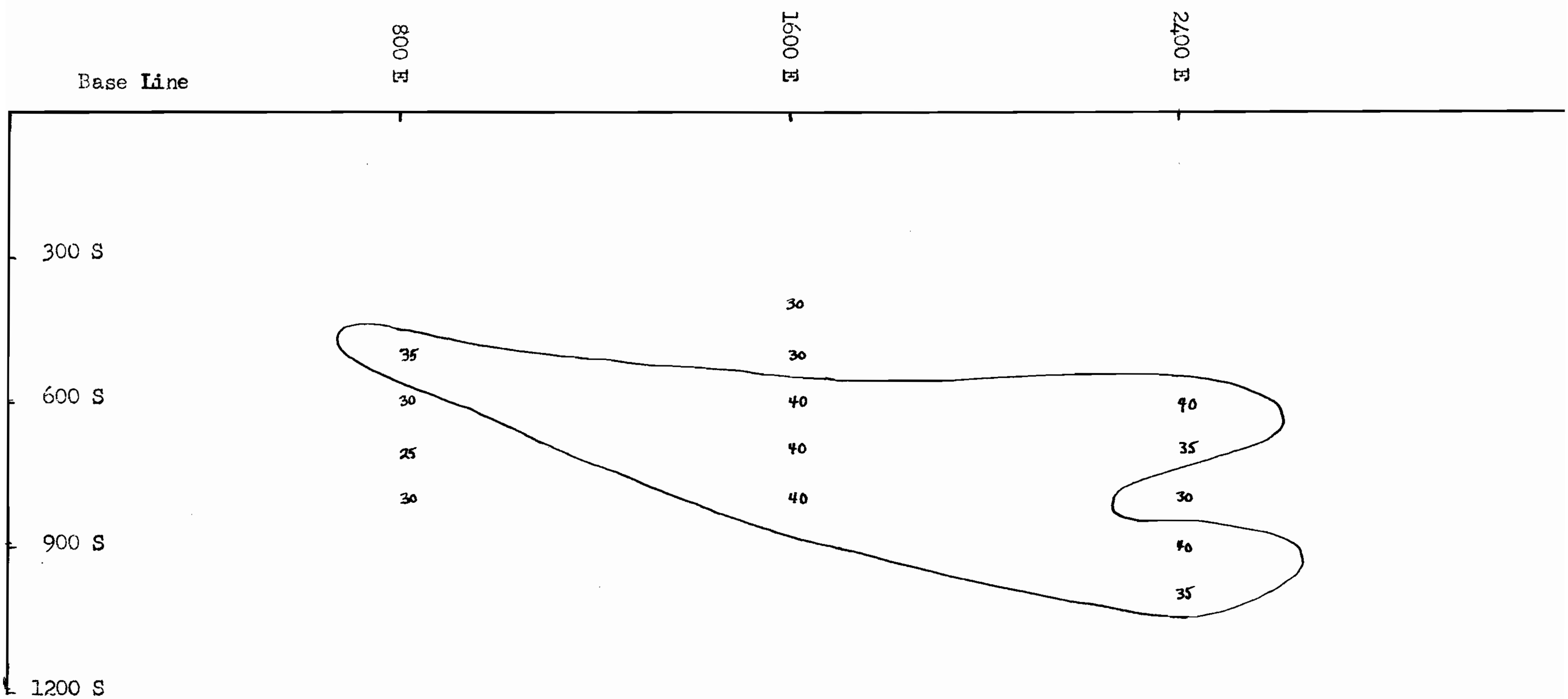


Figure 15. BLACKY BAY BOG - Contour map

Contour interval - 10 ppm (21-30)

Zinc contents of Sweet Gale stems (2 yr. old) in ppm - dry wt.

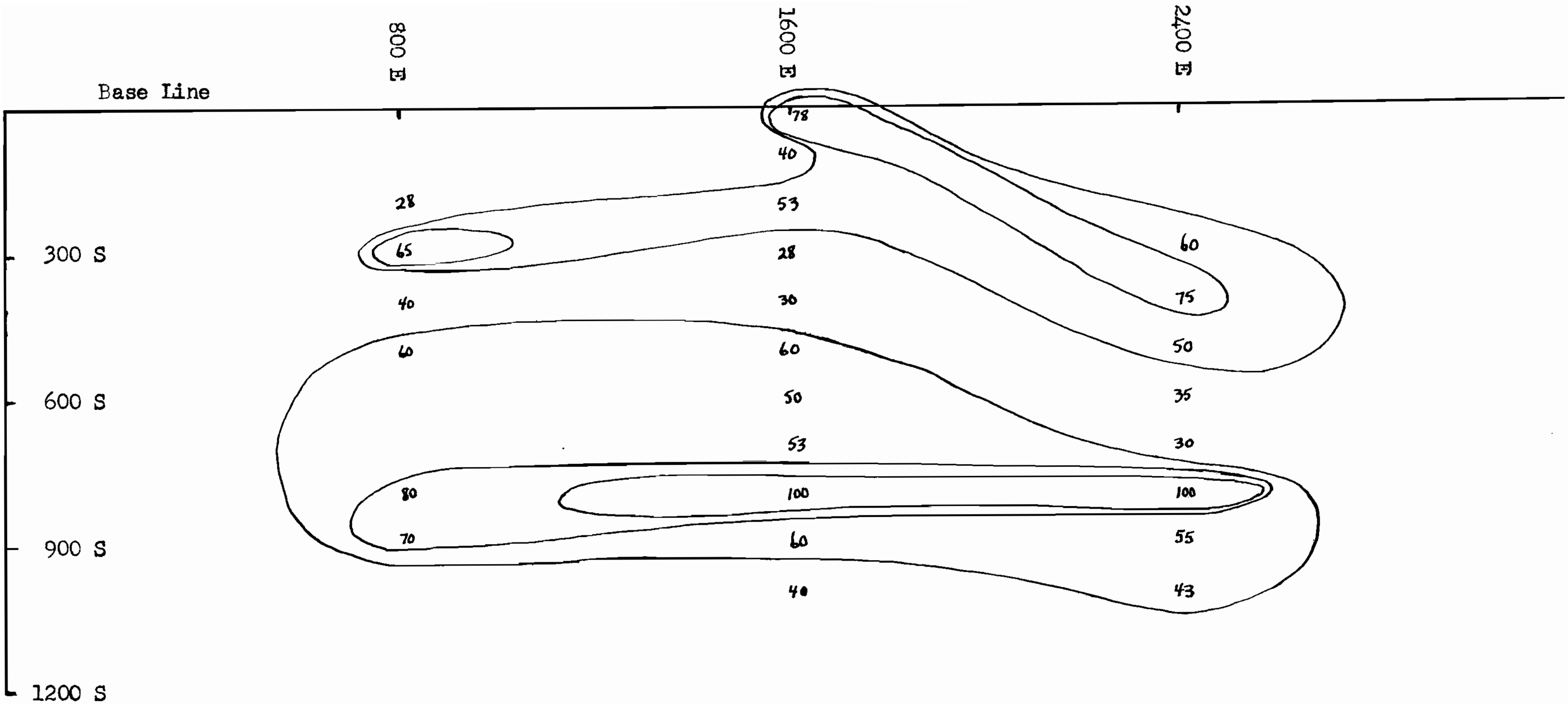


Figure 16. BLACKY BAY BOG - Contour map

Contour interval - 20 ppm (21 - 40)

Zinc contents of False Solomon's-seal plants (whole) in ppm - dry wt.

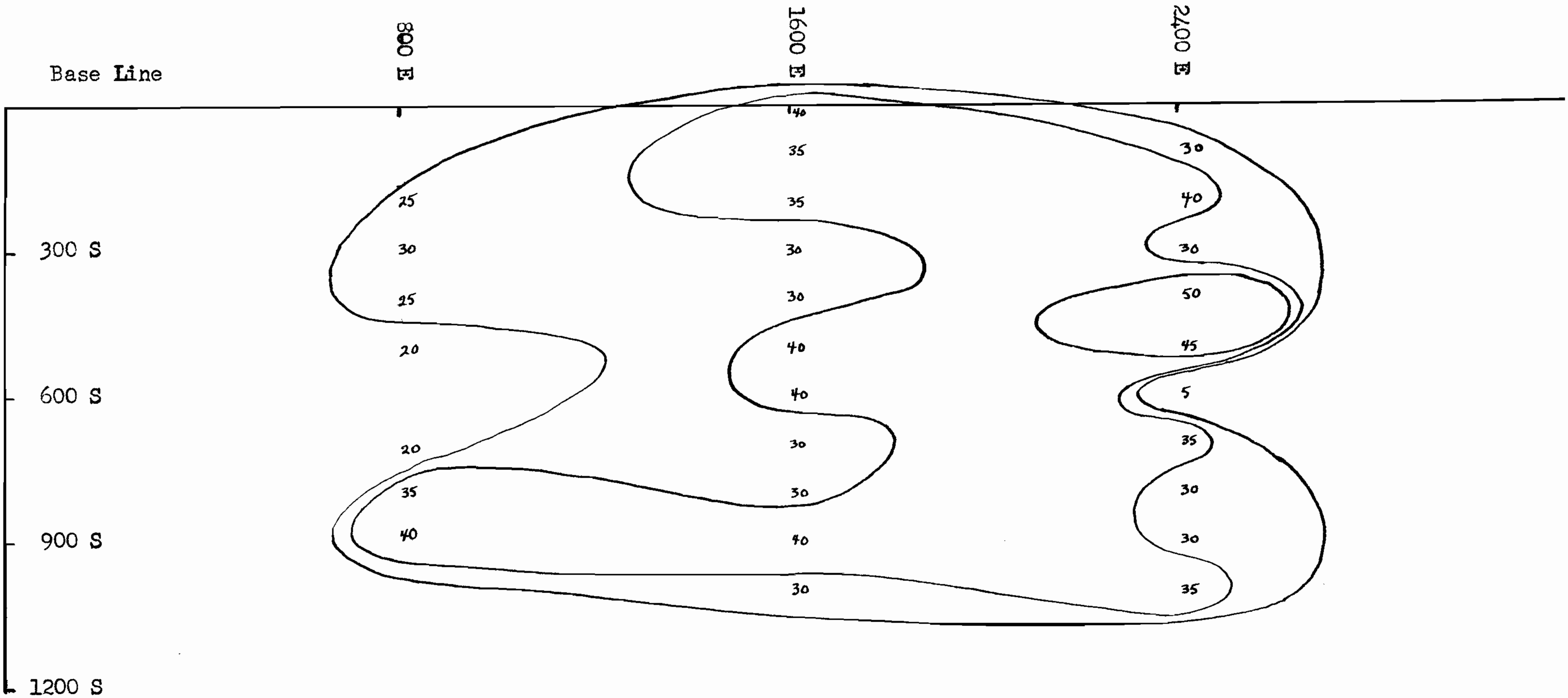


Figure 17. BLACKY BAY BOG - Contour map

Contour interval - 10 ppm (21-30)

Zinc contents of Sedge plants (whole) in ppm - dry wt.

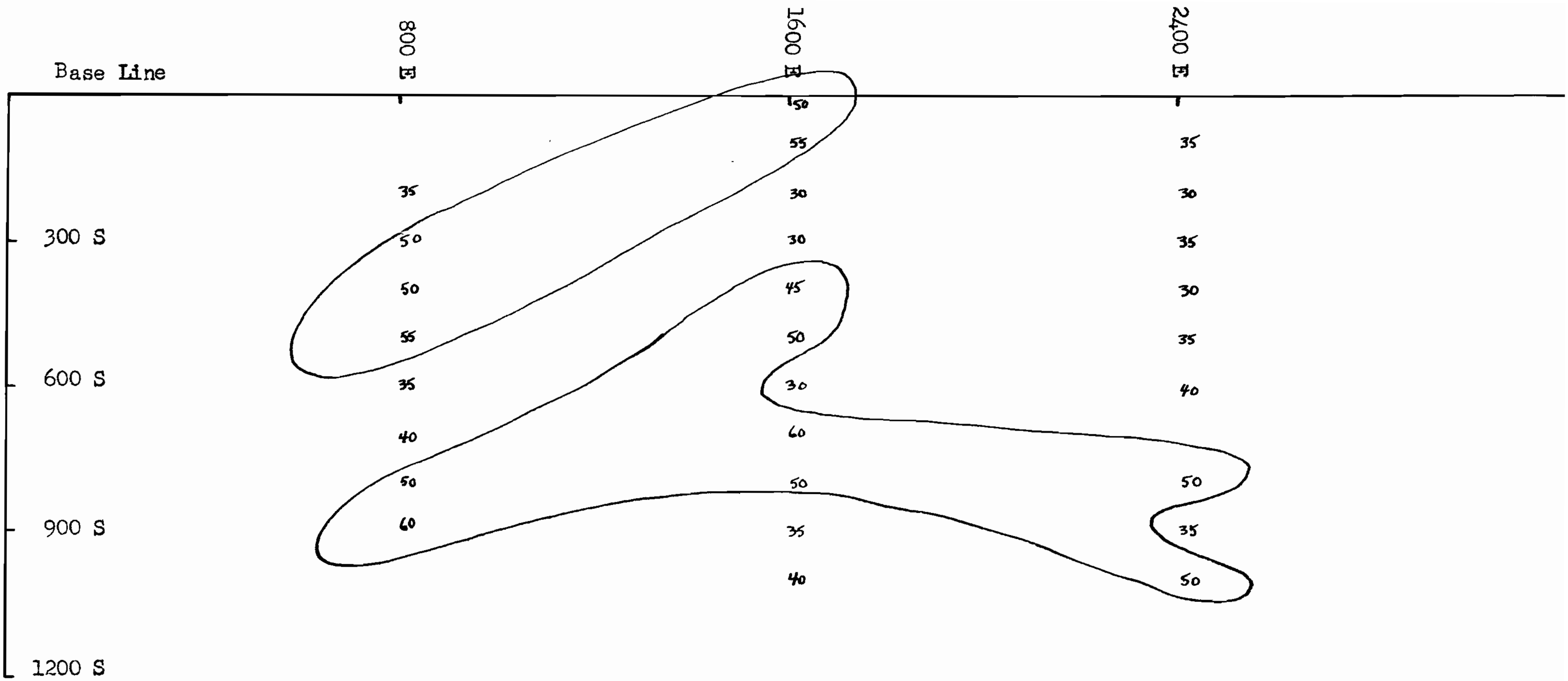


Figure 18. BLACKY BAY BOG - Contour map

Contour interval - 20 ppm (21-40)

Zinc contents of Sphagnum moss plants (whole) in ppm ☉ dry wt.

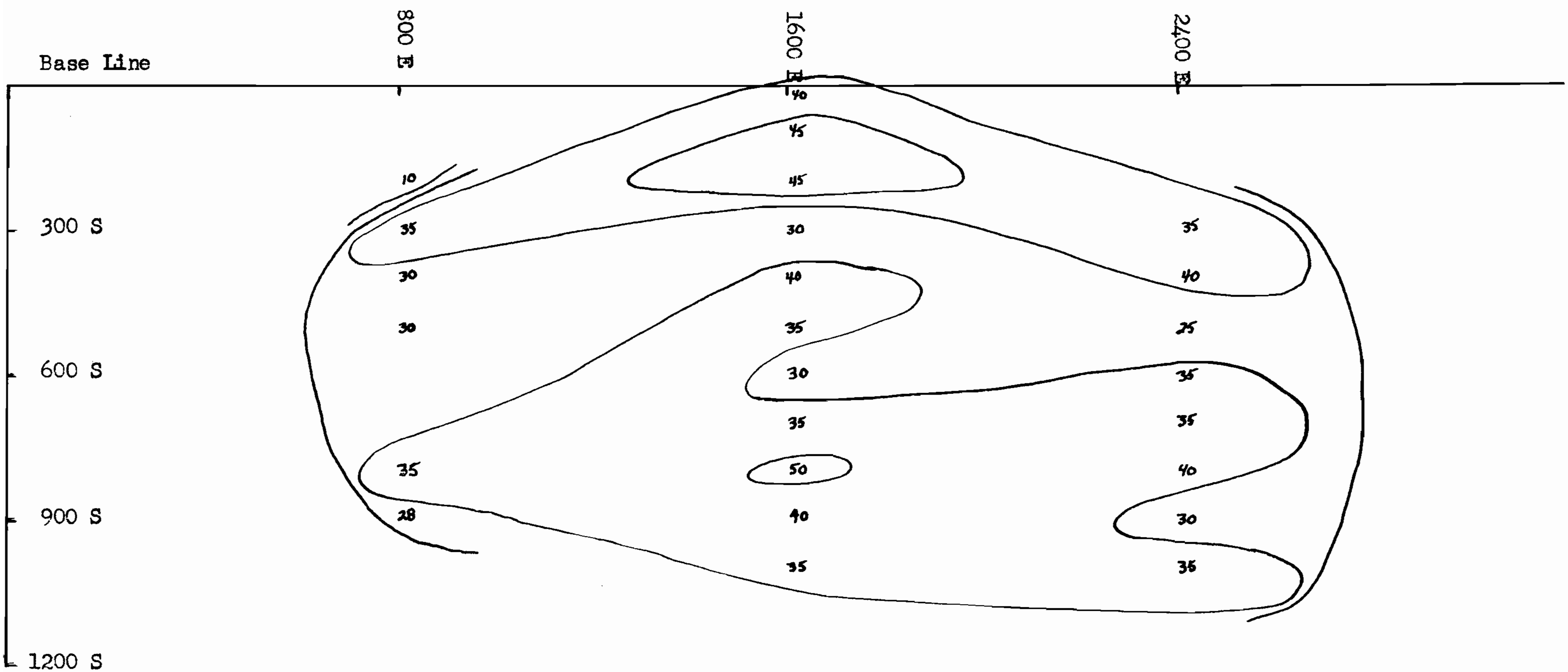


Figure 19. BLACKY BAY BOG - Contour map

Contour interval - 10 ppm (31 - 40)

Zinc contents of Pleurozium moss plants (whole) in ppm - dry wt.

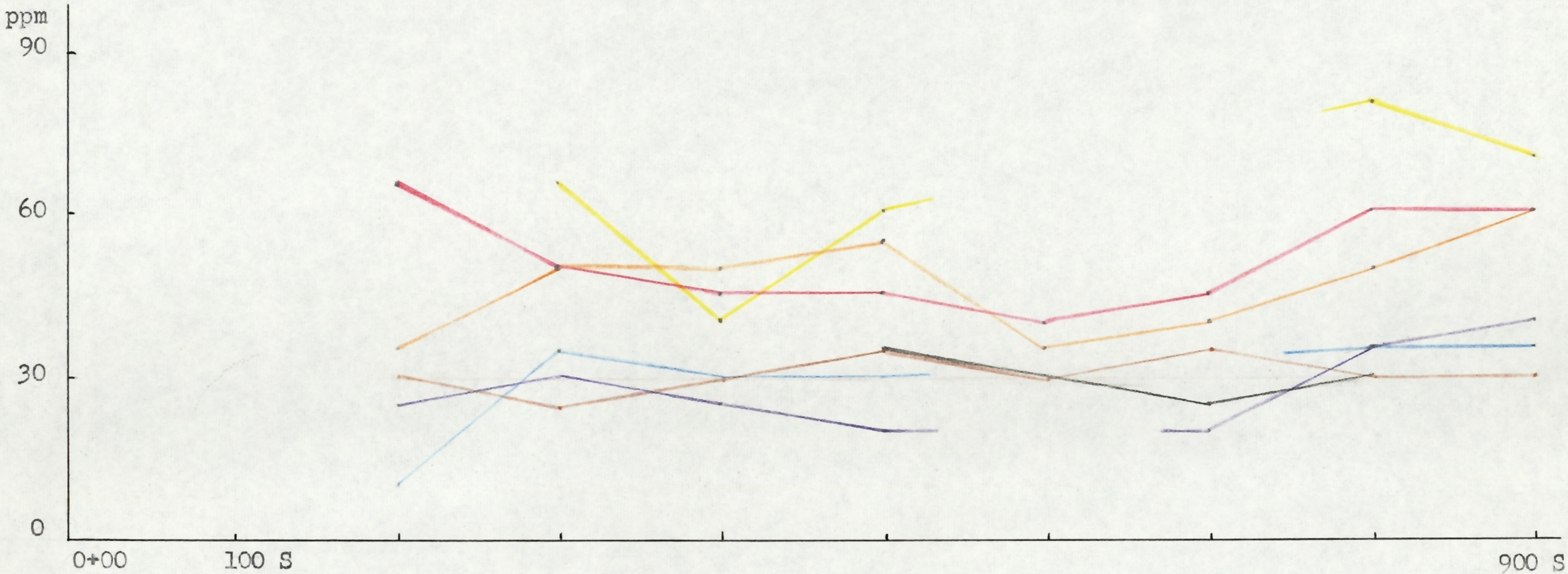


Figure 20. BLACKY BAY BOG. Profile Graph - L 800 E

Zinc contents of plant samples in ppm - dry wt.

Scales: Vert. 1 in. = 30 ppm; Horiz. 1 in. = 100 feet.

- Black Spruce stems (2 yr. old)
- Sweet Gale stems (2 yr. old)
- False Solomon's-seal (whole plants)
- Sedge (whole plants)
- Sphagnum moss (whole plants)
- Pleurozium moss (whole plants)
- Surface peats

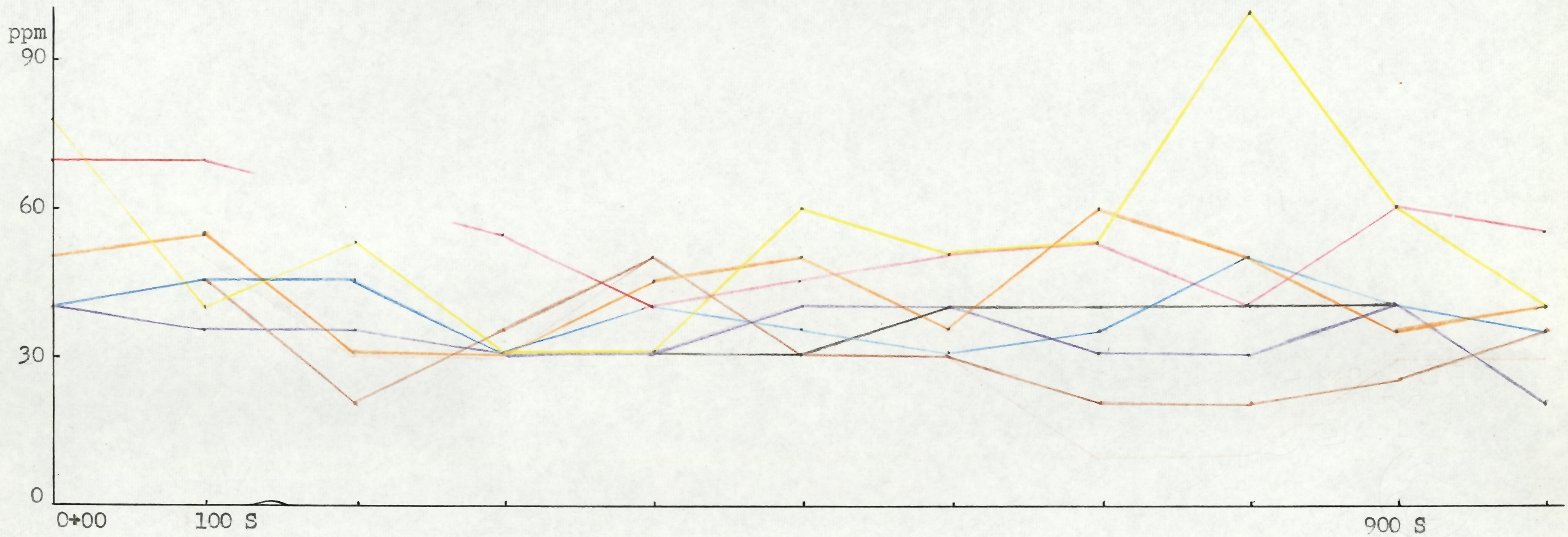


Figure 21. BLACKY BAY BOG. Profile Graph - Line 1600 E

Zinc contents of plant samples in ppm - dry wt.

Scales: Vert. 1 in. = 30 ppm; Horiz. 1 in. = 100 feet.

- Black Spruce stems (2 yr. old)
- Sweet Gale stems (2 yr. old)
- False Solomon's-seal (whole plants)
- Sedge (whole plants)
- Sphagnum moss (whole plants)
- Pleurozium moss (whole plants)
- Surface peats.

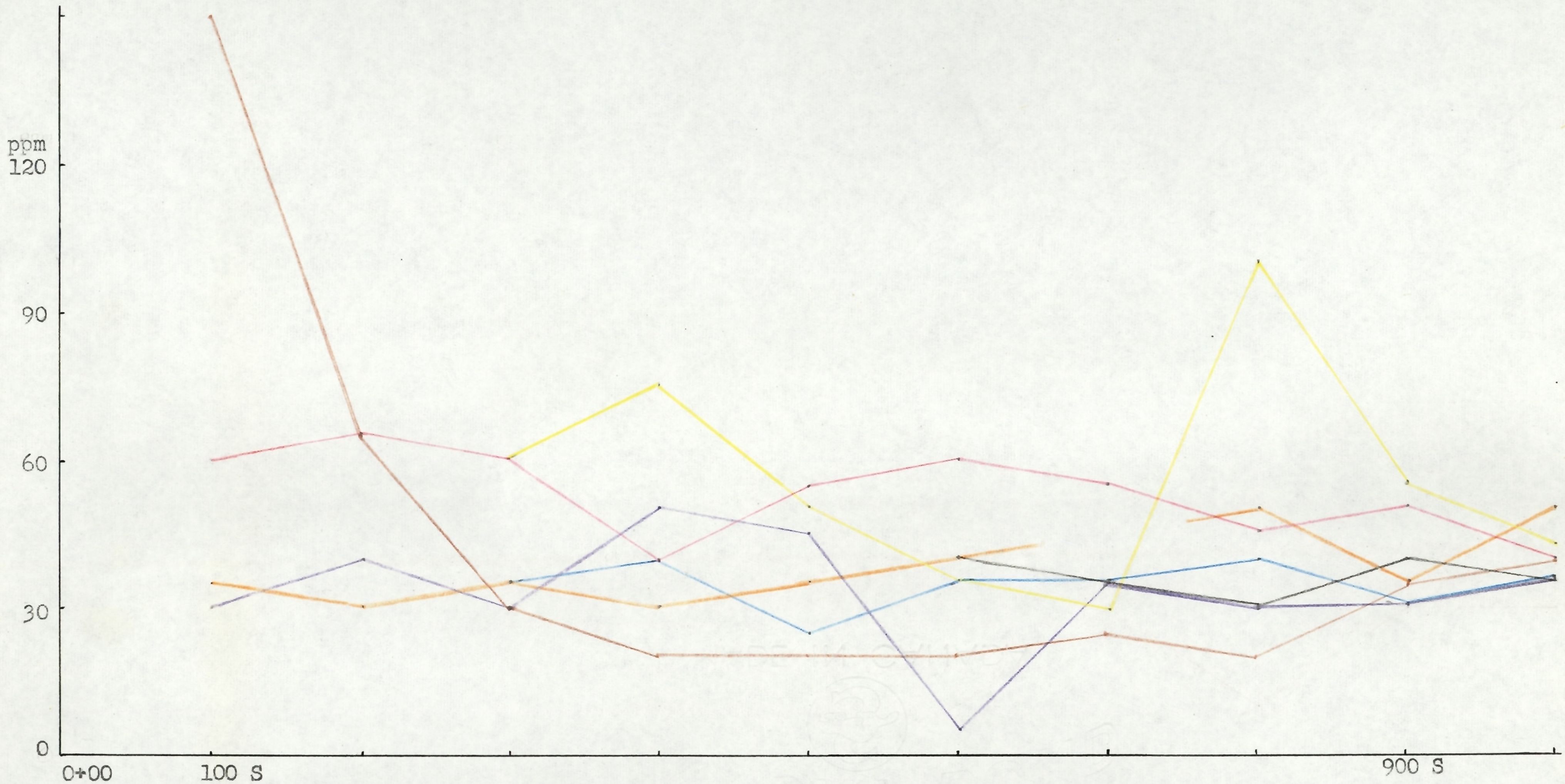


Figure 22. BLACKY BAY BOG. Profile Graph - Line 2400 E

Zinc contents of plant samples in ppm - dry wt.

Scales: Vert. 1 in. = 30 ppm; Horiz. 1 in. = 100 feet.

- Black Spruce stems (2 yr. old)
- Sweet Gale stems (2 yr. old)
- False Solomon's seal (whole plants)
- Sedge (whole plants)
- Sphagnum moss (whole plants)
- Pleurozium moss (whole plants)
- Surface peats

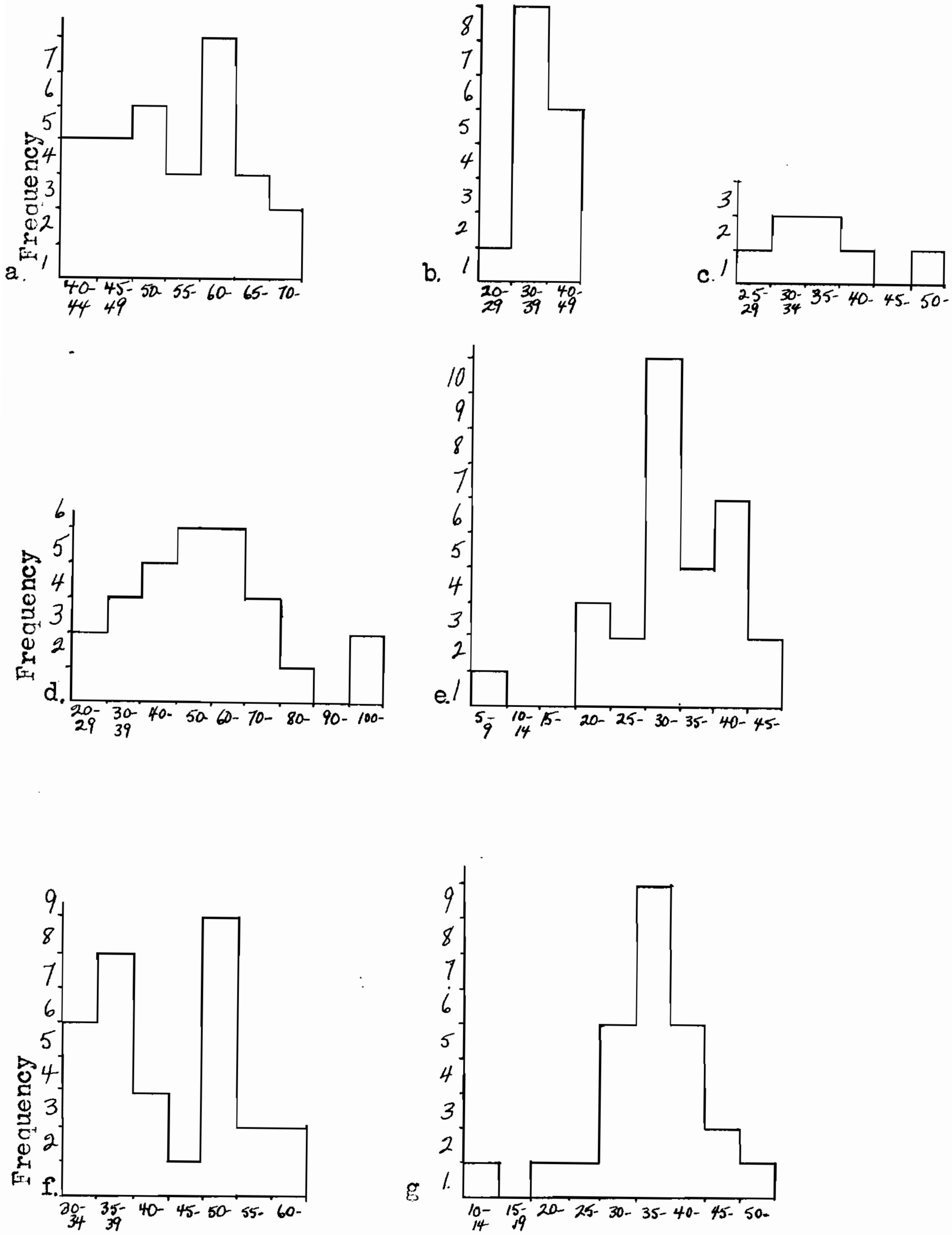


Figure 23. Histograms of Zinc contents (ppm - dry wt.) of plant samples from Blacky Bay Bog.

	Interval
(a) Black Spruce stems (2 yr. old)	5 ppm
(b) Sweet Gale stems (2 yr. old)	10 ppm
(c) Labrador-tea stems (2 yr. old)	5 ppm
(d) False Solomon's-seal (whole plants)	10 ppm
(e) Sedge (whole plants)	5 ppm
(f) Sphagnum moss (whole plants	5 ppm
(g) Pleurozium moss (whole plants)	5 ppm

The copper contents of each species are contoured in figures 32 to 37. There are no definite patterns on the contour maps.

The profile graphs of the copper contents along each sampling line are in figures 38 to 40. Each plant species is independent of the others.

The copper content of each species is shown in a histogram in figure 41. The copper contents of Sedge (figure 41,d) and Sphagnum moss (figure 41,g) give histograms with two peaks. The high values of each species are in different locations, (figures 35 and 36).

Cu:Zn ratio - Profile graphs of the Cu:Zn ratios in all species along each sampling line are given in figures 42 and 43. High Cu:Zn ratios indicate a greater amount of copper or a lesser amount of zinc while low values indicate the reverse. These profiles show a closer relationship between the different plant species than do the profiles of the metal contents alone (see figures 20 to 22, and 38 to 40). Several individual high and low ratios occur while in several cases most or all the ratios are close together at the same location. On L. 2400 E, at points 800 S, 900 S and 1000 S, all the species react in the same manner.

The histograms of the Cu:Zn ratios in figure 44 are all quite normal except those of Sedge (figure 44,b) and

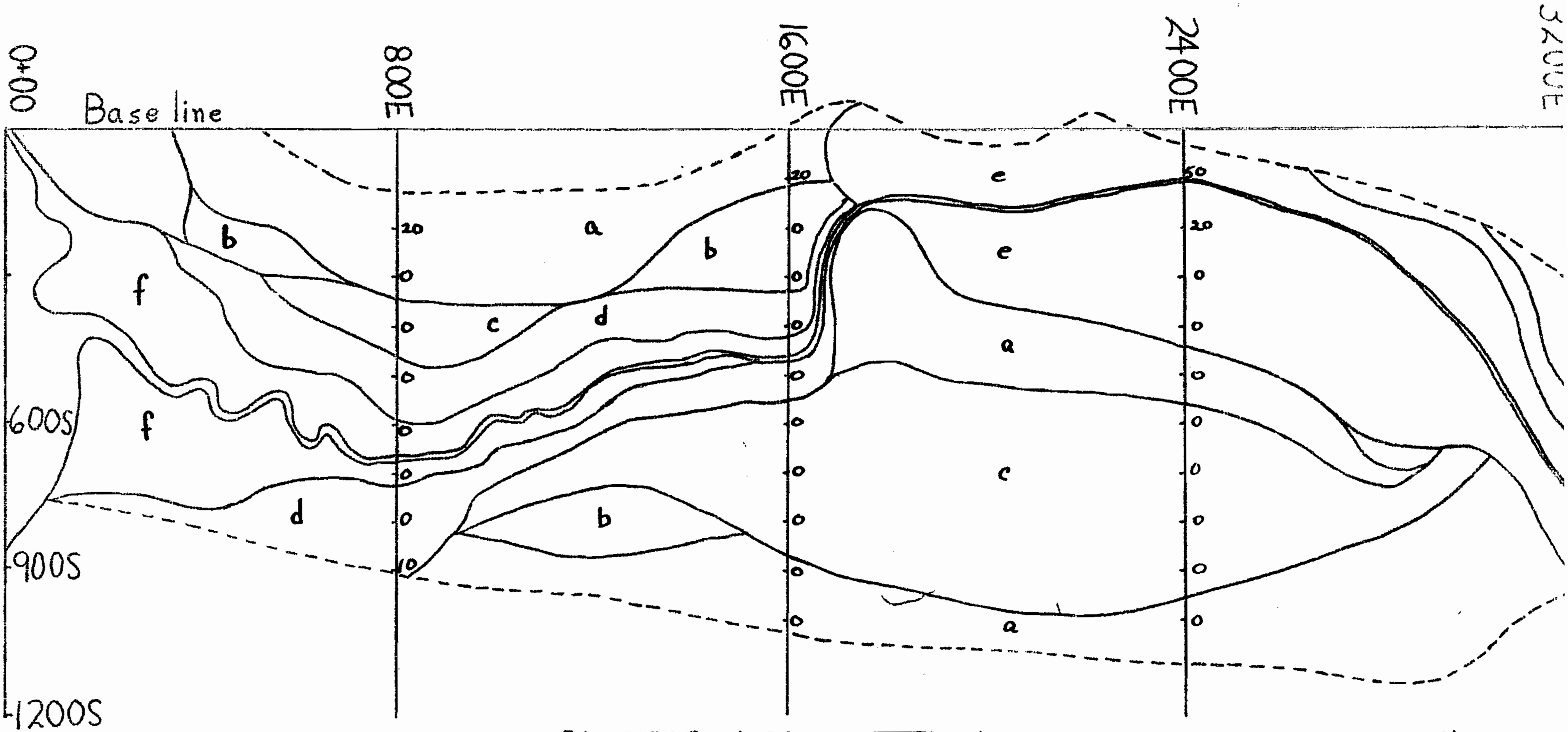


Figure 24

Copper contents of surface peats

in ppm - dry wt.

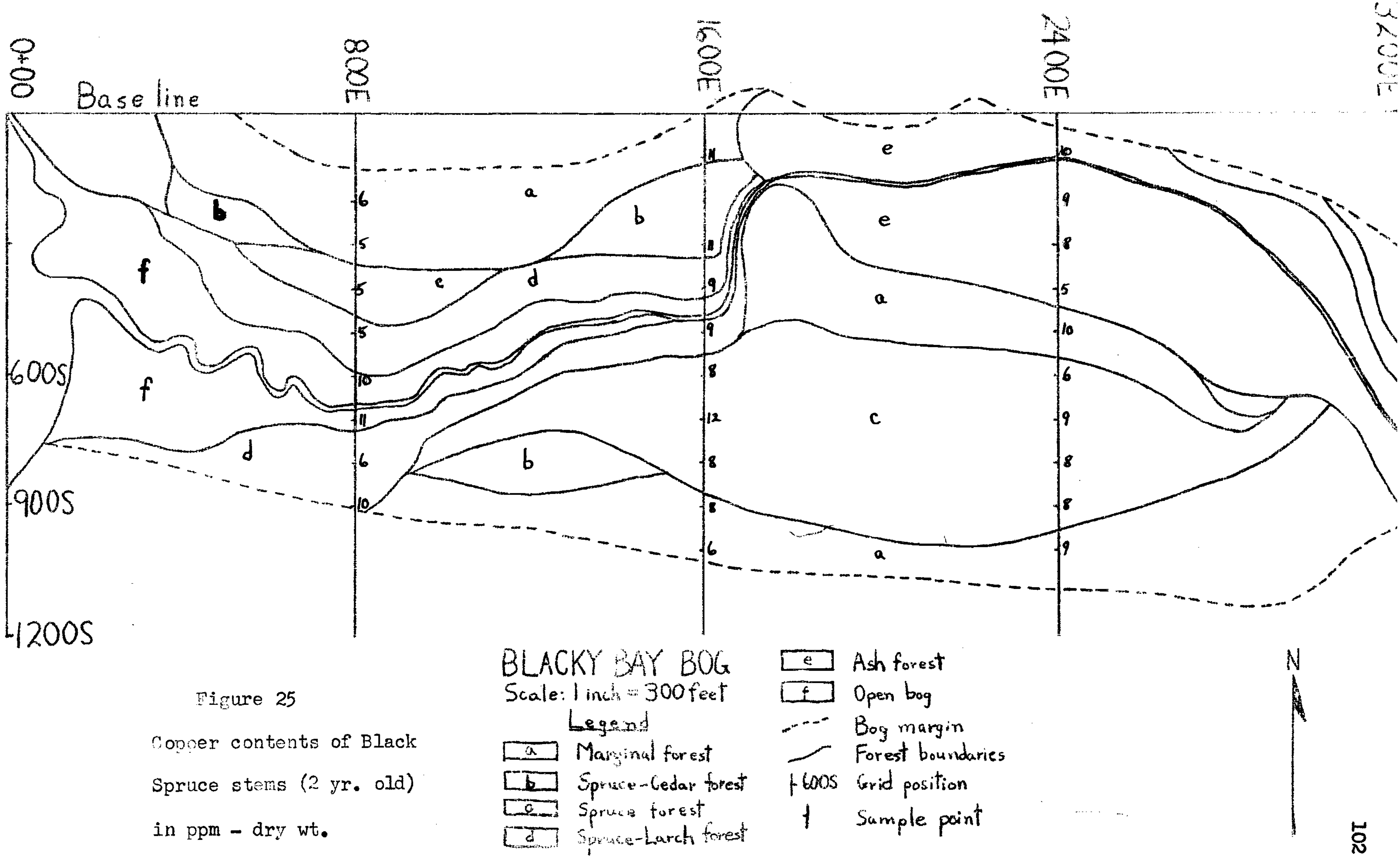


Figure 25

Copper contents of Black Spruce stems (2 yr. old) in ppm - dry wt.

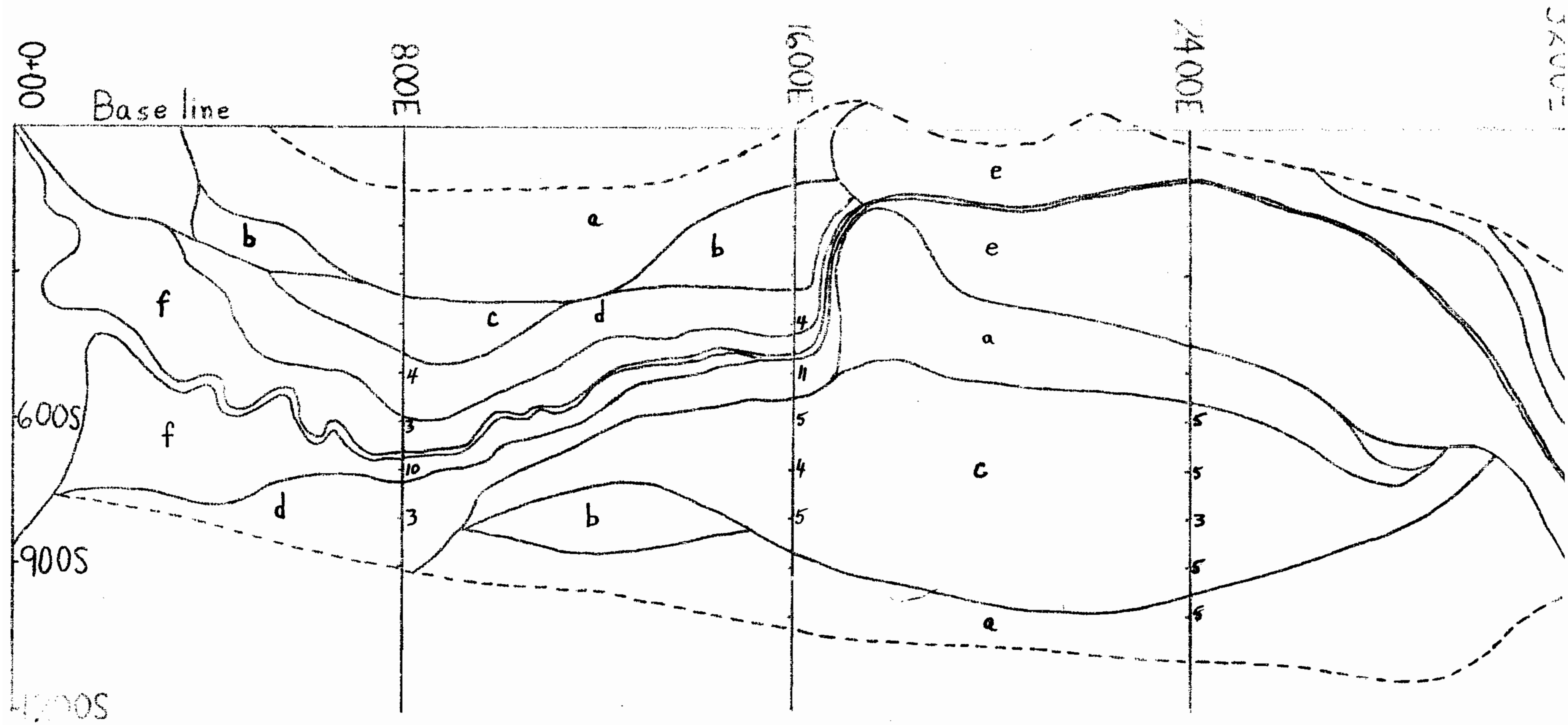


Figure 26

Copper contents of Sweet Gale stems (2 yr. old) in ppm - dry wt.

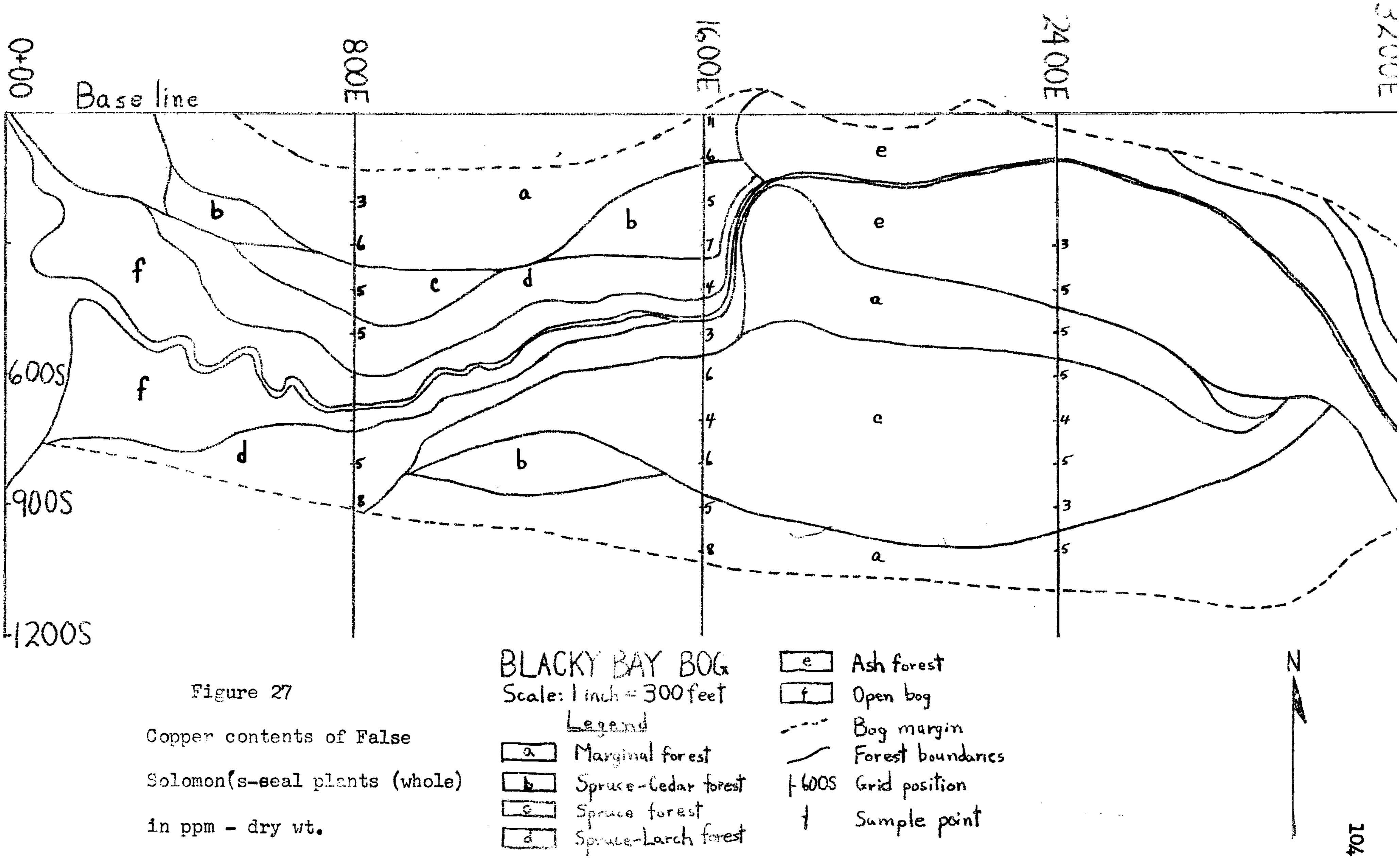


Figure 27

Copper contents of False Solomon(s-seal plants (whole) in ppm - dry wt.

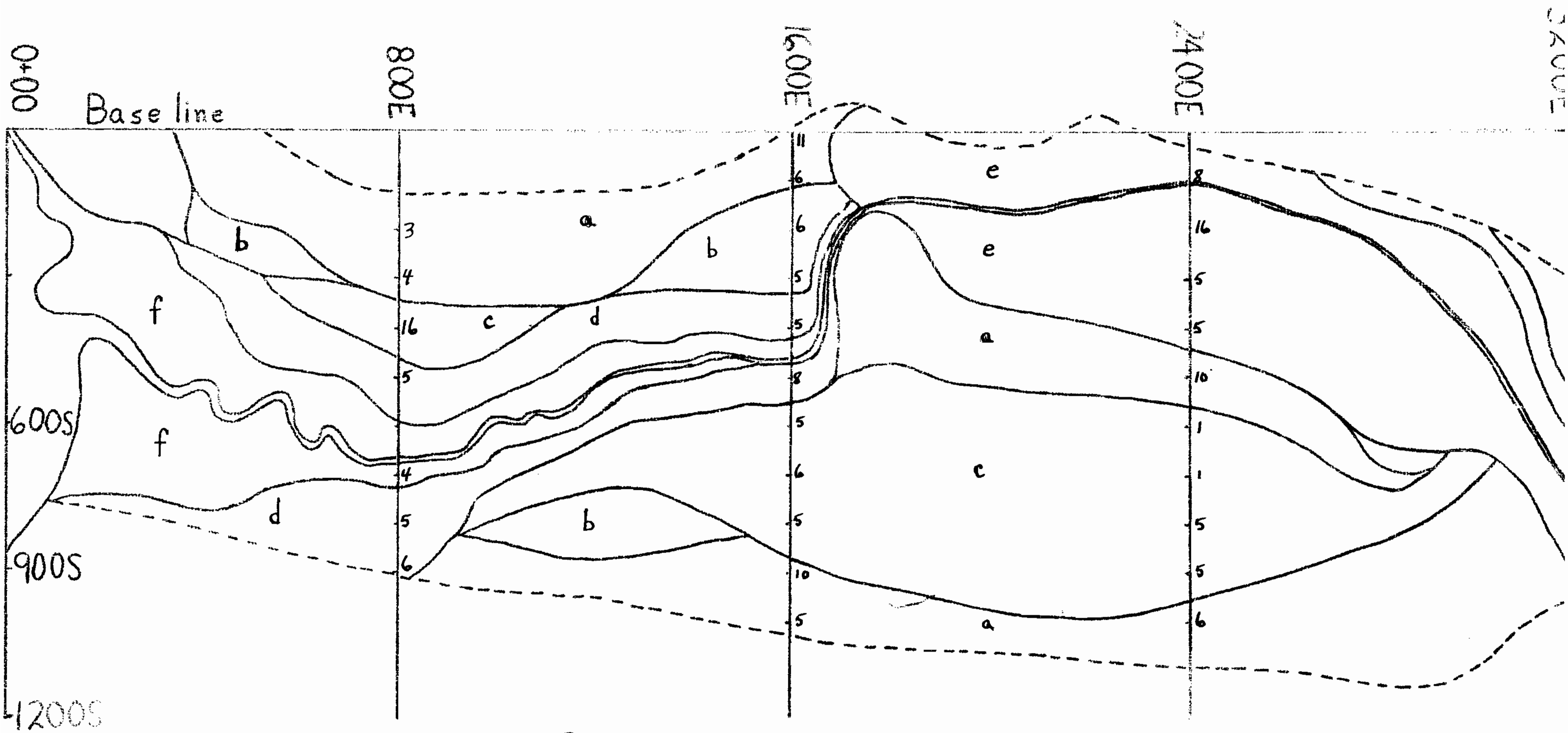


Figure 28

Copper contents of Sedge plants (whole) in ppm - dry wt.

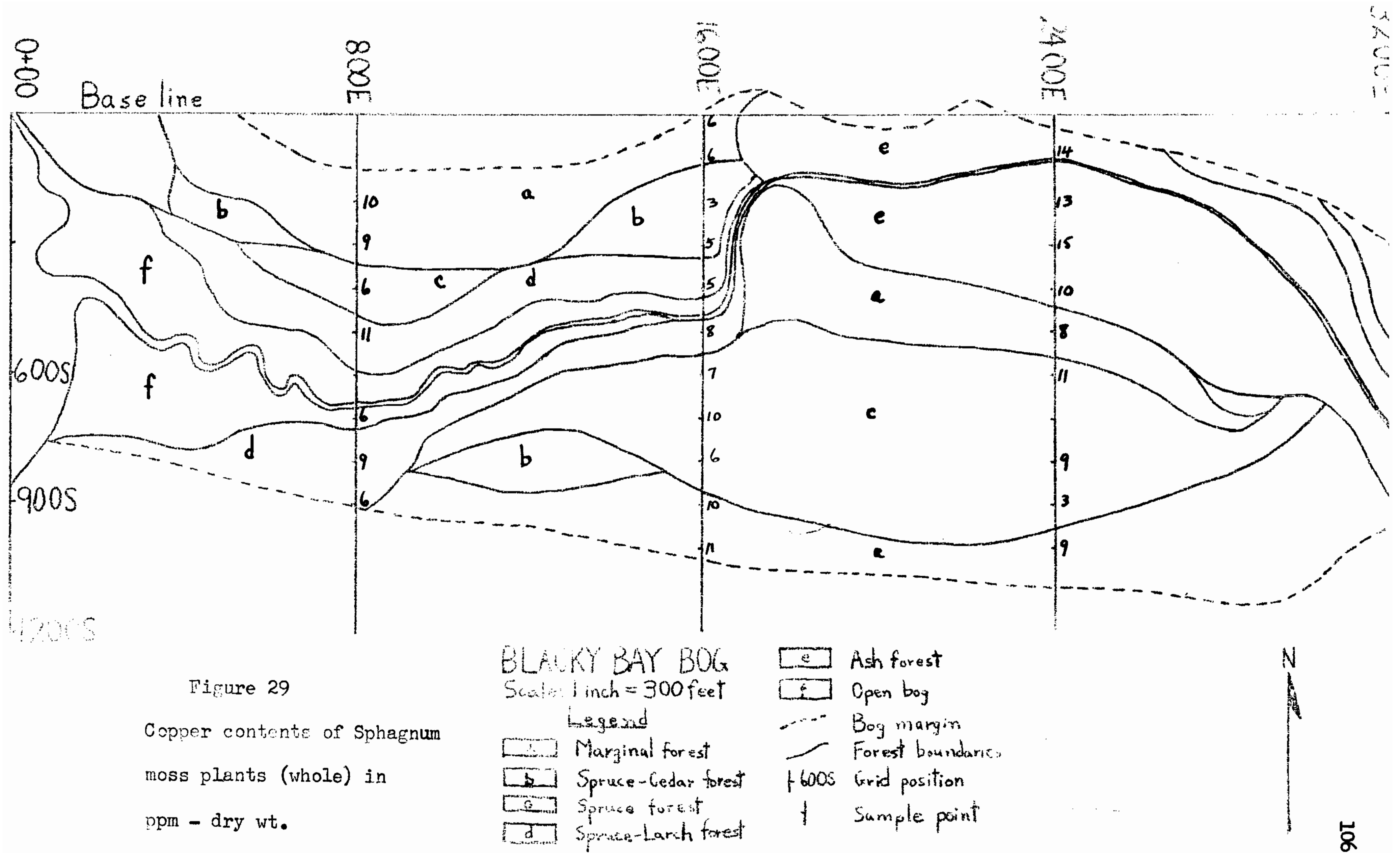


Figure 29

Copper contents of Sphagnum moss plants (whole) in ppm - dry wt.

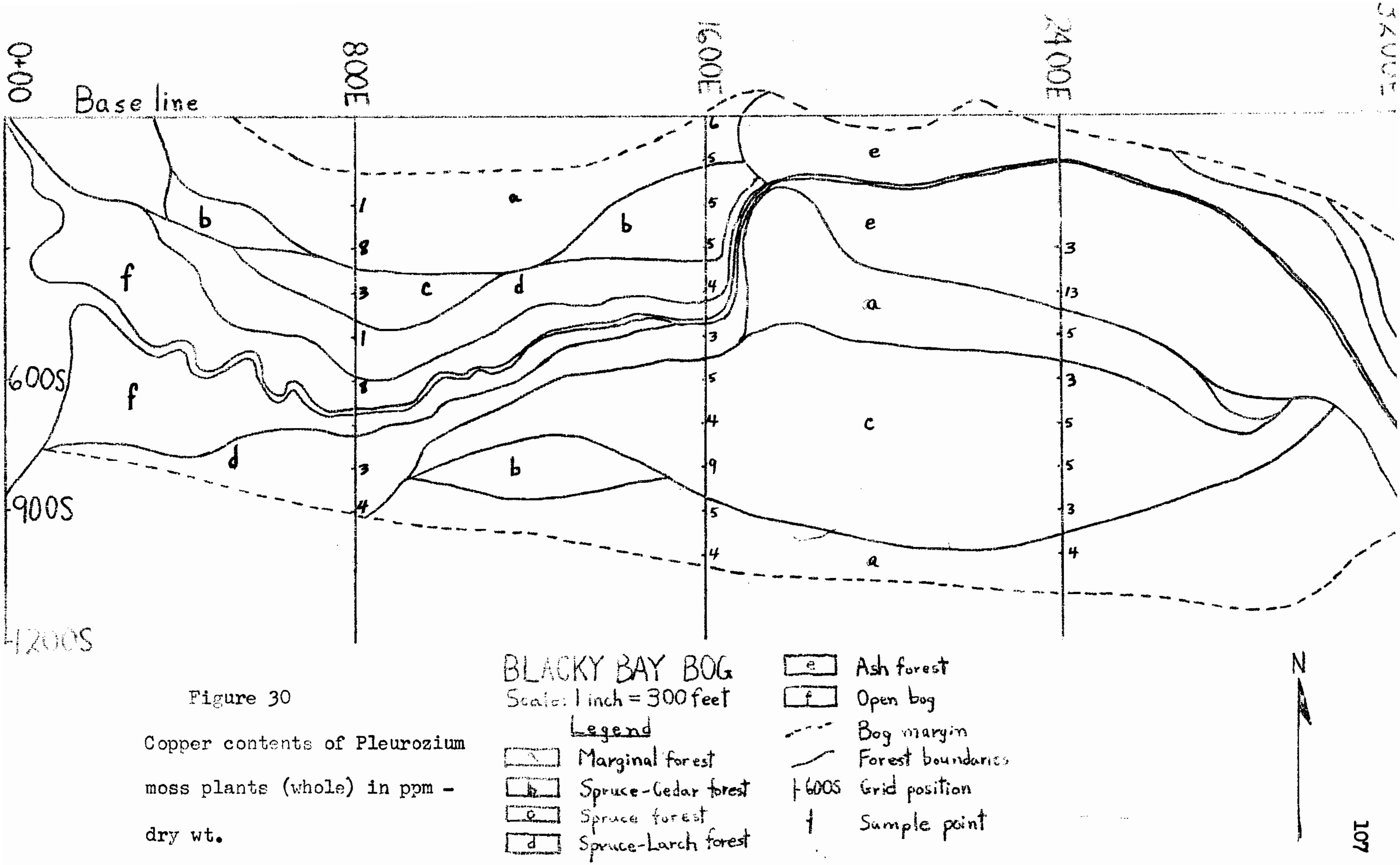


Figure 30

Copper contents of Pleurozium moss plants (whole) in ppm - dry wt.

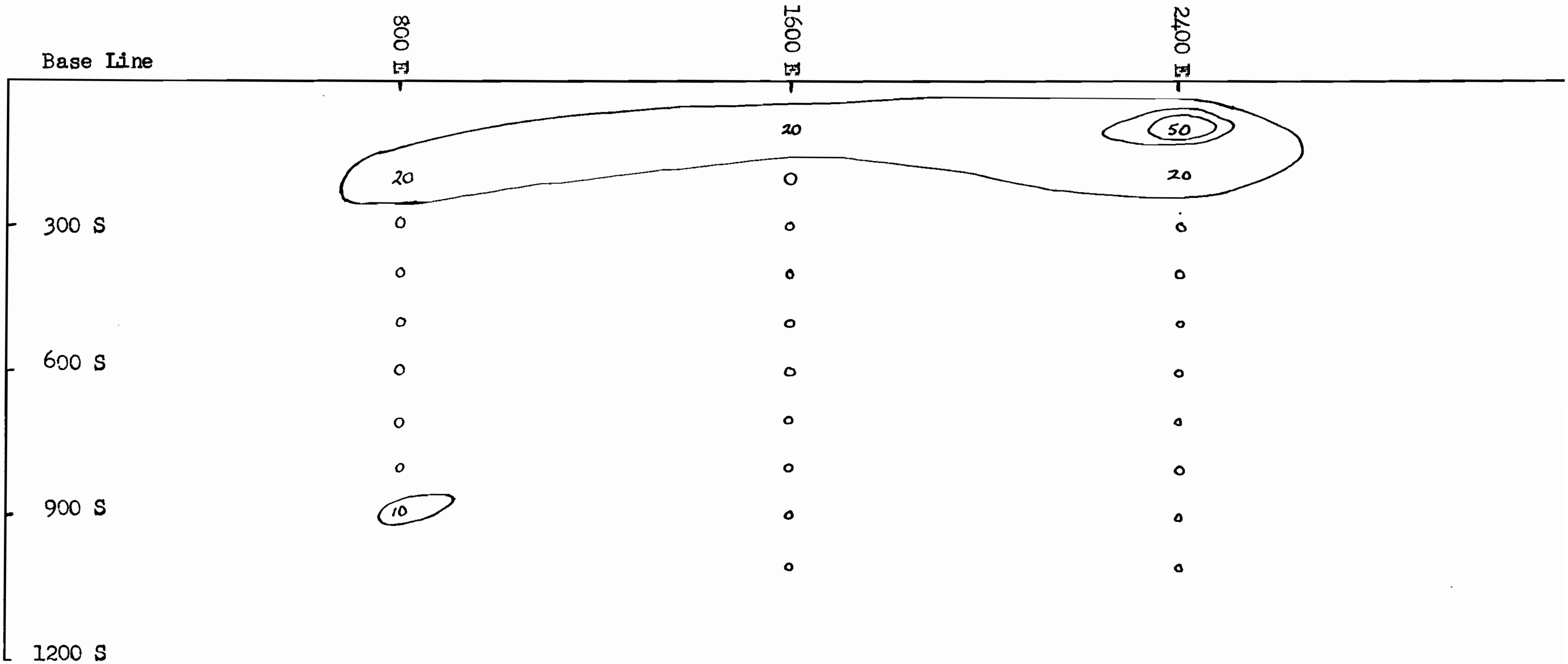


Figure 31. BLACKY BAY BOG - Contour map

Contour interval - 20 ppm (21 - 40)

Copper contents of surface peats in ppm - dry wt.

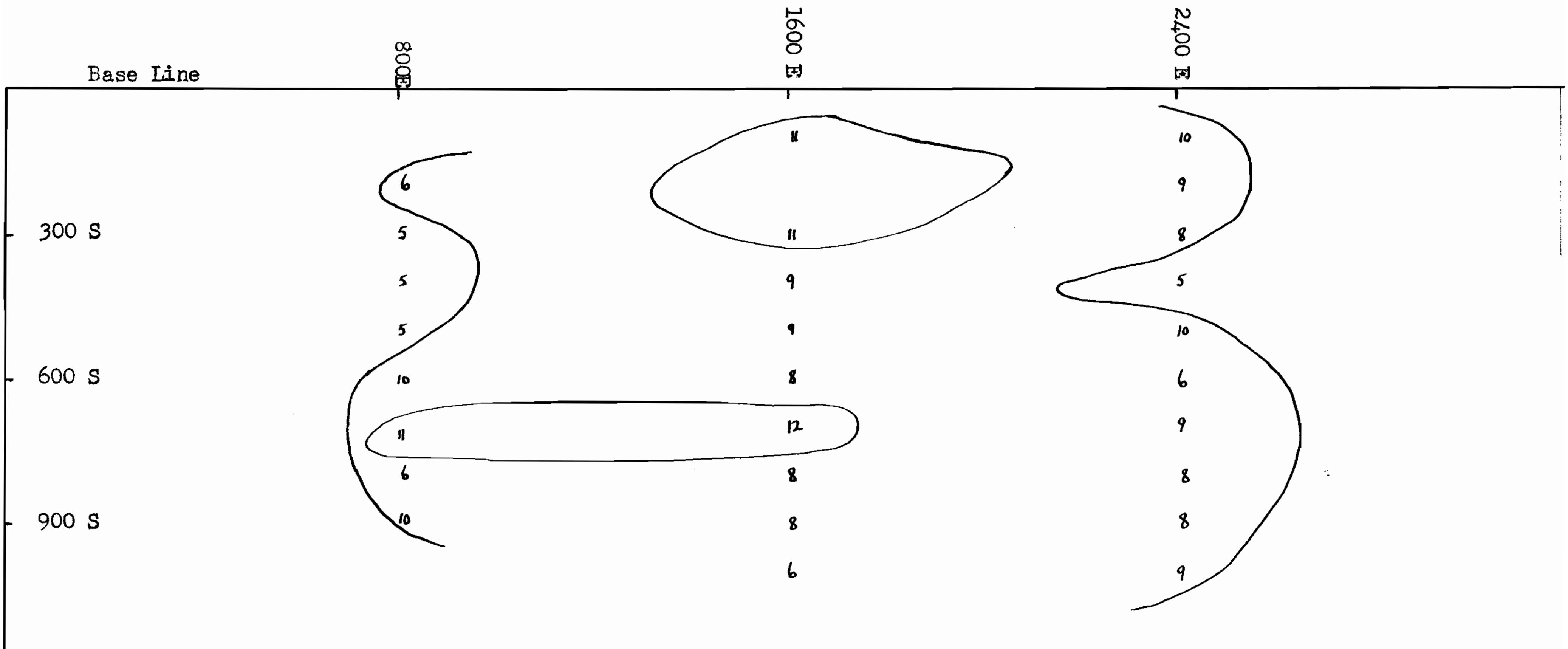


Figure 32. BLACKY BAY BOG - Contour map

Contour interval - 5 ppm (11 - 15)

Copper contents of Black Spruce stems (2 yr. old) in ppm - dry wt.

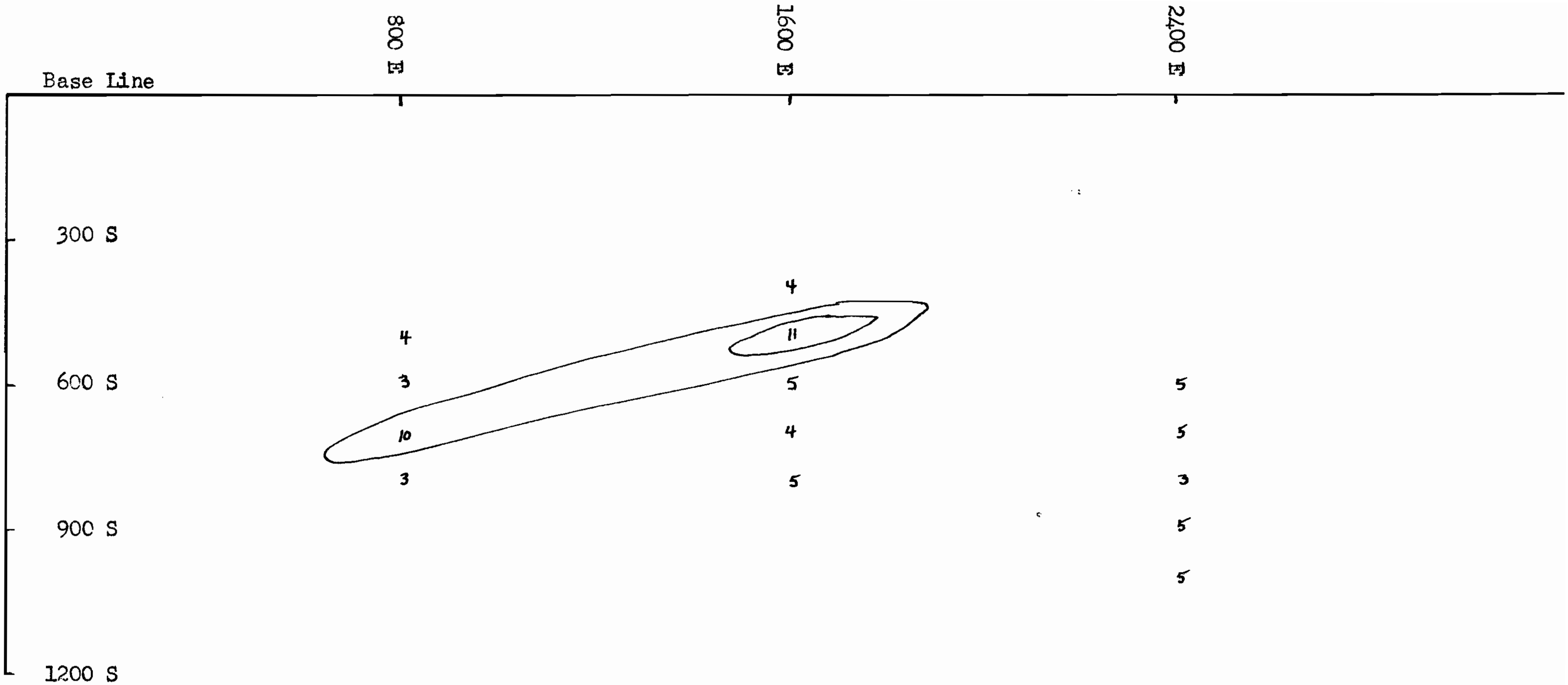


Figure 33. BLACKY BAY BOG - Contour map

Contour interval - 5 ppm (11 - 15)

Copper contents of Sweet Gale stems (2 yr. old) in ppm - dry wt.

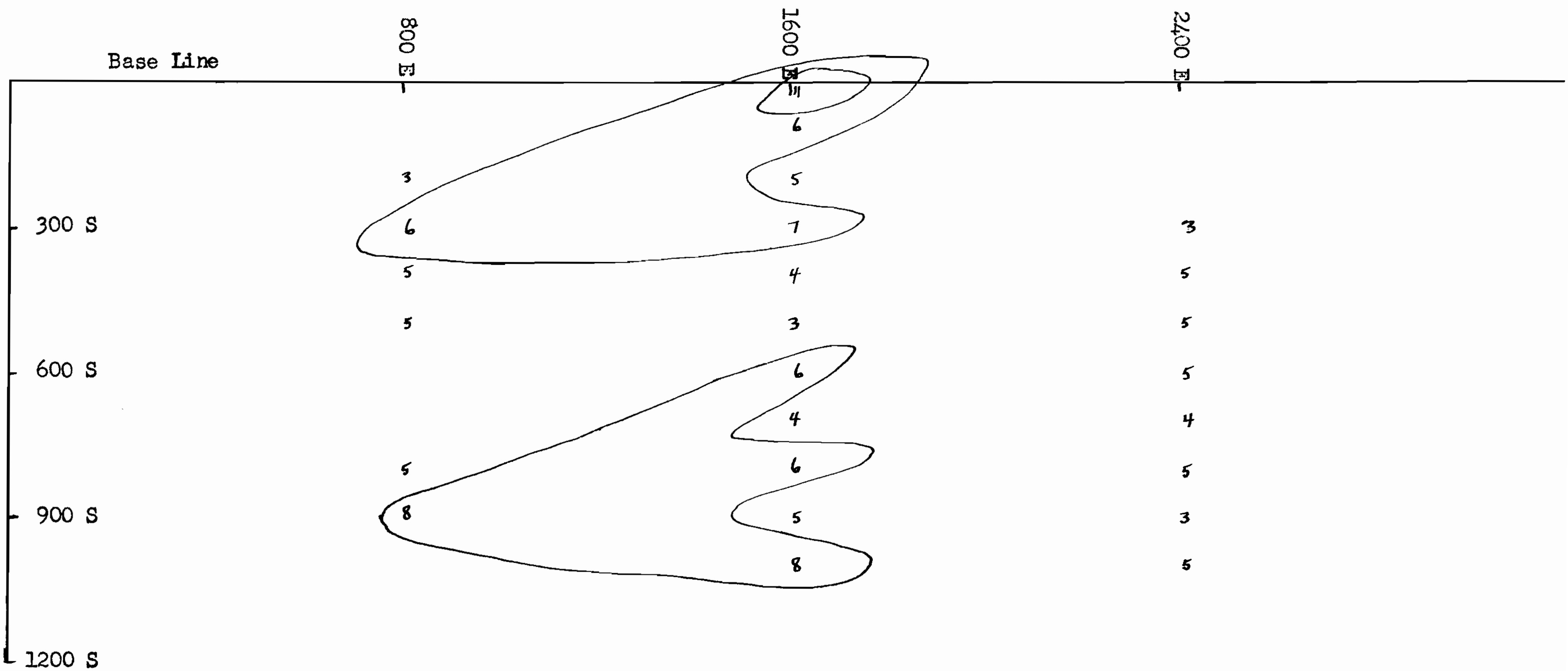


Figure 34. BLACKY BAY BOG - Contour map

Contour interval - 5 ppm (6 - 10)

Copper contents of False Solomon's-seal plants (whole) in ppm - dry wt.

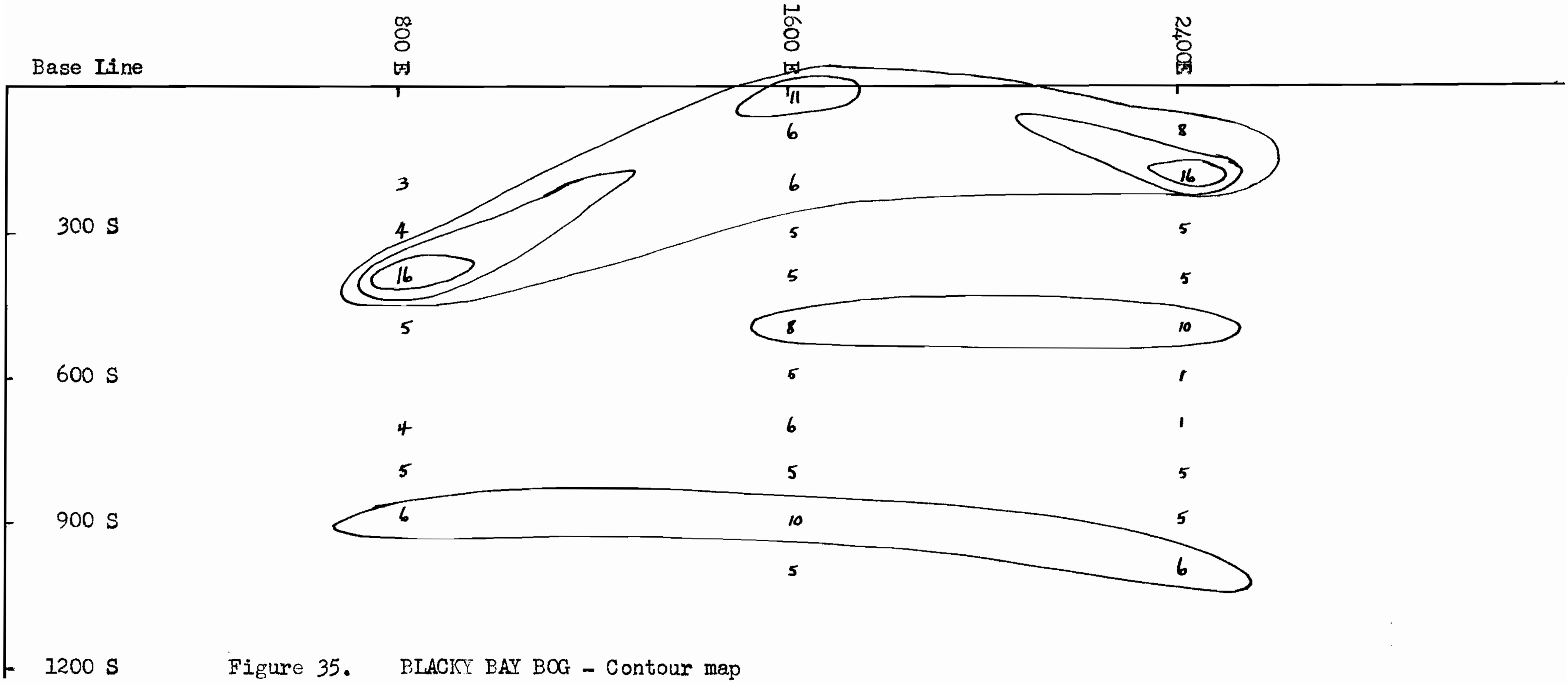


Figure 35. BLACKY BAY BOG - Contour map

Contour interval - 5 ppm (6 - 10)

Copper contents of Sedge plants (whole) in ppm - dry wt.

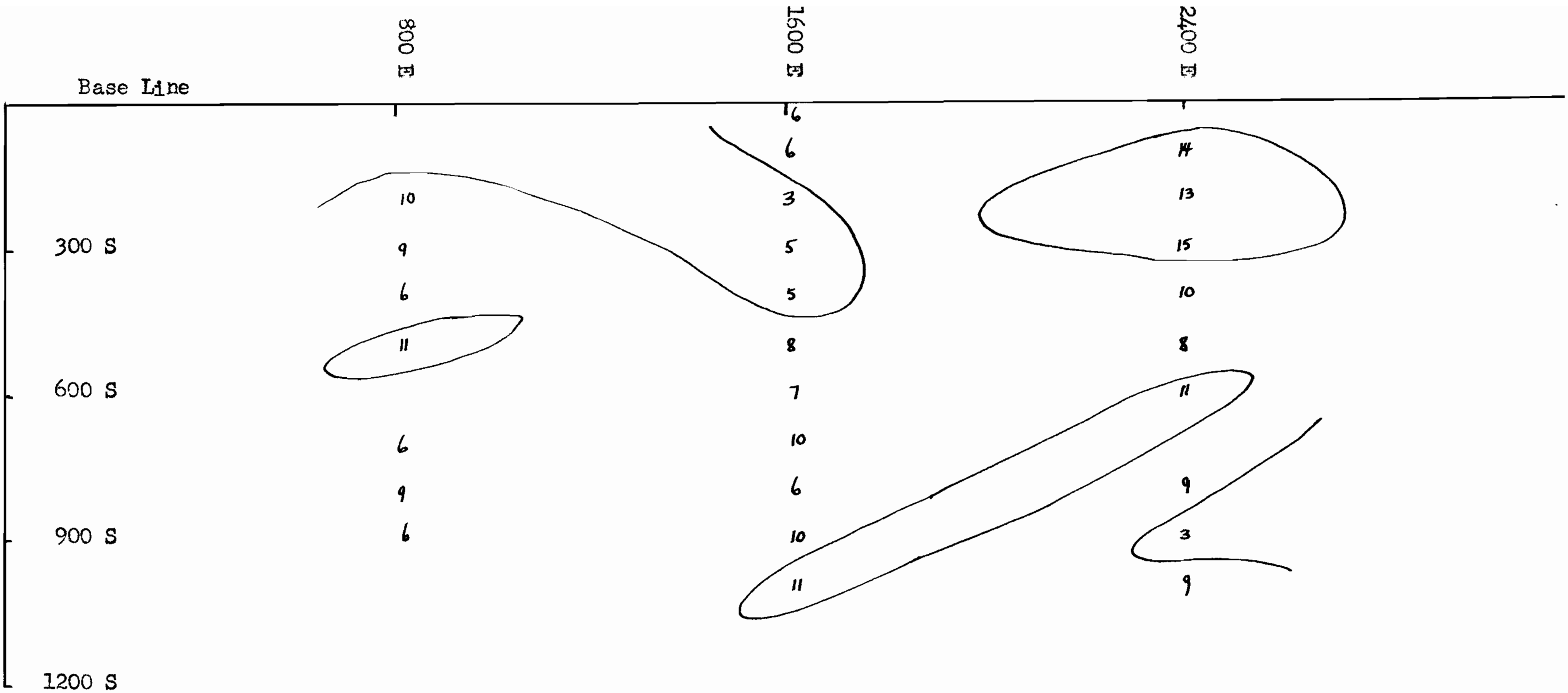


Figure 36. BLACKY BAY BOG - Contour map

Contour interval - 5 ppm (6 - 10)

Copper contents of Sphagnum moss plants (whole) in ppm - dry wt.

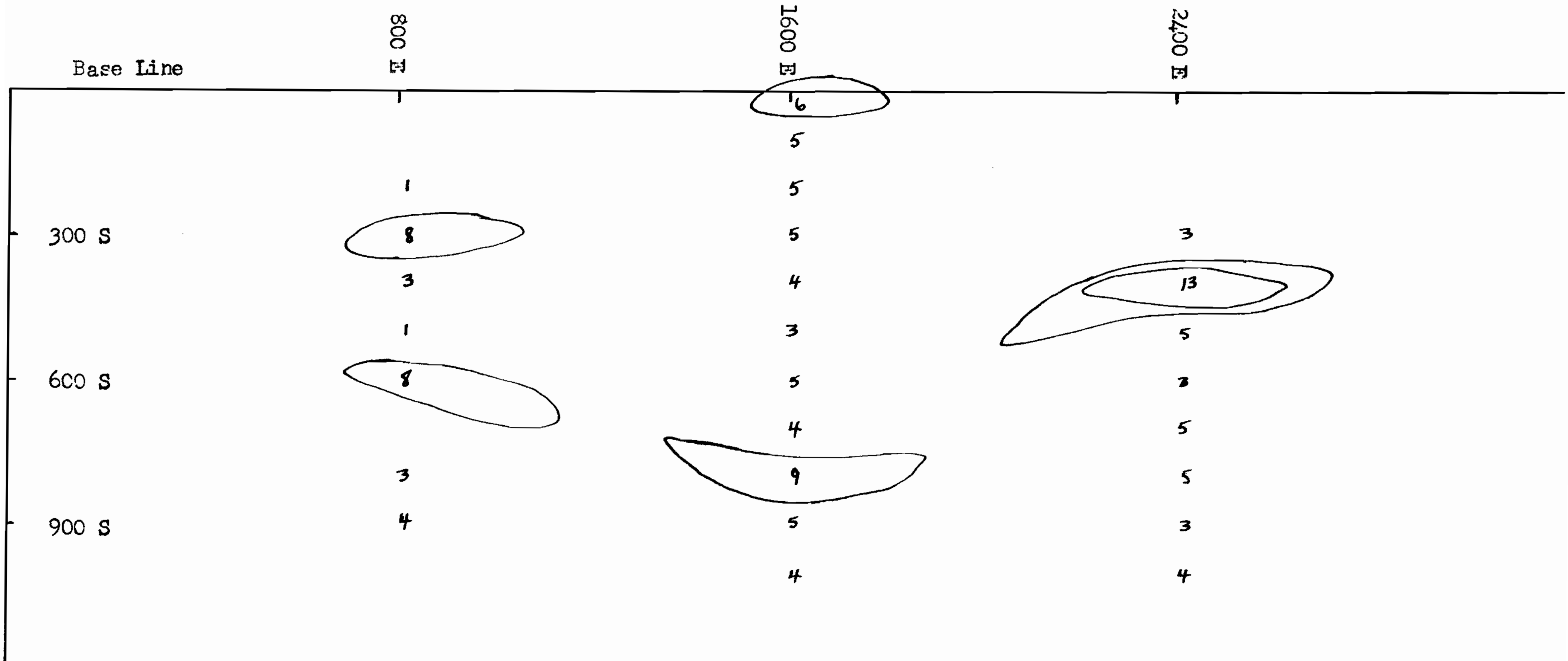


Figure 37. BLACKY BAY BOG - Contour map

Contour interval - 5 ppm (6 - 10)

Copper contents of Pleurozium moss plants (whole) in ppm - dry wt.

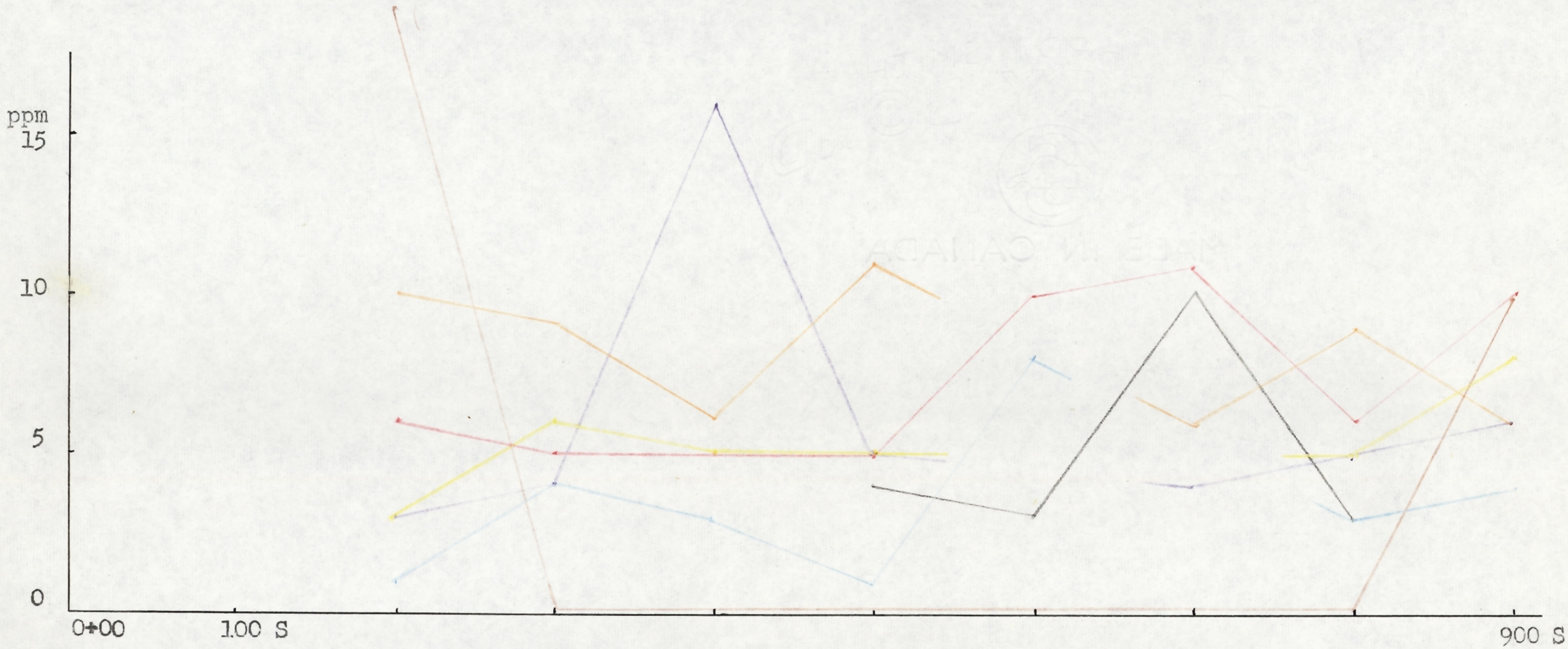


Figure 38. BLACKY BAY BOG. Profile Graph - Line 800 E
Copper contents of plant samples in ppm - dry wt.
Scales: Vert. 1 in. = 5 ppm; Horiz. 1 in. = 100 feet

- Black Spruce stems (2 yr. old)
- Sweet Gale stems (2 yr. old)
- False Solomon's-seal (whole plants)
- Sedge (whole plants)
- Sphagnum moss (whole plants)
- Pleurozium moss (whole plants)
- Surface peats.

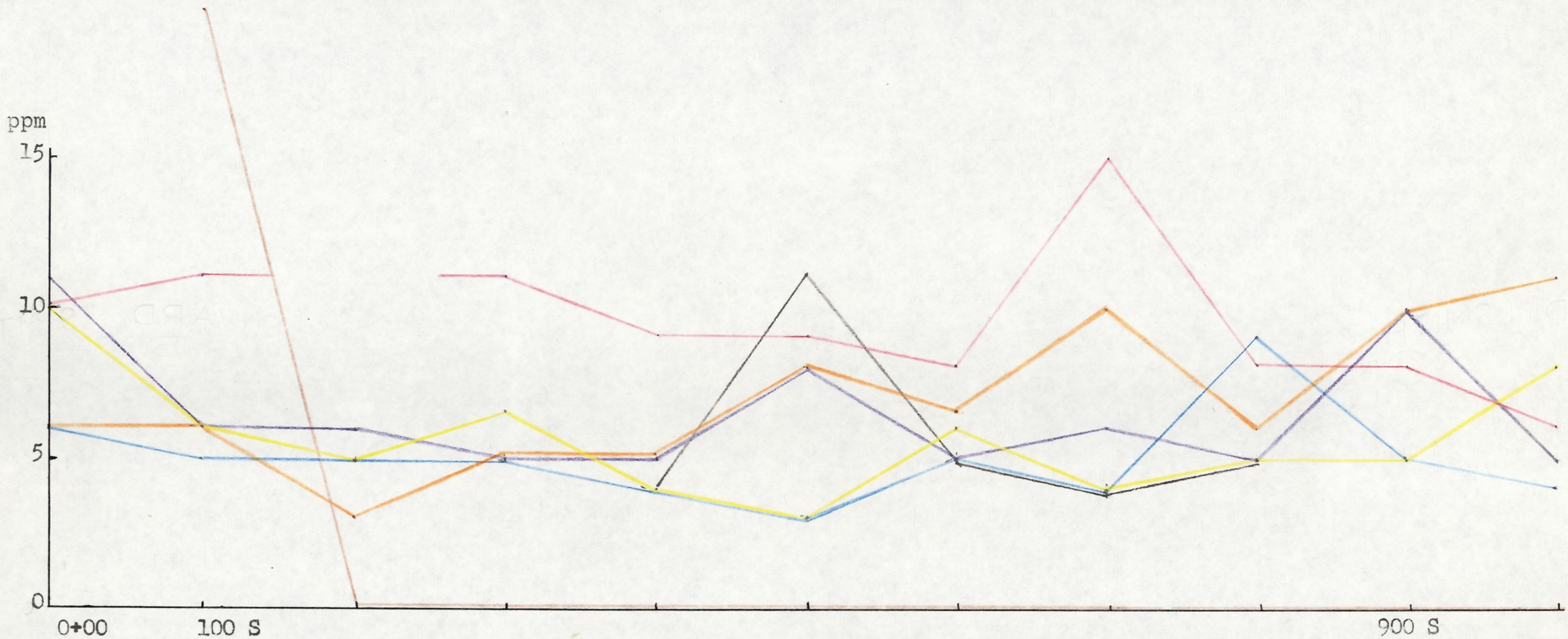


Figure 39. BLACKY BAY BOG. Profile graph - Line 1600 E
Copper contents of plant samples in ppm - dry wt.
Scales: Vert. 1 in. = 5 ppm; Horiz. 1 in. = 100 feet

- Black Spruce stems (2 yr. old)
- Sweet Gale stems (2 yr. old)
- False Solomon's-seal (whole plants)
- Sedge (whole plants)
- Sphagnum moss (whole plants)
- Pleurozium moss (whole plants)
- Surface peats.

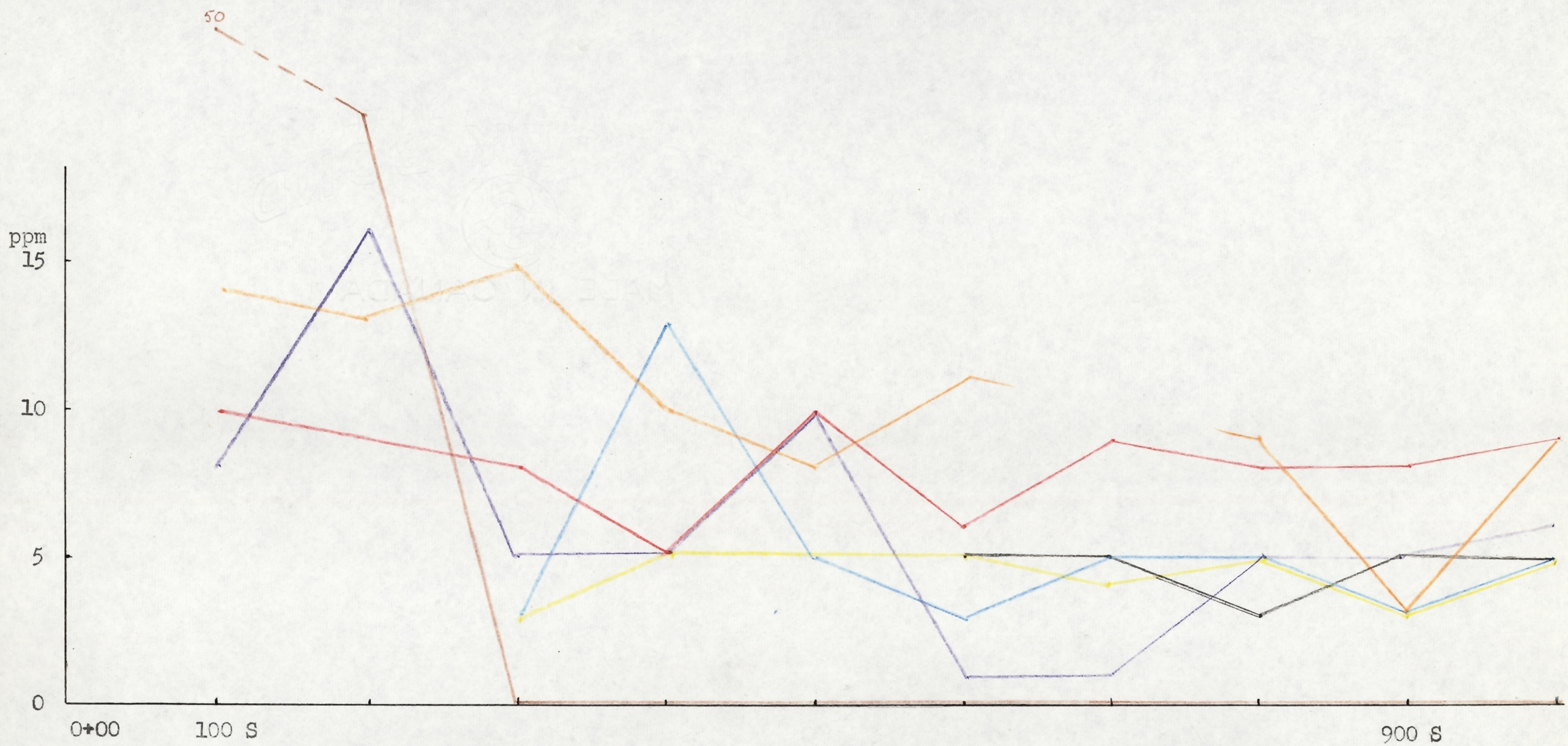


Figure 40. BLACKY BAY BOG. Profile Graph - Line 2400 E
Copper contents of plant samples in ppm - dry wt.
Scales: Vert. 1 in. = 5 ppm; Horiz. 1 in. = 100 feet

- Black Spruce stems (2 yr. old)
- Sweet Gale stems (2 yr. old)
- False Solomon's-seal (whole plants)
- Sedge (whole plants)
- Sphagnum moss(whole plants)
- Pleurozium moss (whole plants)
- Surface peats.

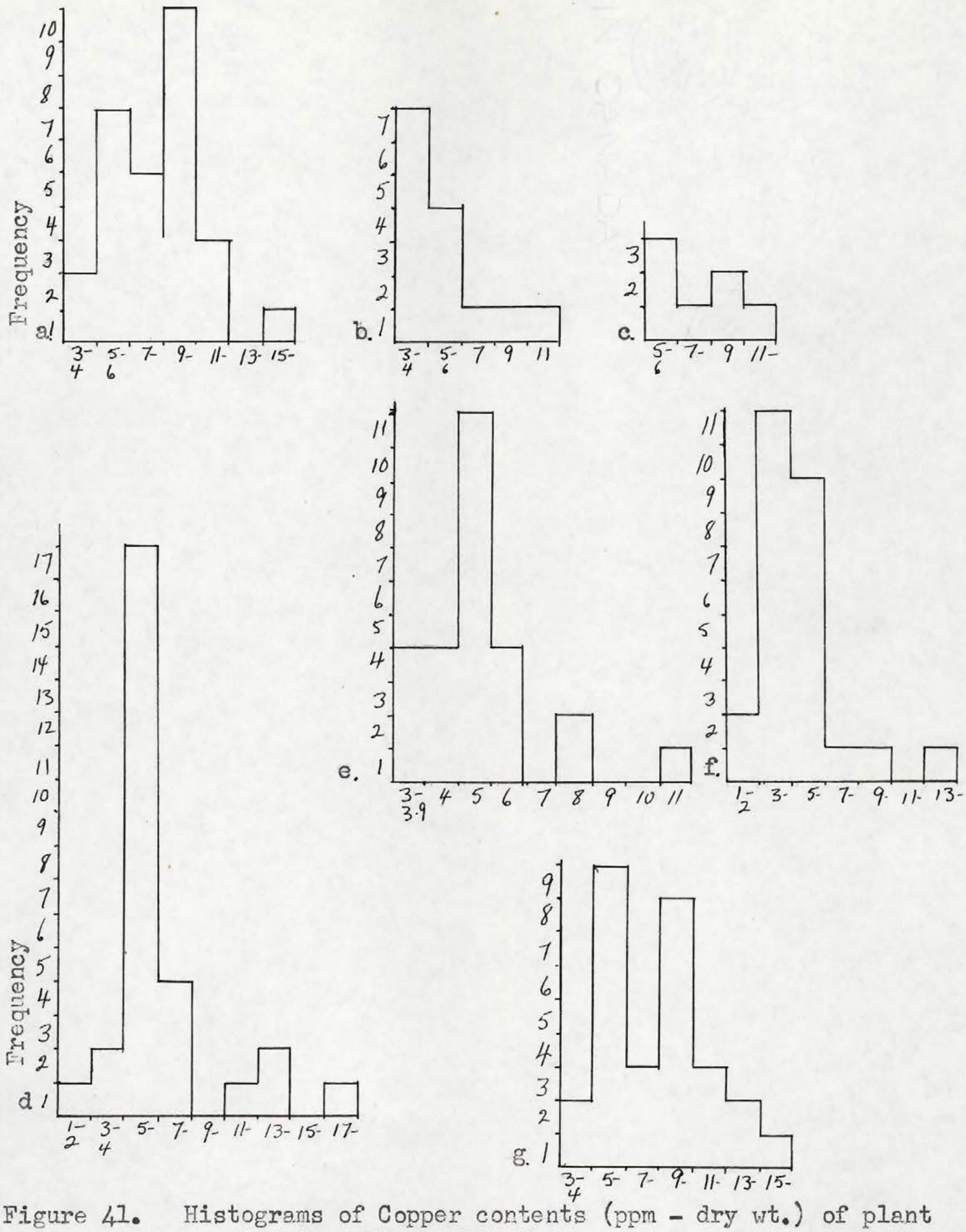


Figure 41. Histograms of Copper contents (ppm - dry wt.) of plant samples from Blacky Bay Bog.

	Interval
(a) Black Spruce stems (2 yr. old)	2 ppm
(b) Sweet Gale stems (2 yr. old)	2 ppm
(c) Labrador-tea stems (2 yr. old)	2 ppm
(d) Sedge (whole plants)	2 ppm
(e) False Solomon's -seal (whole plants)	1 ppm
(f) Pleurozium moss (whole plants)	2 ppm
(g) Sphagnum moss (whole plants)	2 ppm

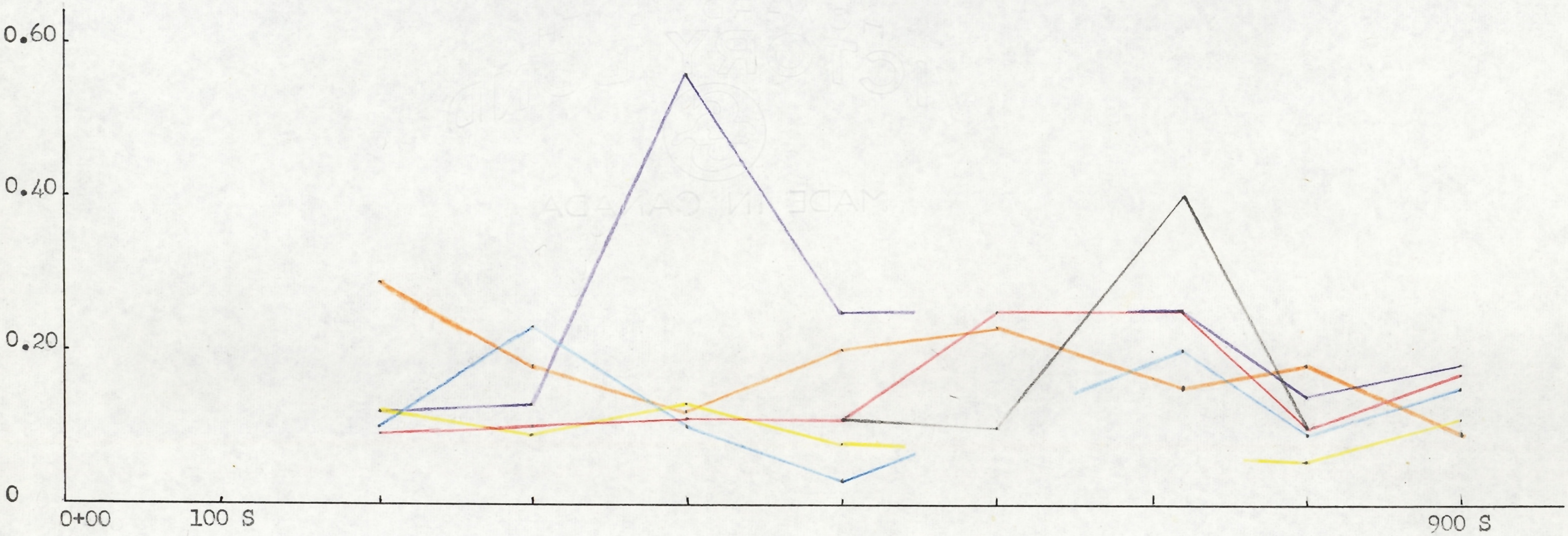


Figure 42. BLACKY BAY BOG. Profile graph - Line 800 E
Copper:Zinc ratios in plant samples

— Black Spruce stems (2 yr. old)
— Sweet Gale stems (2 yr. old)
— False Solomon's-seal (whole plants)
— Sedge (whole plants)
— Sphagnum moss (whole plants)
— Pleurozium moss (whole plants)

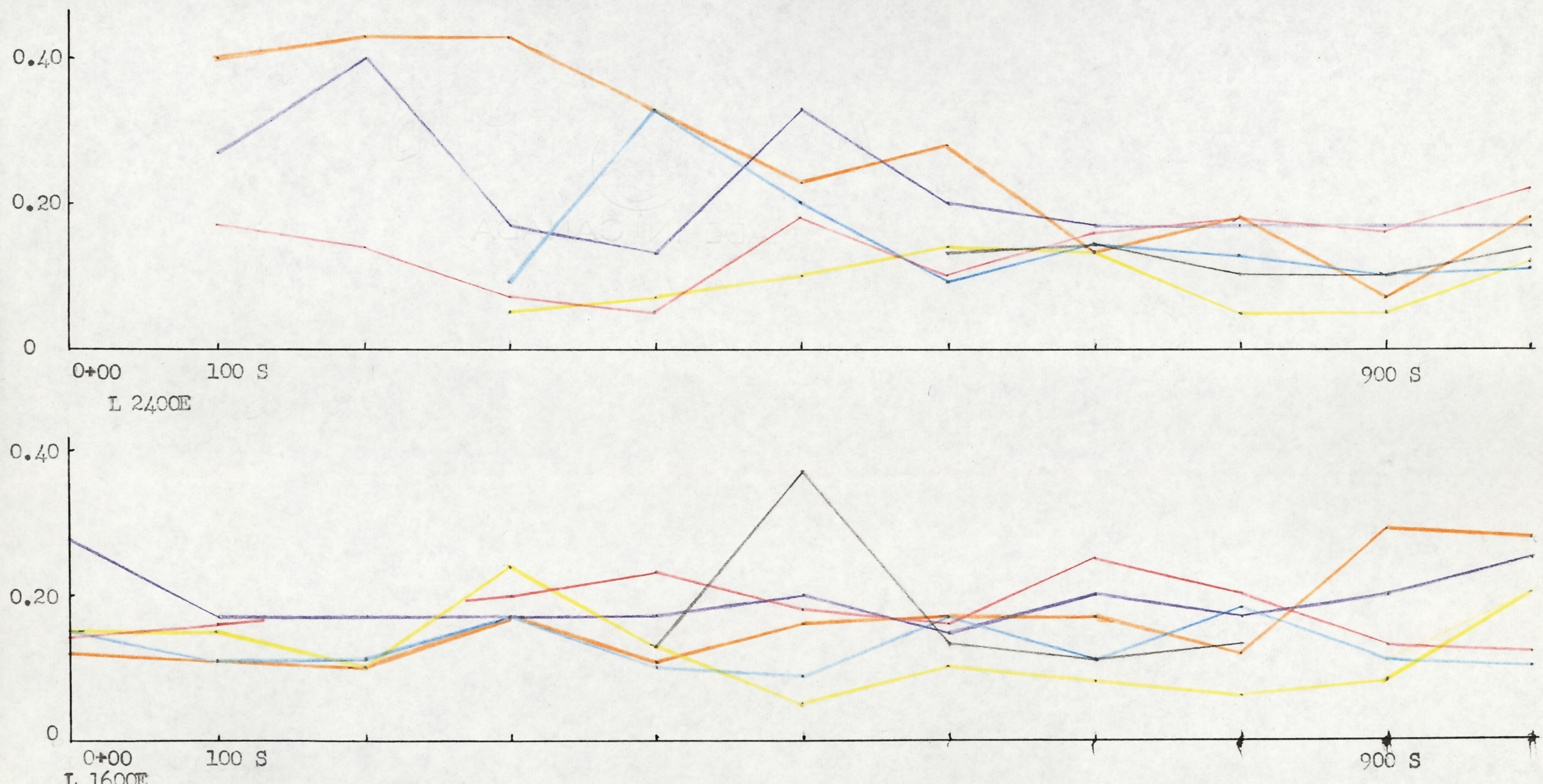


Figure 43. BLACKY BAY BOG. Profile graph - Lines 1600 E, 2400 E.
Copper:Zinc ratios in plant samples

- Black Spruce stems (2 yr. old)
- Sweet Gale stems (2 yr. old)
- False Solomon's-seal (whole plants)
- Sedge (whole plants)
- Sphagnum moss (whole plants)
- Pleurozium moss (whole plants)

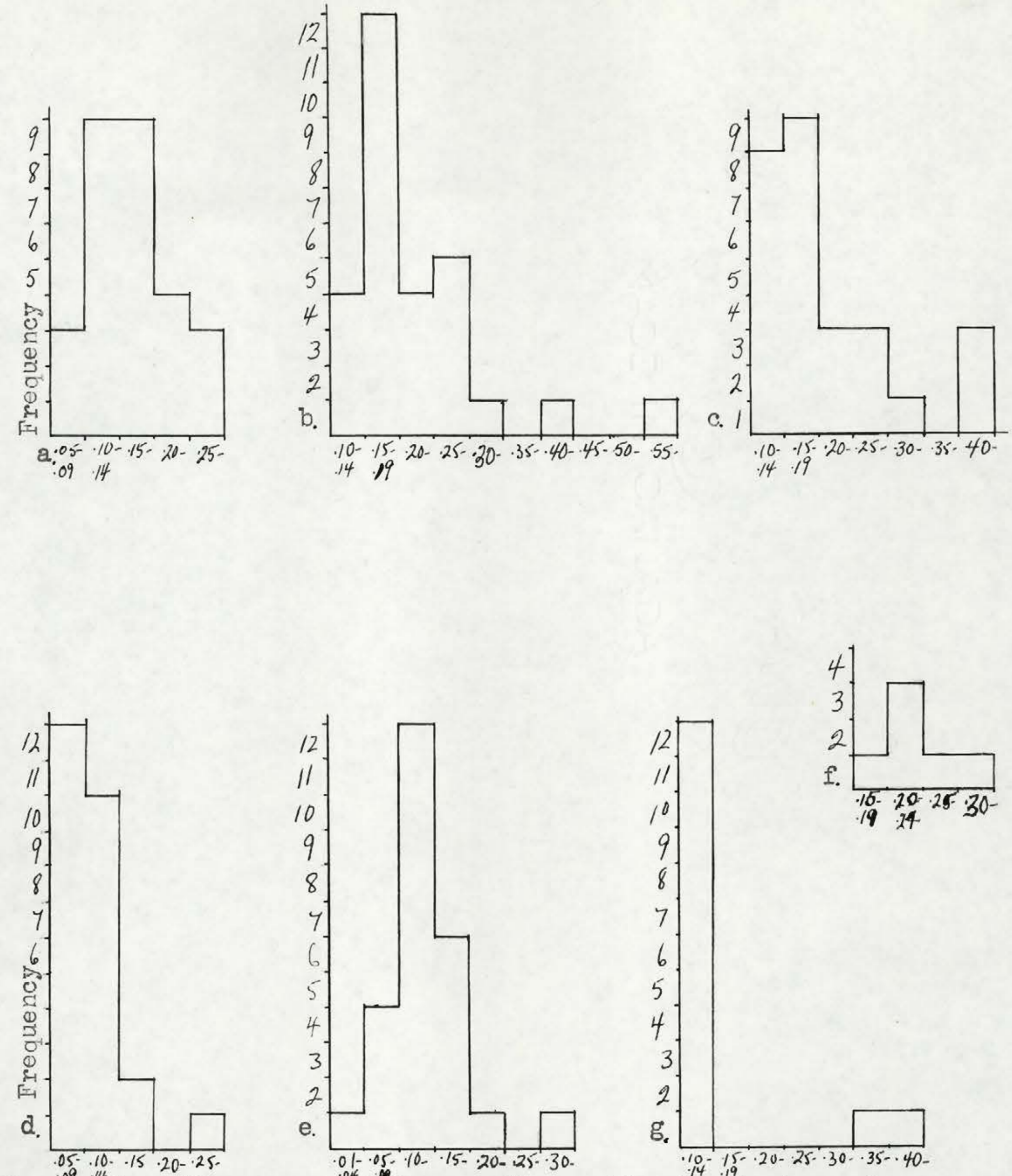


Figure 44. Histograms of Copper: Zinc ratios in plant samples from Blacky Bay Bog.

	Interval
(a) Black Spruce stems (2 yr. old)	0.05
(b) Sedge (whole plants)	0.05
(c) Sphagnum moss (whole plants)	0.05
(d) False Solomon's-seal (whole plants)	0.05
(e) Pleurozium moss (whole plants)	0.05
(f) Labrador-tea stems (2 yr. old)	0.05
(g) Sweet Gale stems (2 yr. old)	0.05

Sphagnum moss (figure 44,c). These two show secondary highs similar to those in the copper contents histograms (figure 41).

Lead - The lead contents of each species are plotted on plant association maps in figures 45 to 49. Very little or no lead occurred in samples of Sweet Gale.

The lead contents of two species are contoured in figures 50 to 51. Many samples of the other species contained no lead.

The lead contents of each species are compared in the profile graphs of figure 52. These graphs are quite smooth when compared with the profiles of copper and zinc contents (figures 20 to 22, and 38 to 40).

The histograms of the lead contents of each species (figure 53) are normal in shape except for the large number of zero values.

Nickel - The nickel contents of the surface peats and each plant species are plotted on plant association maps in figures 54 to 56. Nearly all nickel contents of the other species were zero.

The nickel contents are contoured in figures 58 and 59. High values occur on each side of the bog.

Figure 60 shows the profile graphs of the nickel contents of the Sphagnum and Pleurozium moss samples.

The histograms of the nickel contents of each species are in figure 61.

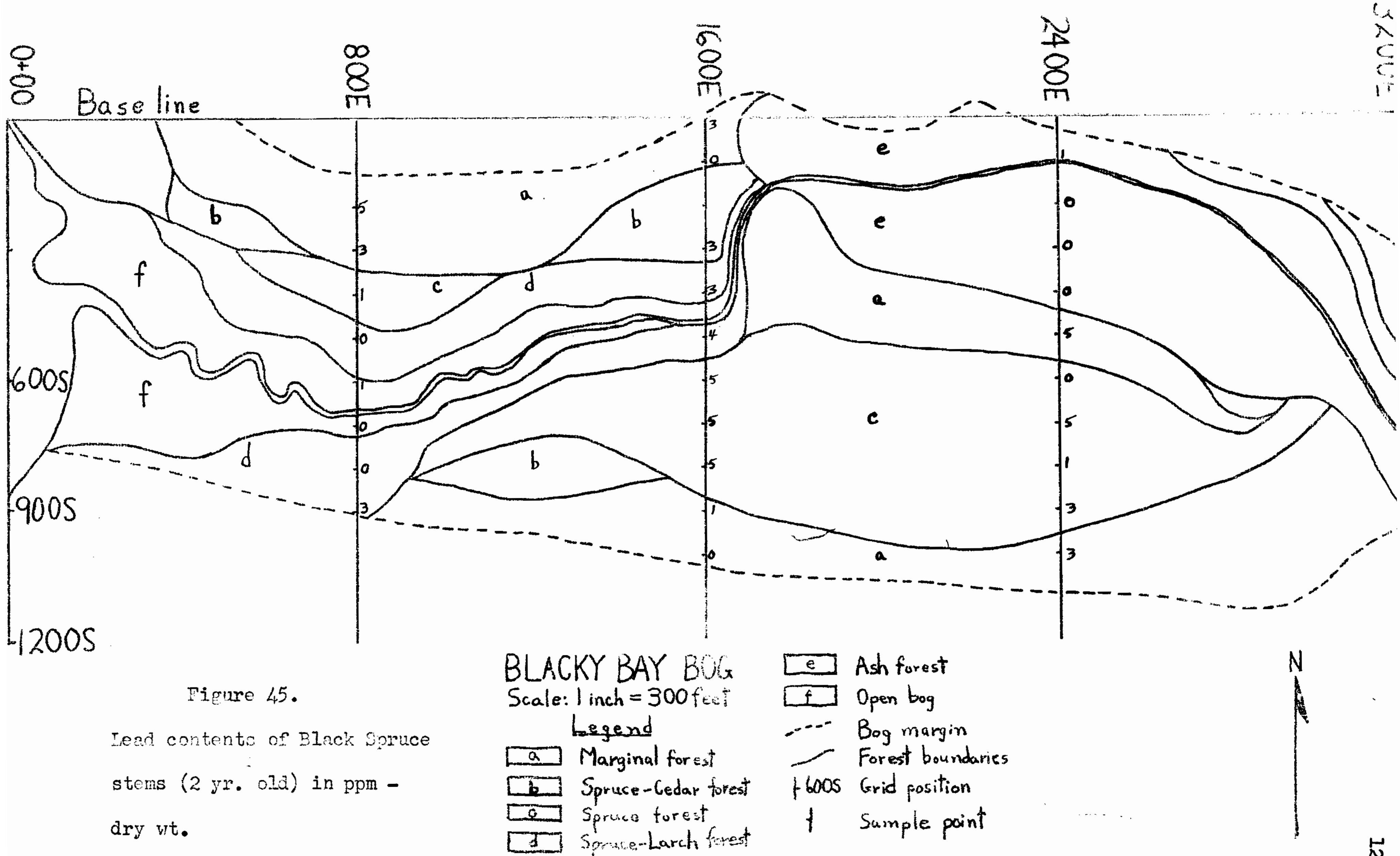
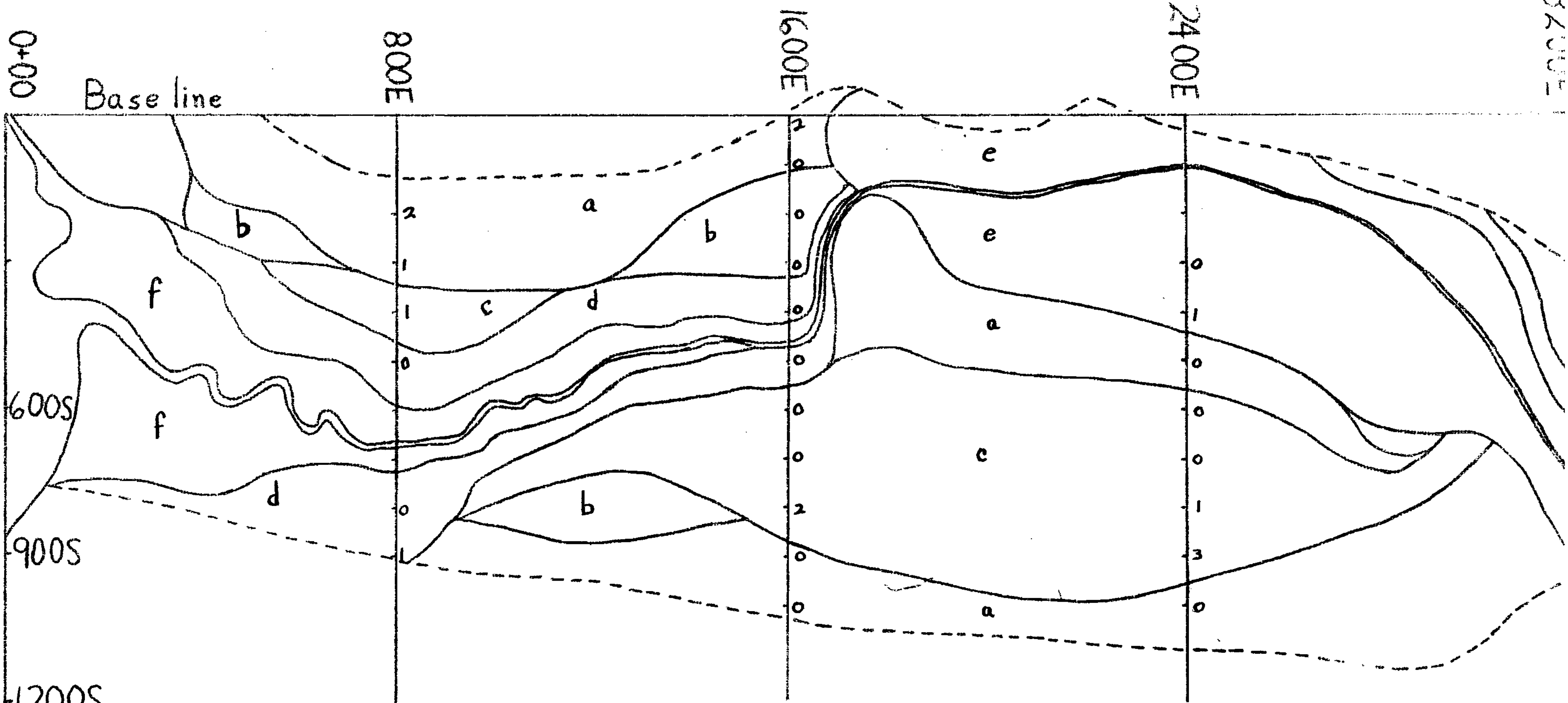


Figure 45.

Lead contents of Black Spruce stems (2 yr. old) in ppm - dry wt.



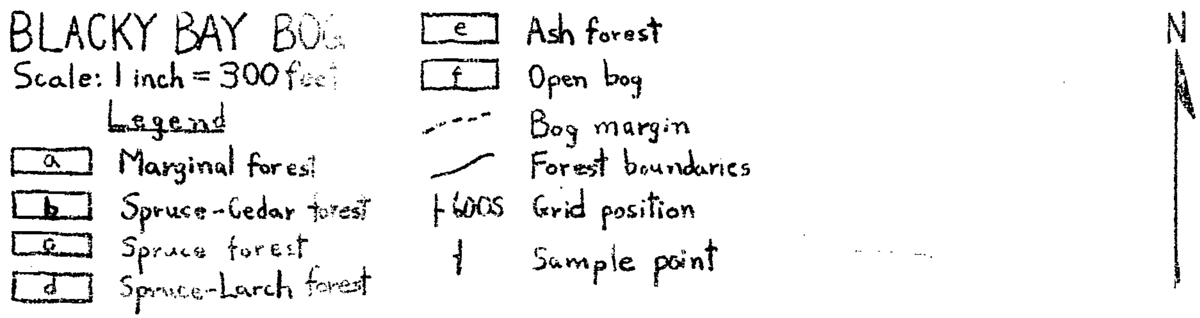
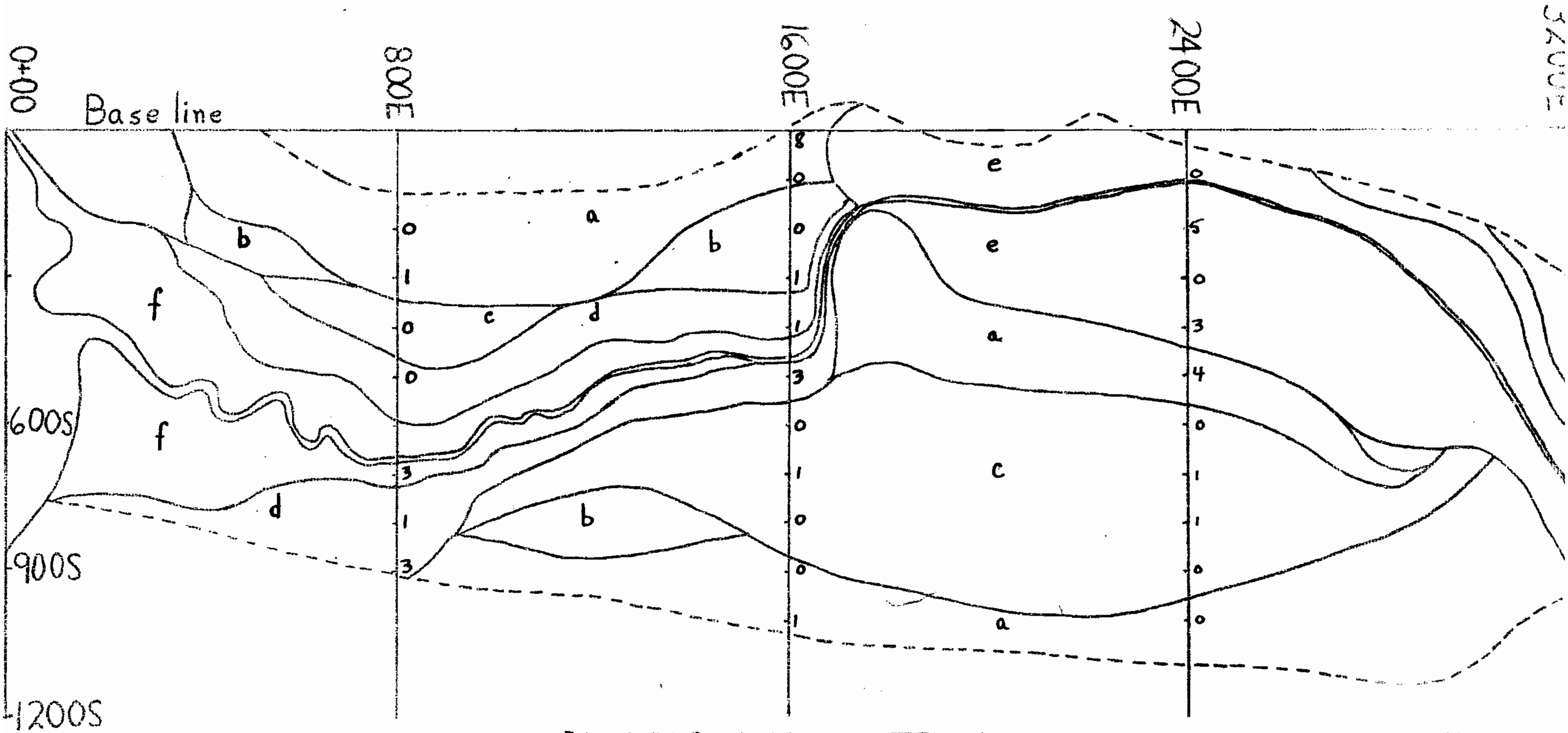


Figure 46

Lead contents of False Solomon's-seal plants (whole) in ppm - dry wt.



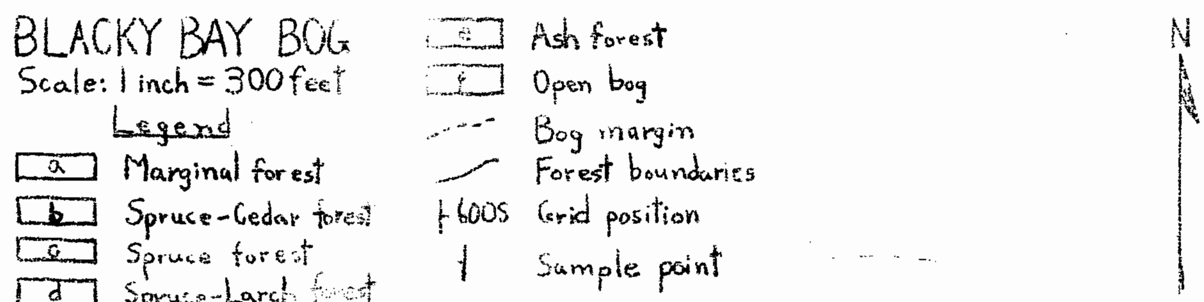
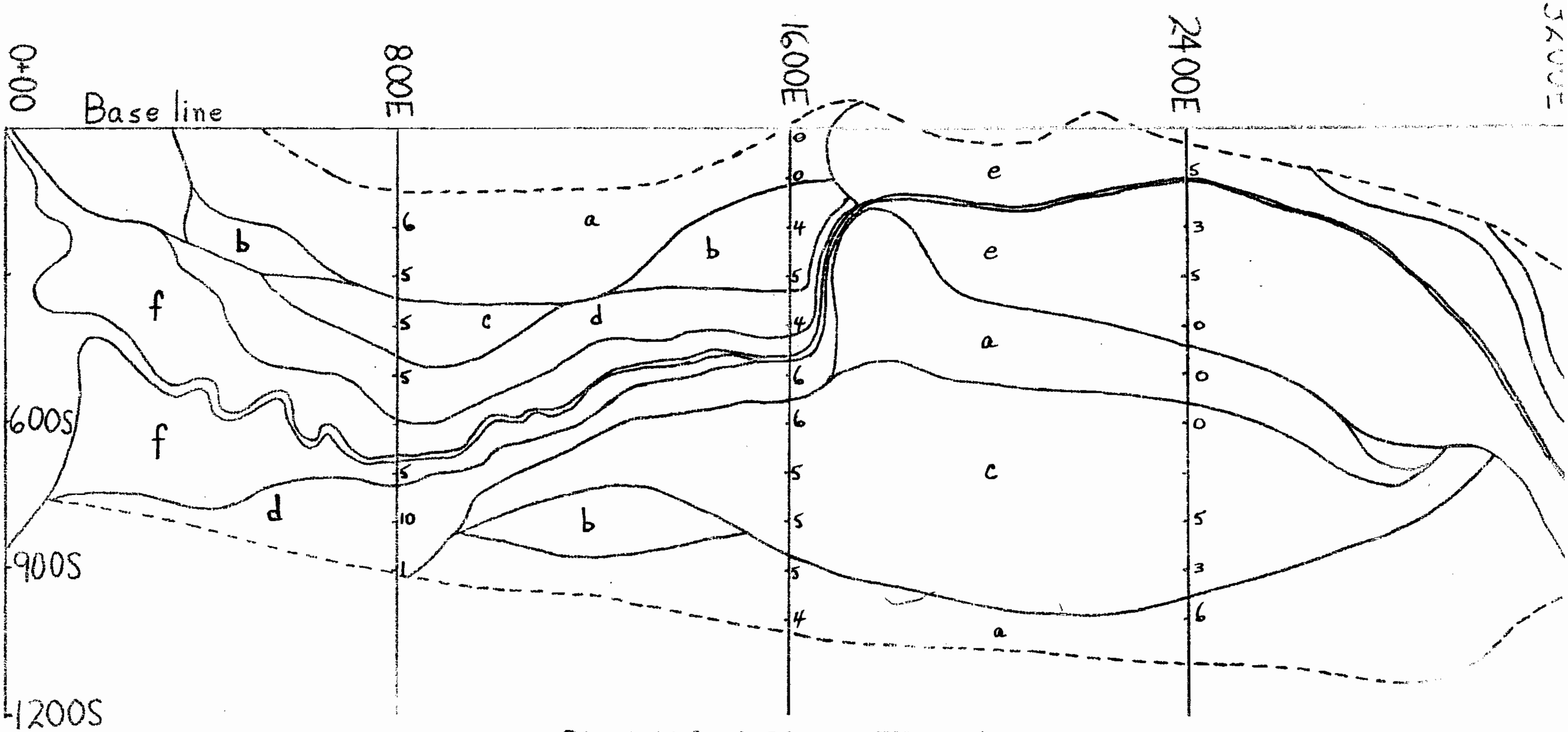


Figure 47

Lead contents of Sedge plants (whole) in ppm - dry wt.



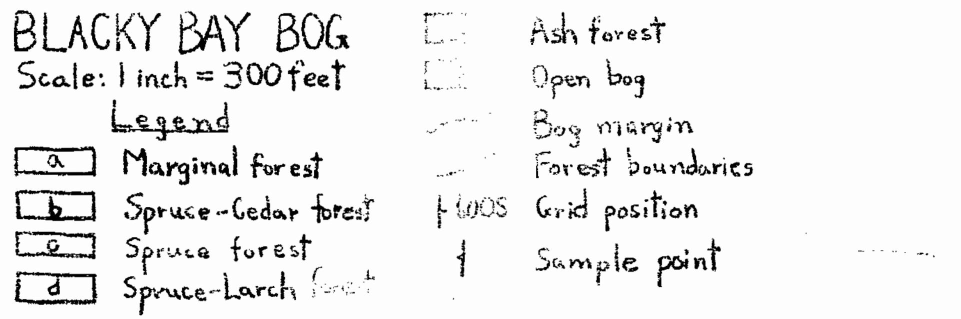


Figure 48

Lead contents of Sphagnum moss plants (whole) in ppm - dry wt.

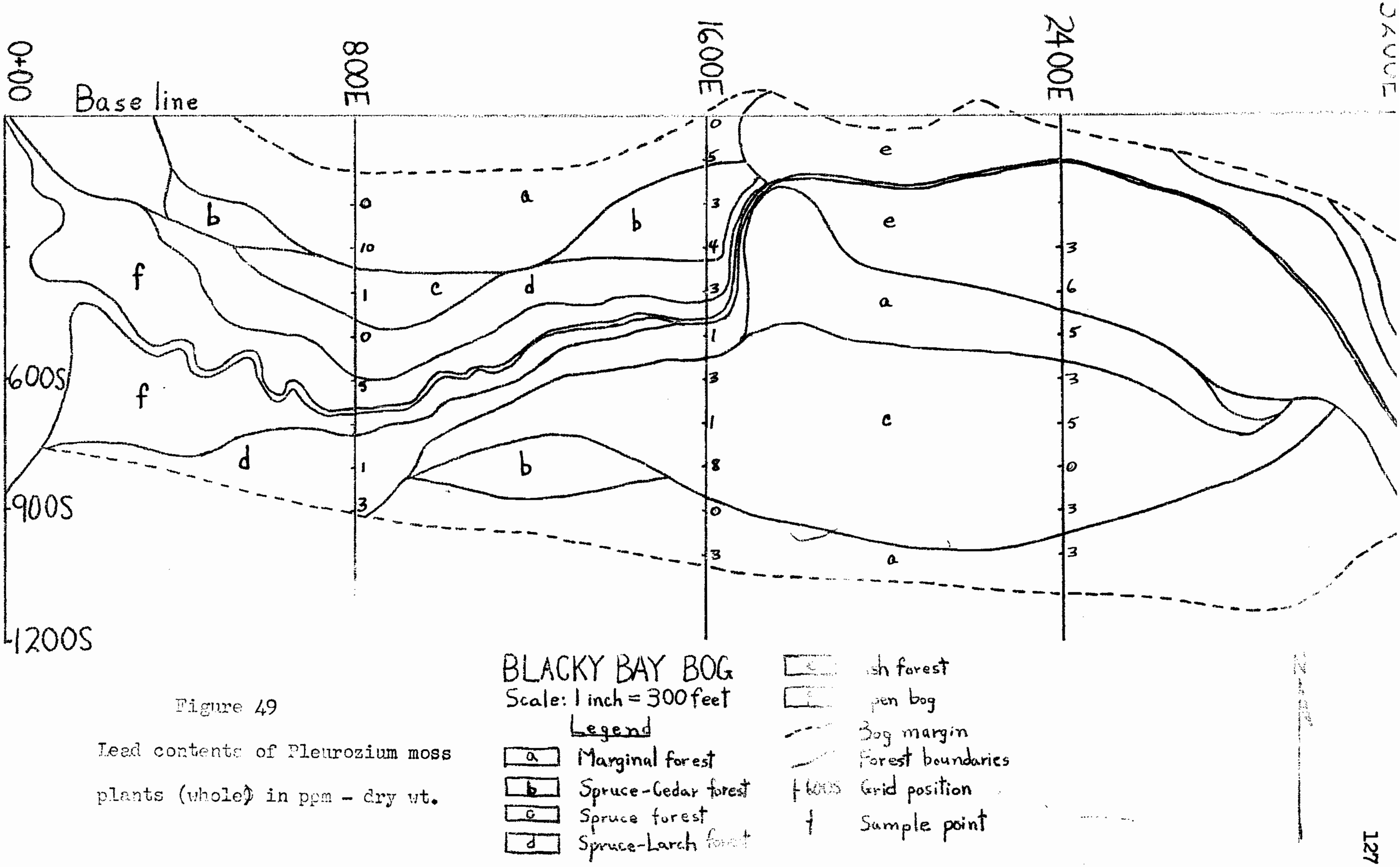


Figure 49

Lead contents of Pleurozium moss plants (whole) in ppm - dry wt.

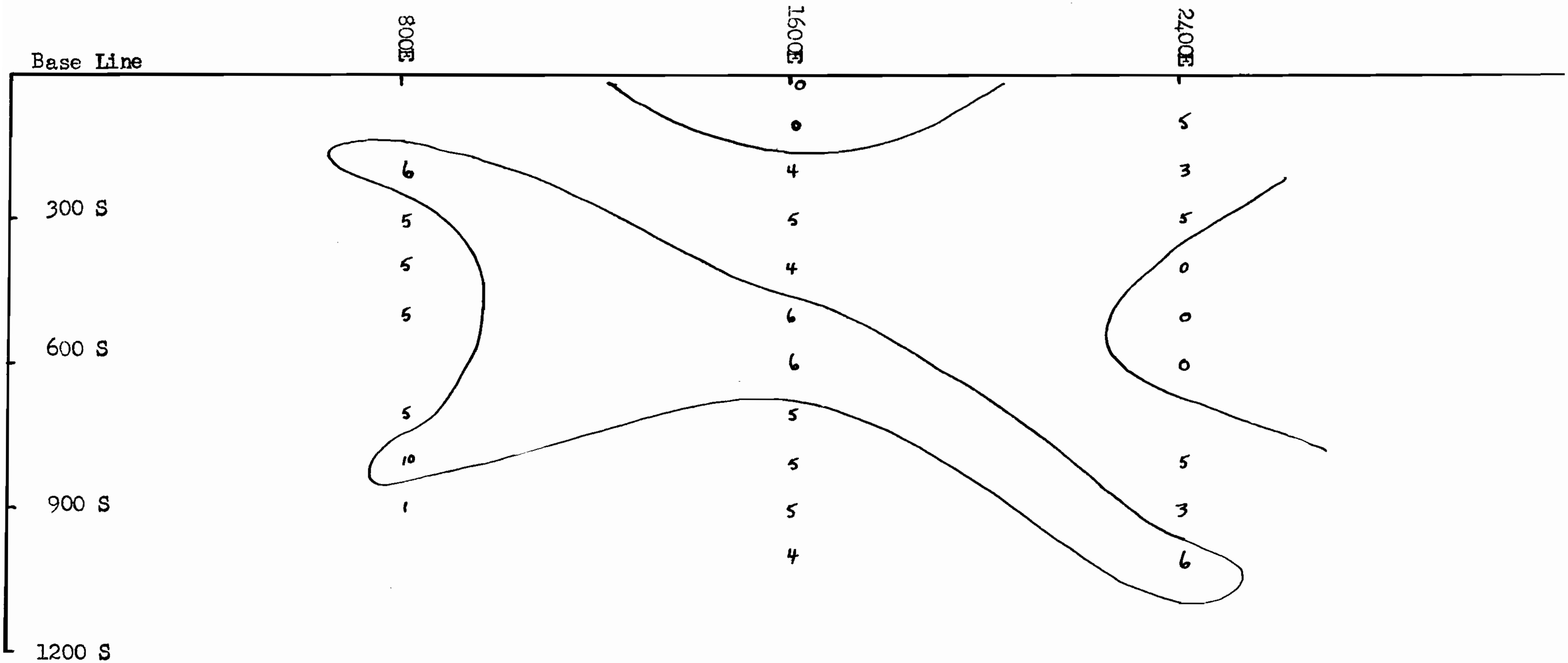


Figure 50. BLACKY BAY BOG - Contour map.
Contour interval - 5 ppm (6 - 10)
Lead contents of Sphagnum moss plants (whole) in ppm - dry wt.

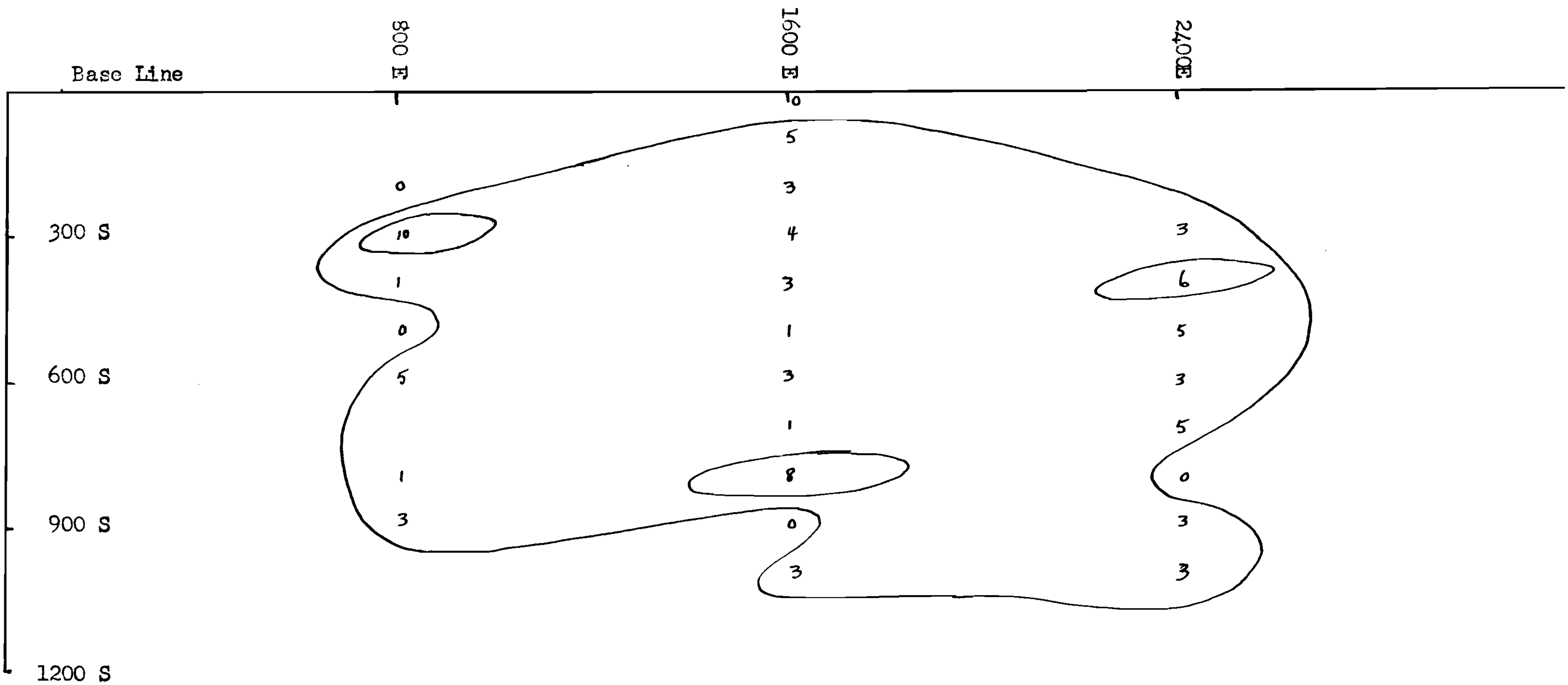


Figure 51. BLACKY BAY BOG – Contour map.

Contour interval – 5 ppm (6 – 10)

Lead contents of Pleurozium moss plants (whole) in ppm – dry wt.

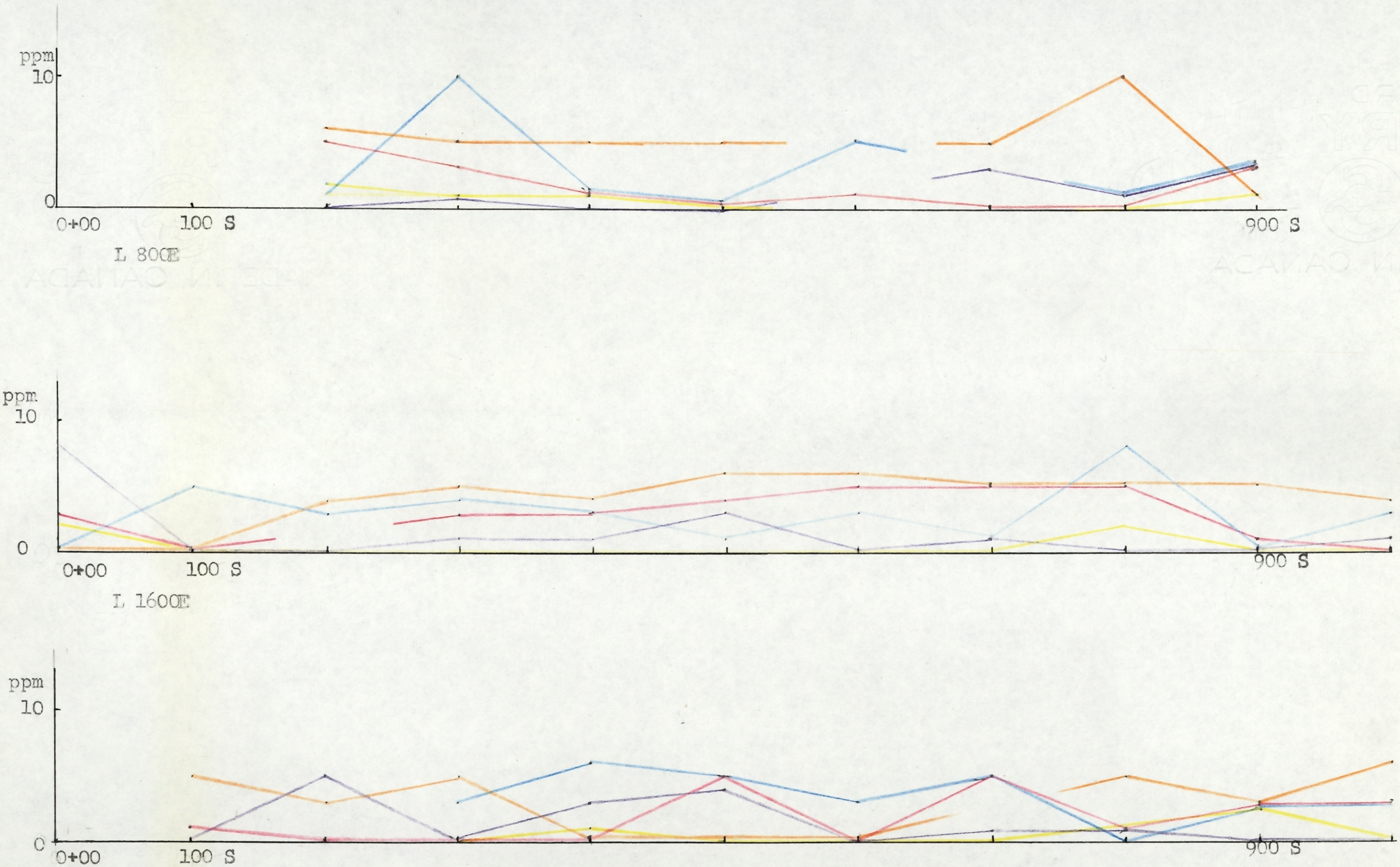


Figure 52. BLACKY BAY BOG. Profile graph - Lines 800 E, 1600 E, and 2400 E.
Lead contents of plant samples in ppm - dry wt. Scales: Vert. 1 in.=10 ppm; Horiz. 1 in.=100 feet.

- Black Spruce stems (2 yr. old)
- False Solomon's-seal (whole plants)
- Sedge (whole plants)
- Sphagnum moss (whole plants)
- Pleurozium moss (whole plants)

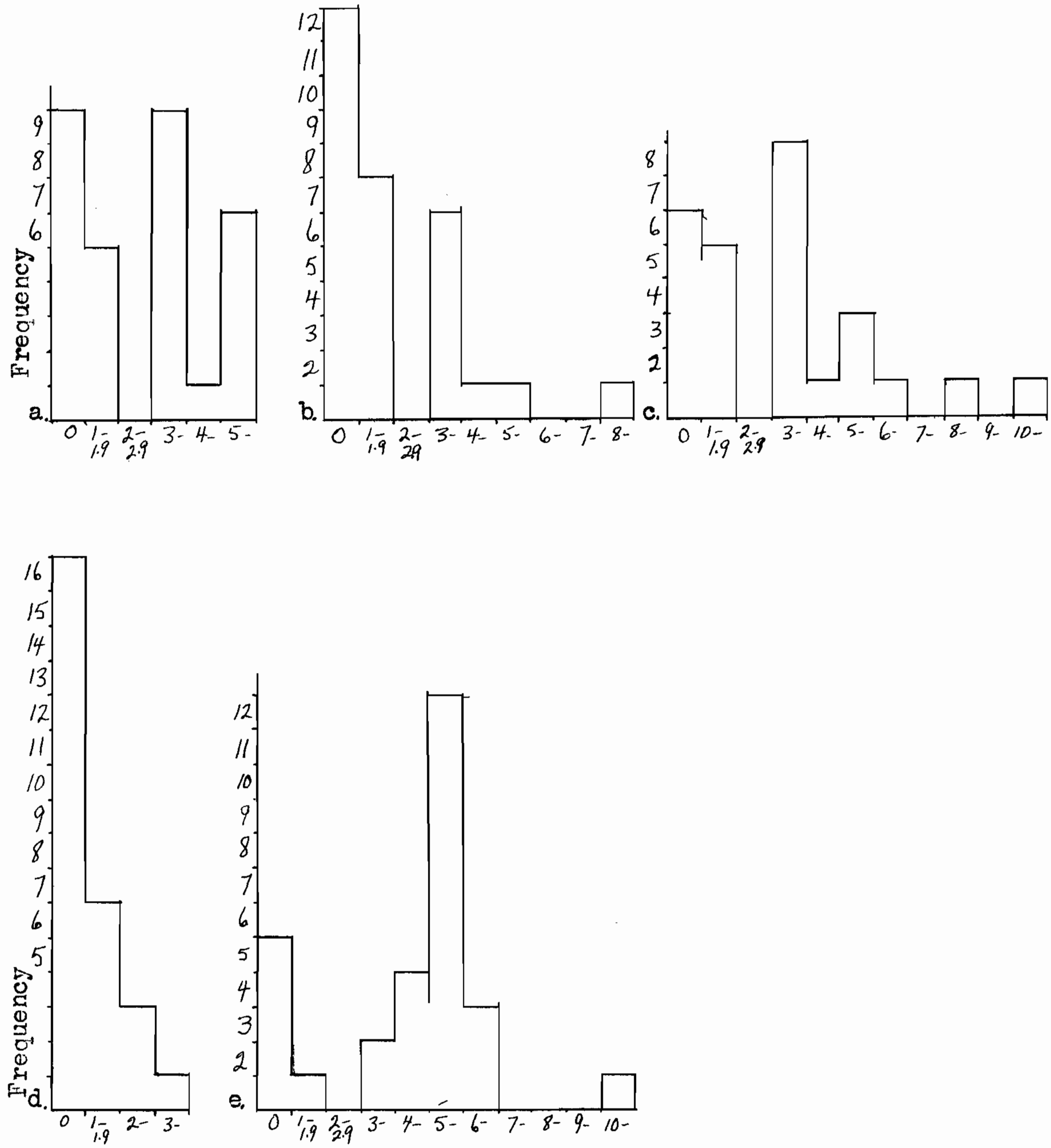


Figure 53. Histograms of the Lead contents (ppm - dry wt.) of plant samples from Blacky Bay Bog.

	Interval
(a) Black Spruce stems (2 yr. old)	1 ppm
(b) Sedge (whole plants)	1 ppm
(c) Pleurozium moss (whole plants)	1 ppm
(d) False Solomon's-seal (whole plants)	1 ppm
(e) Sphagnum moss (whole plants)	1 ppm

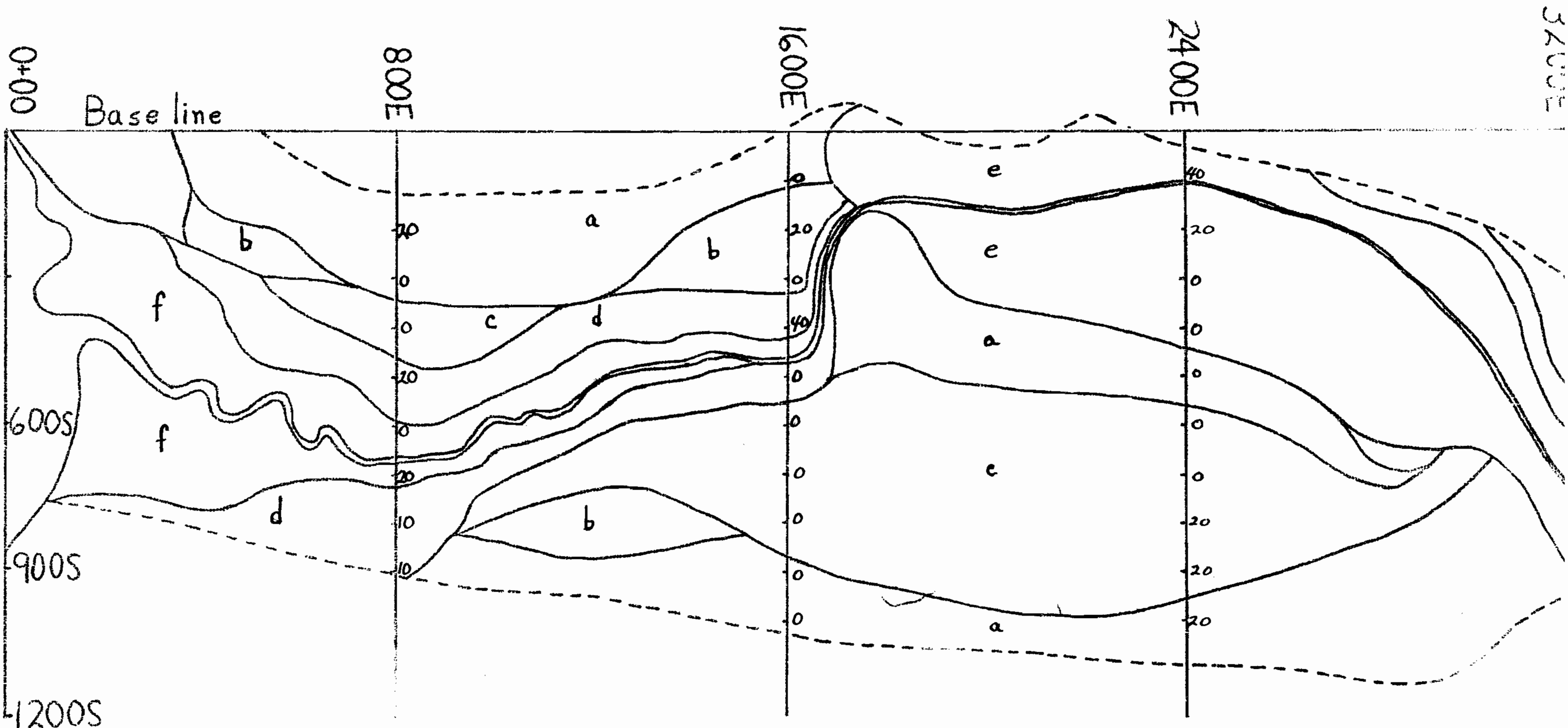


Figure 54.

Nickel contents of surface peats in ppm - dry wt.

BLACKY BAY BOG

Scale: 1 inch = 300 feet

Legend

a Marginal forest

b Spruce-Cedar forest

c Spruce forest

d Spruce-Larch forest

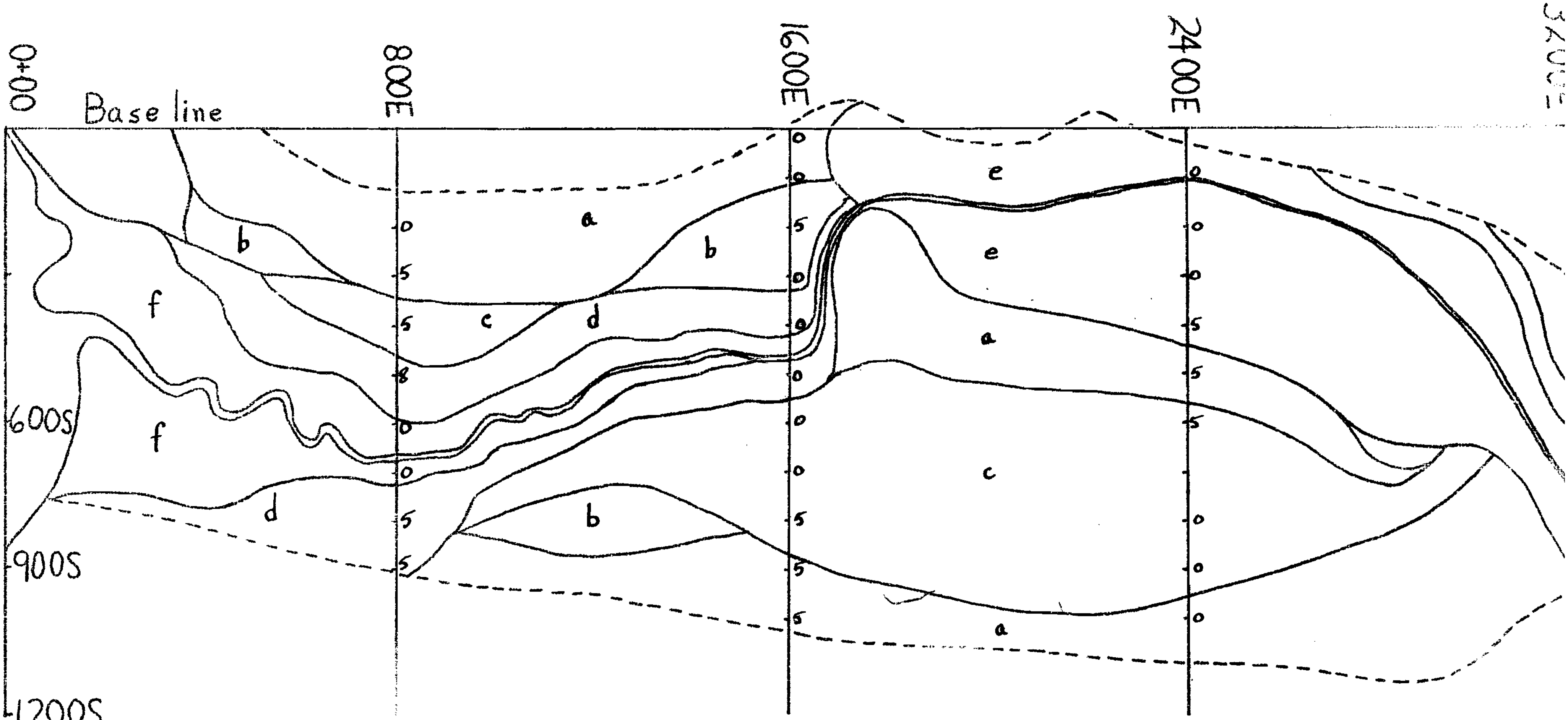
Bog margin

Forest boundaries

Grid position

Sample point

N



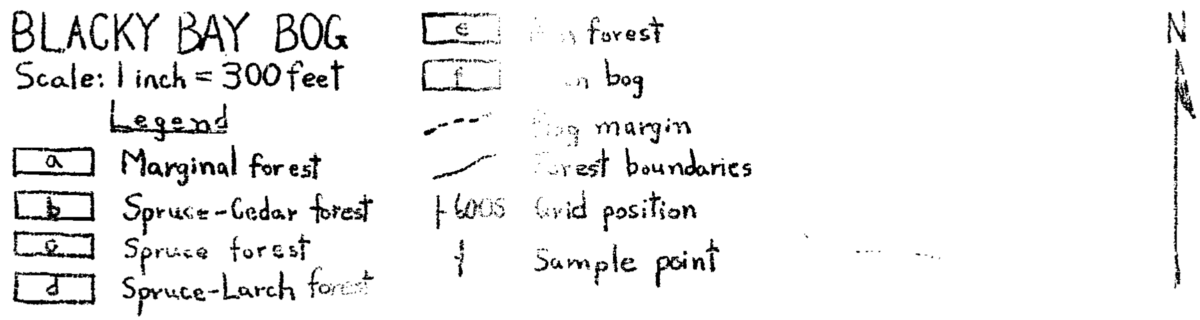
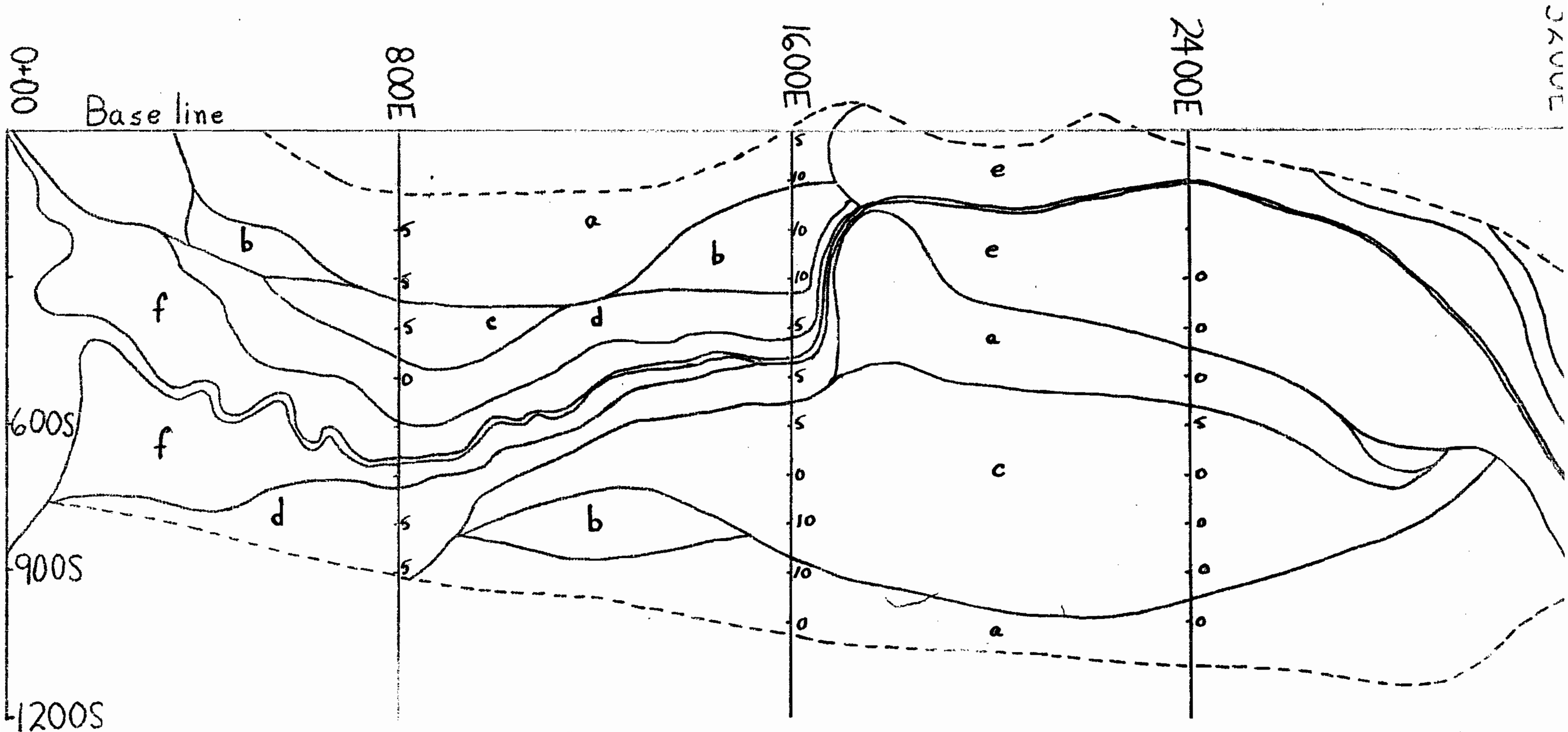


Figure 55

Nickel contents of Sphagnum moss plants (whole) in ppm - dry wt.



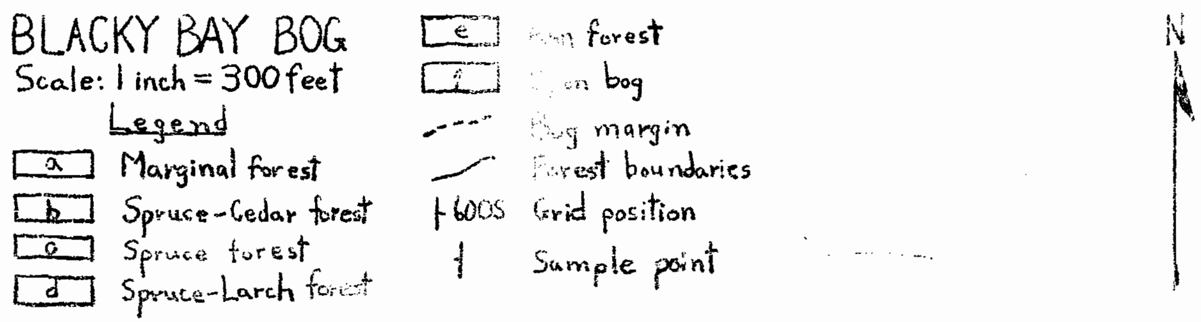


Figure 56

Nickel contents of Pleurozium moss plants (whole) in ppm-dry wt.

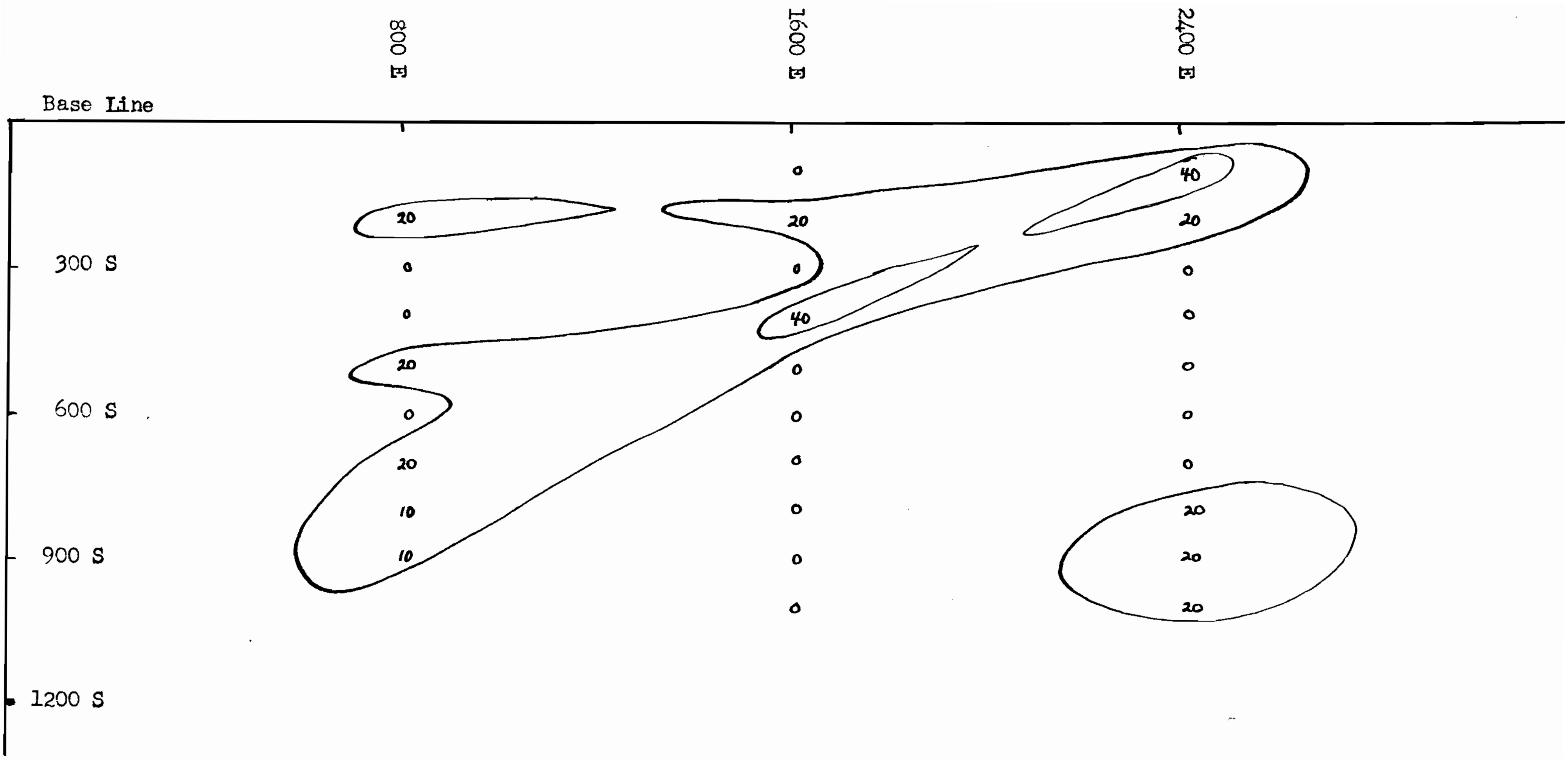


Figure 57. BLACKY BAY BOG - Contour map
Contour interval - 20 ppm (21 - 40)
Nickel contents of surface peats in ppm - dry wt.

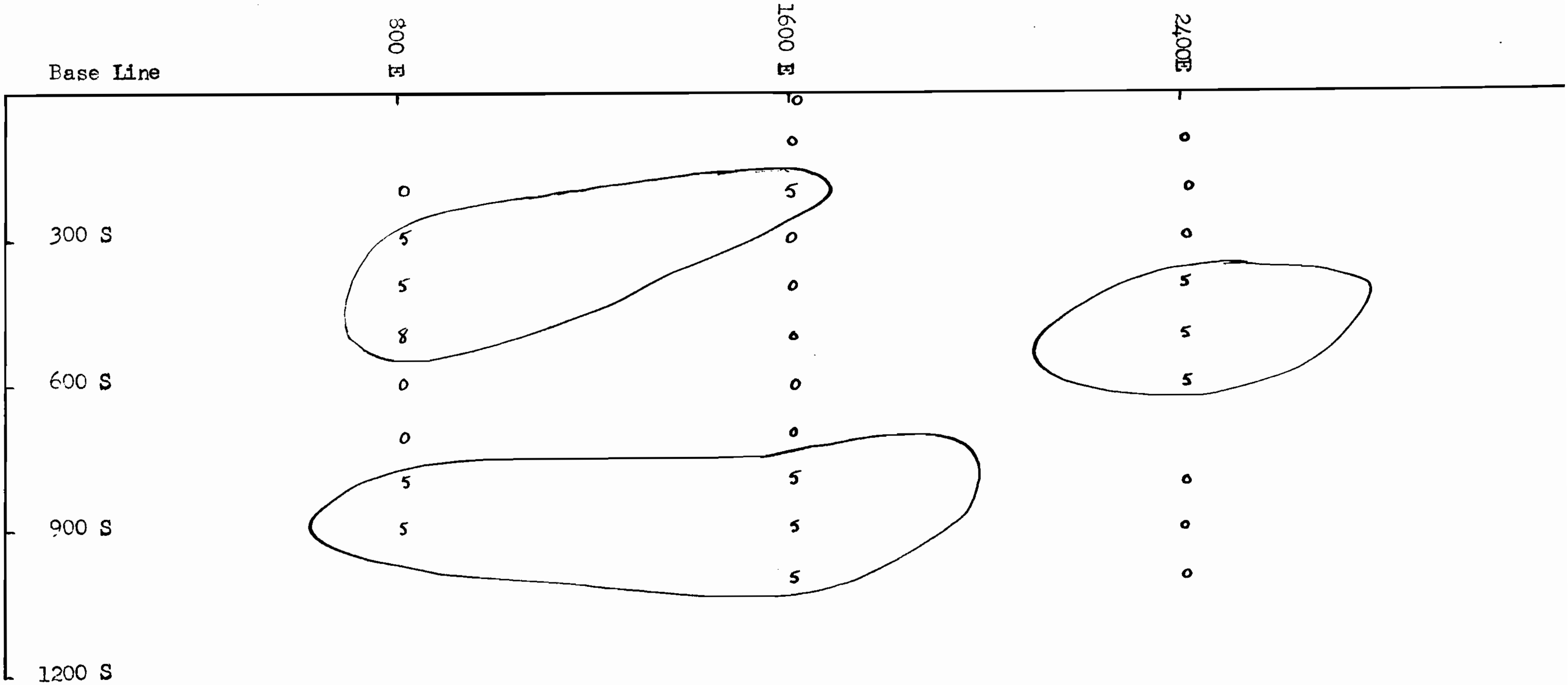


Figure 58. BLACKY BAY BOG - Contour map
Contour interval - 5 ppm (1 - 5)
Nickel contents of Sphagnum moss plants (whole) in ppm - dry wt.

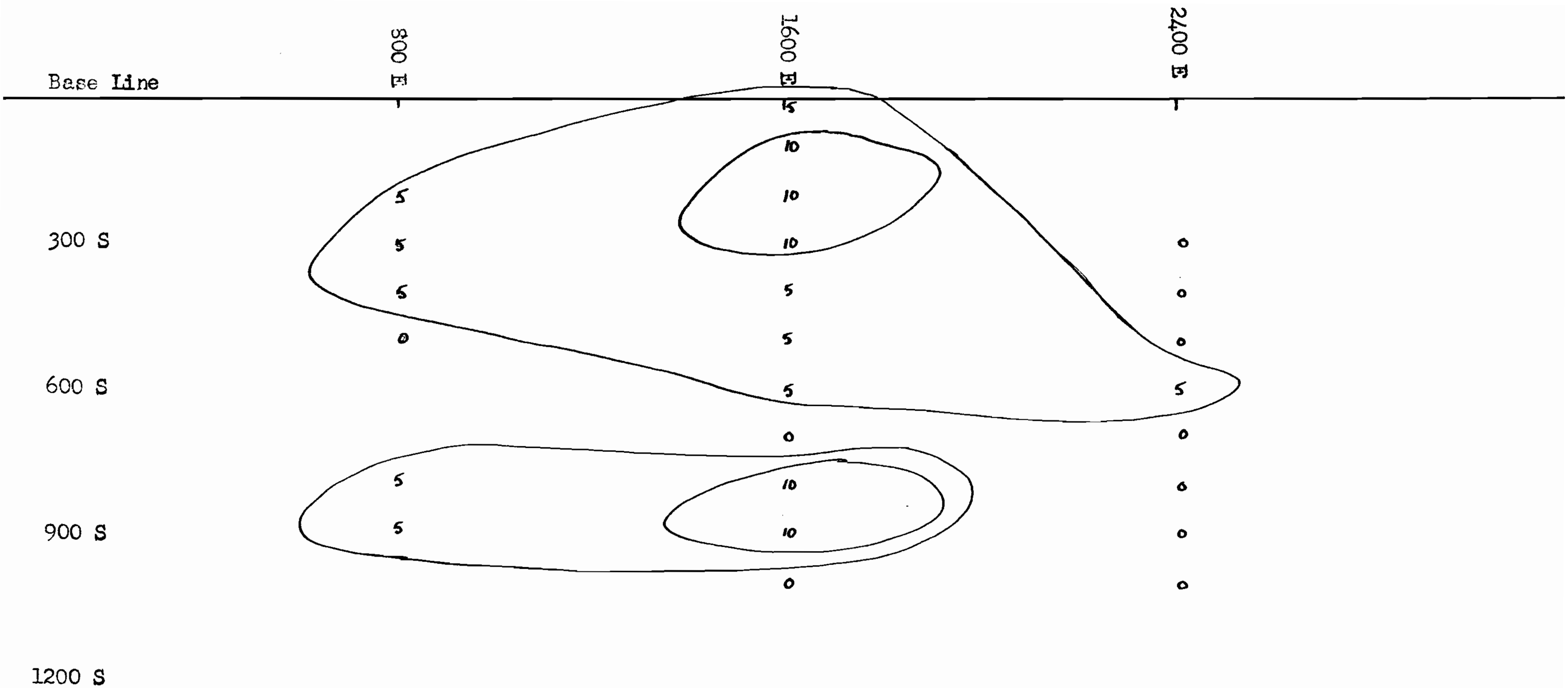
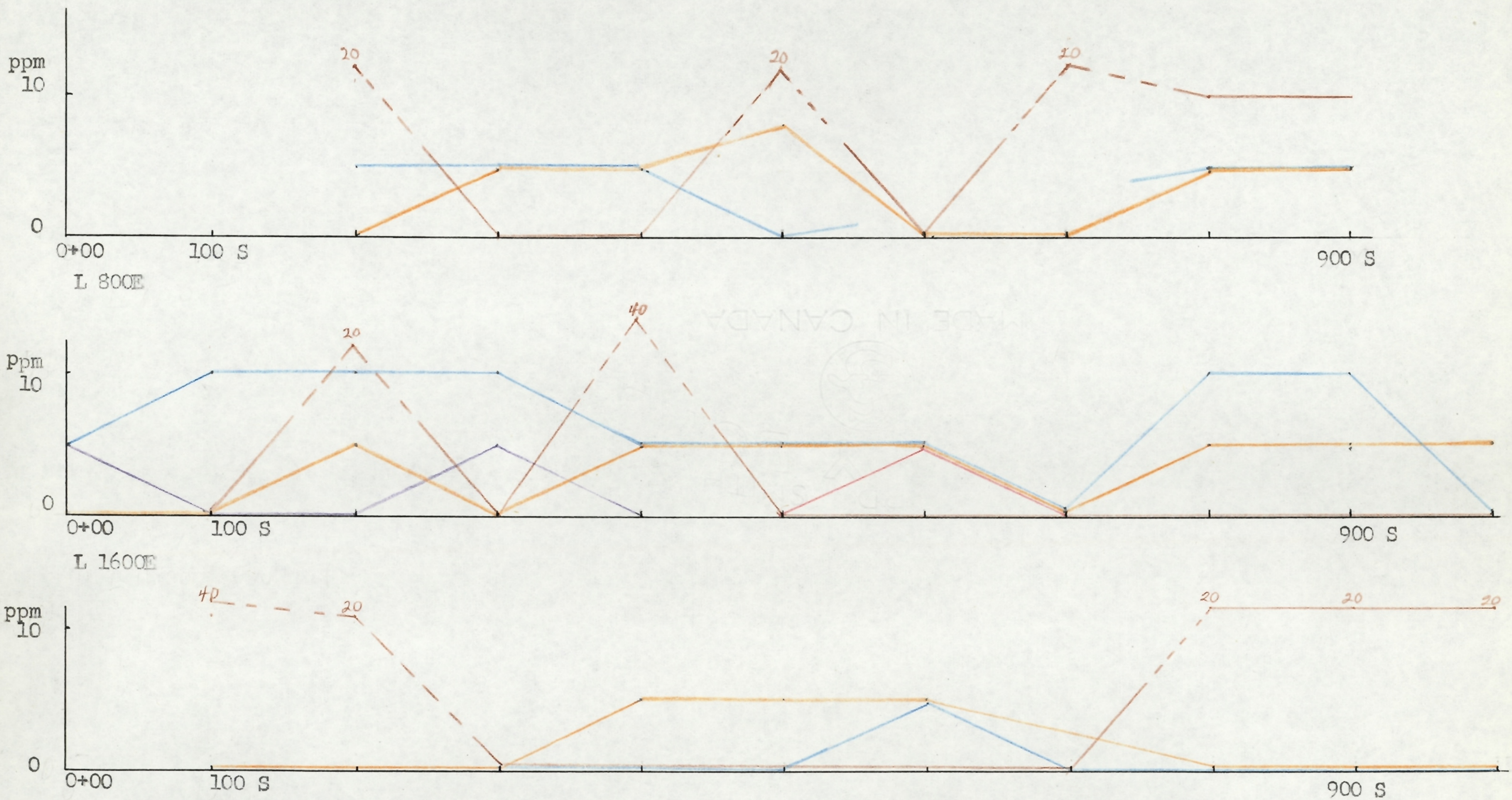


Figure 59. BLACKY BAY BOG - Contour map
Contour interval - 5 ppm (6 - 10)
Nickel contents of Pleurozium moss plants (whole) in ppm - dry wt.



L 2400E Figure 60. BLACKY BAY BOG. Profile graph - Lines 800 E, 1600 E, and 2400 E.
Nickel contents of plant samples in ppm - dry wt. Scales: Vert. 1 in = 10 ppm; Horiz. 1 in=100 ft

Black Spruce stems (2 yr. old)
Sedge (whole plants)
Sphagnum moss (whole plants)
Pleurozium moss (whole plants)

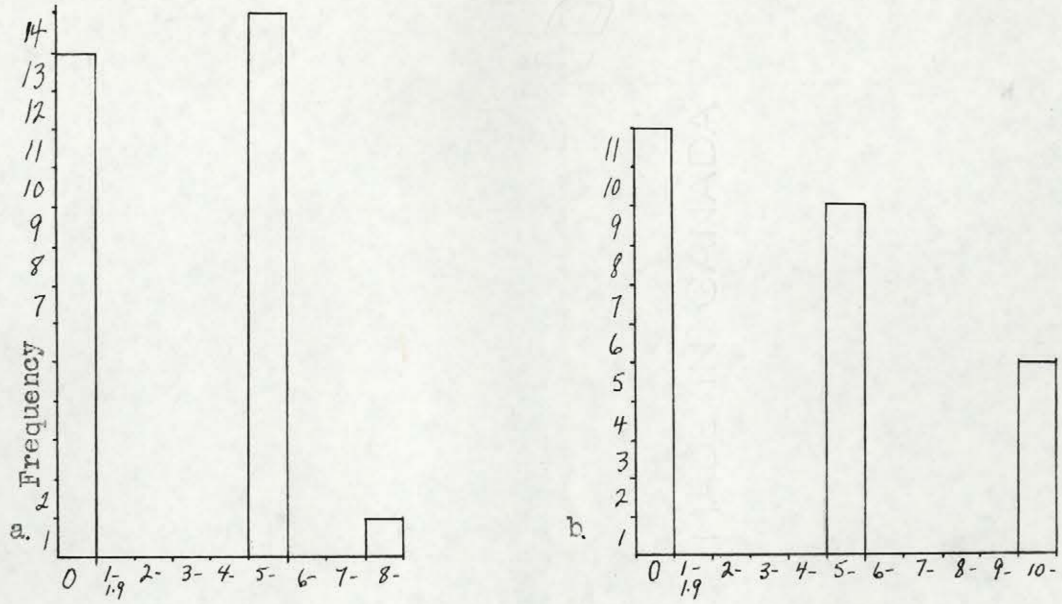


Figure 61. Histograms of Nickel contents (ppm - dry wt.) of plant samples from Blacky Bay Bog.

	Interval
(a) Sphagnum moss (whole plants)	1 ppm
(b) Pleurozium moss (whole plants)	1 ppm

SCOTT LAKE BOG

Introduction

Sampling points - The sampling of plants for metal analysis on Scott Lake Bog took place at a total of 24 points on the grid. The sampling points occurred at 800 foot intervals south from the base line, along lines 2586 west, 1724 west, 862 west, 0, and 862 east (L 2586 W, L 1724 W, L 862 W, L 0+00 and L 862 E), the lines were 862 feet apart. Exceptions to the above 800 foot interval were the points 1400 south on L 862 E, 1200 and 800 north on L 0+00, and 300 north on L 862 W. The sampling points are marked on figure 62.

Species collected and analyzed - The trees, Black Spruce and American Larch (*Larix laricina* (DuRoi) K. Koch) were usually present in all parts of the bog. Twigs of both species were collected. The 2 year - old stems of Black Spruce and stems (2 to 4 years - old) of Larch were analyzed. The stems and leaves of the shrub Leather-leaf (*Chamaedaphne calyculata* (L.) Moench var. *latifolia* (Ait.) Fern.) were collected. The leaves and stems (2 years - old) of Leather-leaf were analyzed.

All the plant samples were analyzed for copper, zinc, lead and nickel. The metal contents are expressed in parts per million on the basis of the air - dried weight (ppm - dry wt.)

and in parts per million on the basis of the ash weight (ppm - ash). The copper:zinc ratio and the percentage ash of each sample were calculated. Only the ppm - dry wt. figures are used here, except for the ppm - ash of Black Spruce given for comparison.

Zinc - The zinc contents of each species are plotted on plant association maps in figures 63 to 66.

The zinc contents of each species are contoured in figures 68 to 72. The zinc contents of Black Spruce are given in ppm - ash in figure 69. The ppm - ash and ppm - dry wt. contour maps show corresponding contours. There seems to be no one pattern for all contour maps but in figures 68, 69 and 71, a high area occurs in the south and east central parts of the bog.

The profiles of figures 73 and 74 show the varying response of each species at the same sampling point. Exceptions are noted however, in figure 73, at L 862 W, 4000 S, and figure 74, at L 0+00, 800 S, where all species record low values at the same location.

The histograms of figure 75, e to h, show normal patterns for each species.

Copper - The copper contents of each species are plotted on plant association maps in figures 77 to 80.

The copper contents of each species contoured in figures 82 to 86. The copper contents of Black Spruce in ppm -

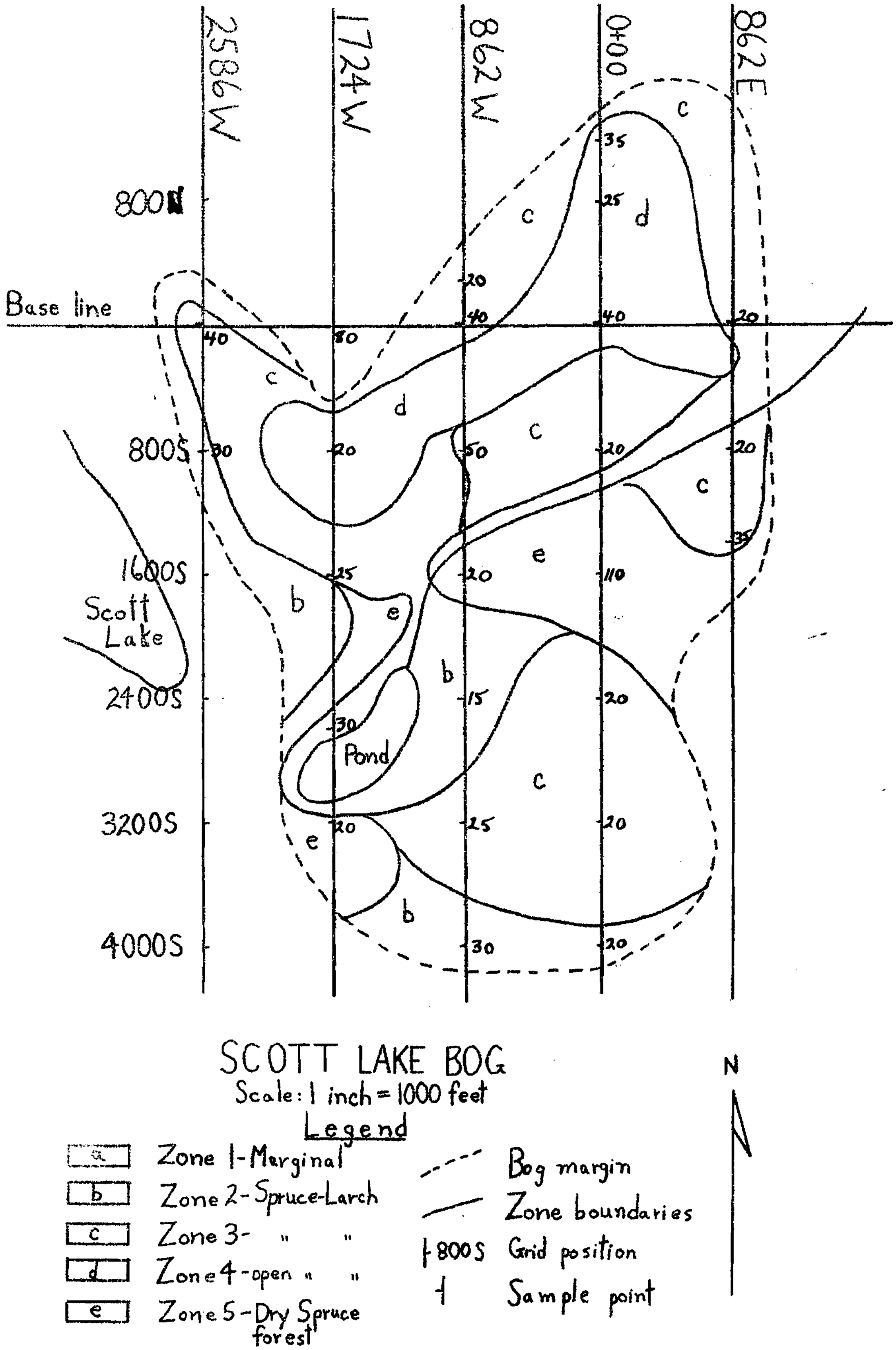


Figure 62. Zinc content of surface peats in ppm - dry wt.

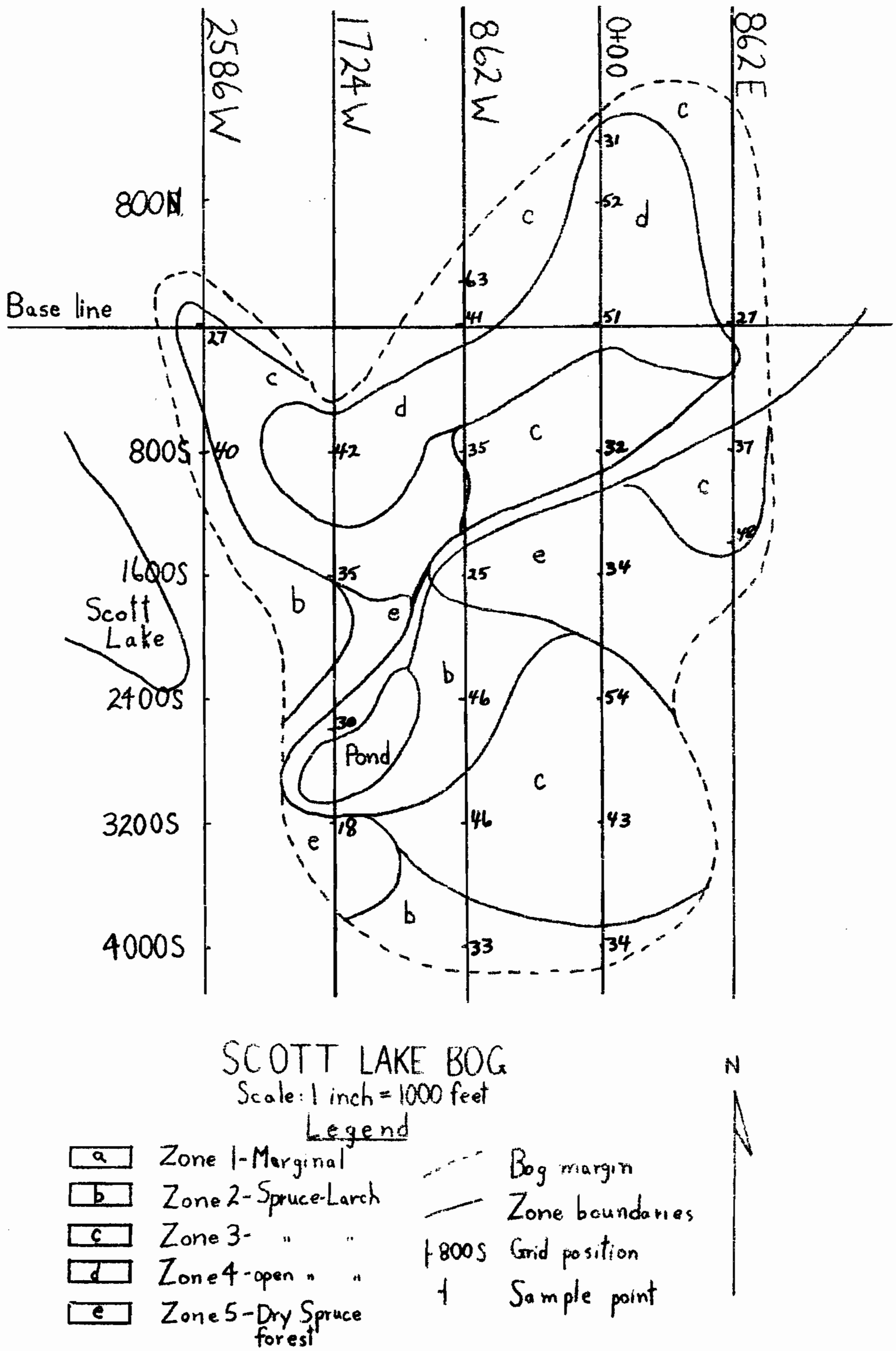


Figure 63. Zinc content of Black Spruce stems (2 yr. old) in ppm - dry wt.

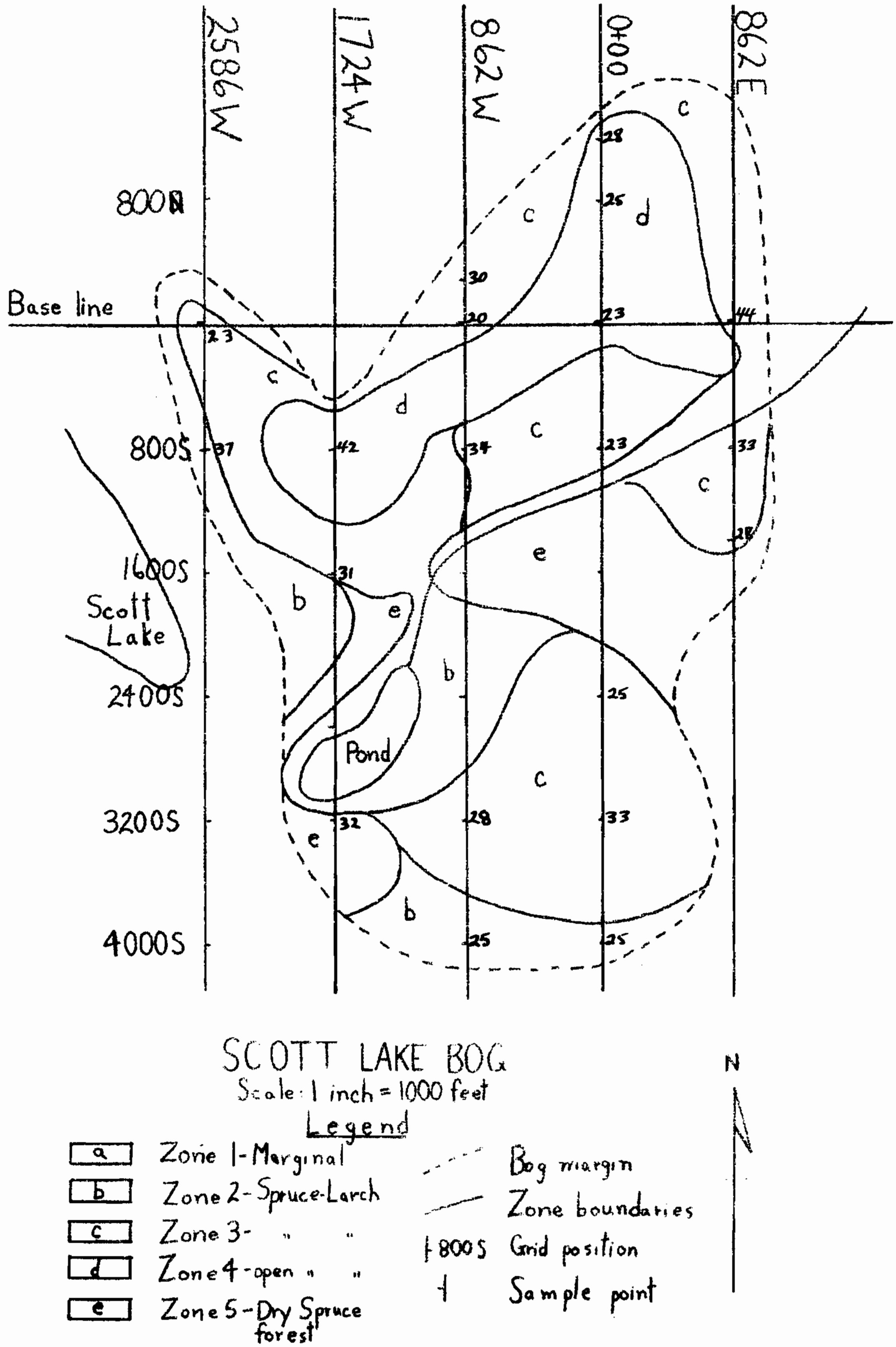


Figure 64. Zinc content of Larch stems

(2 - 4 yr. old) in ppm. - dry wt.

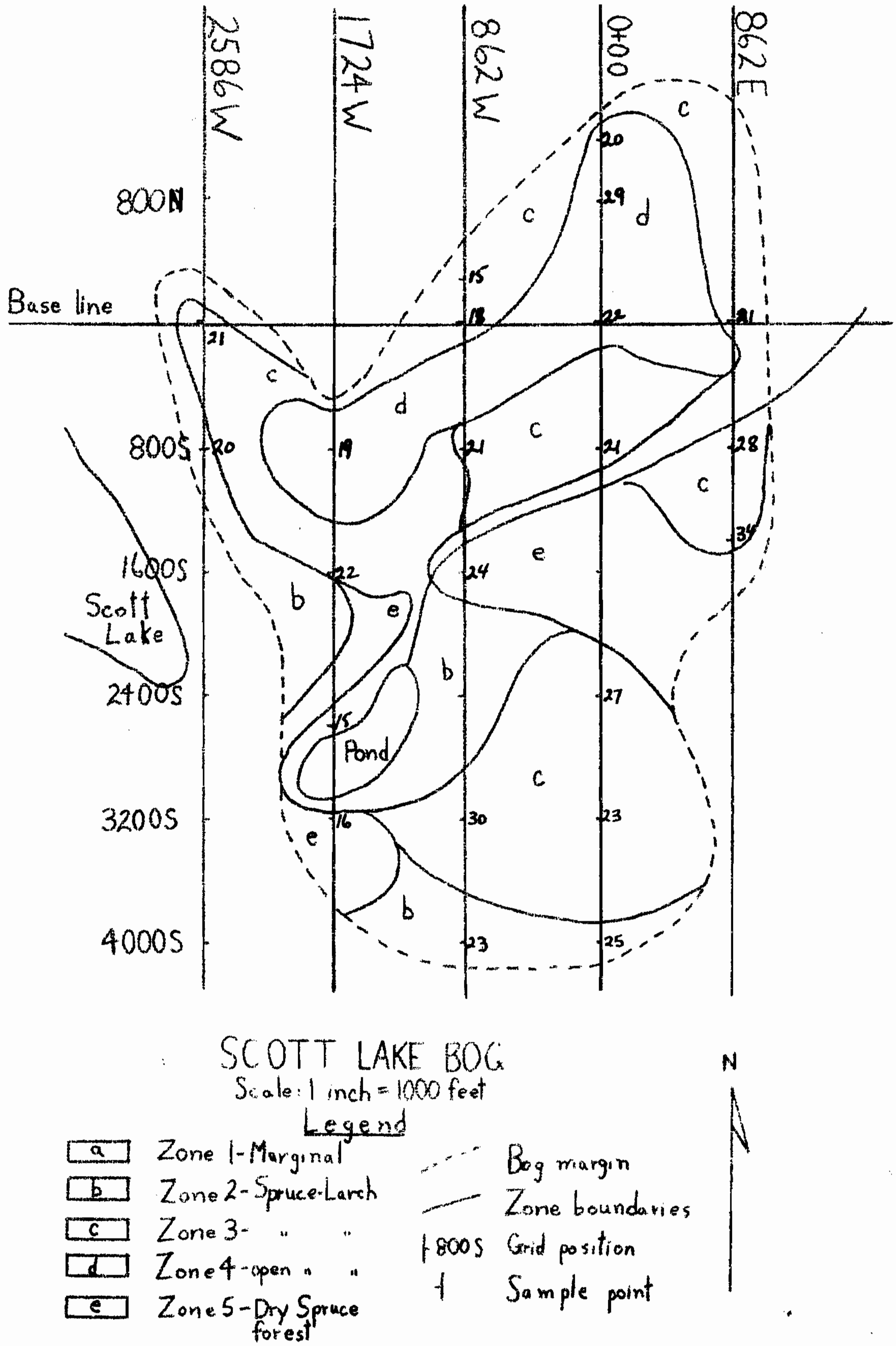


Figure 65. Zinc content of Leather-leaf stems (2 yr. old) in ppm - dry wt.

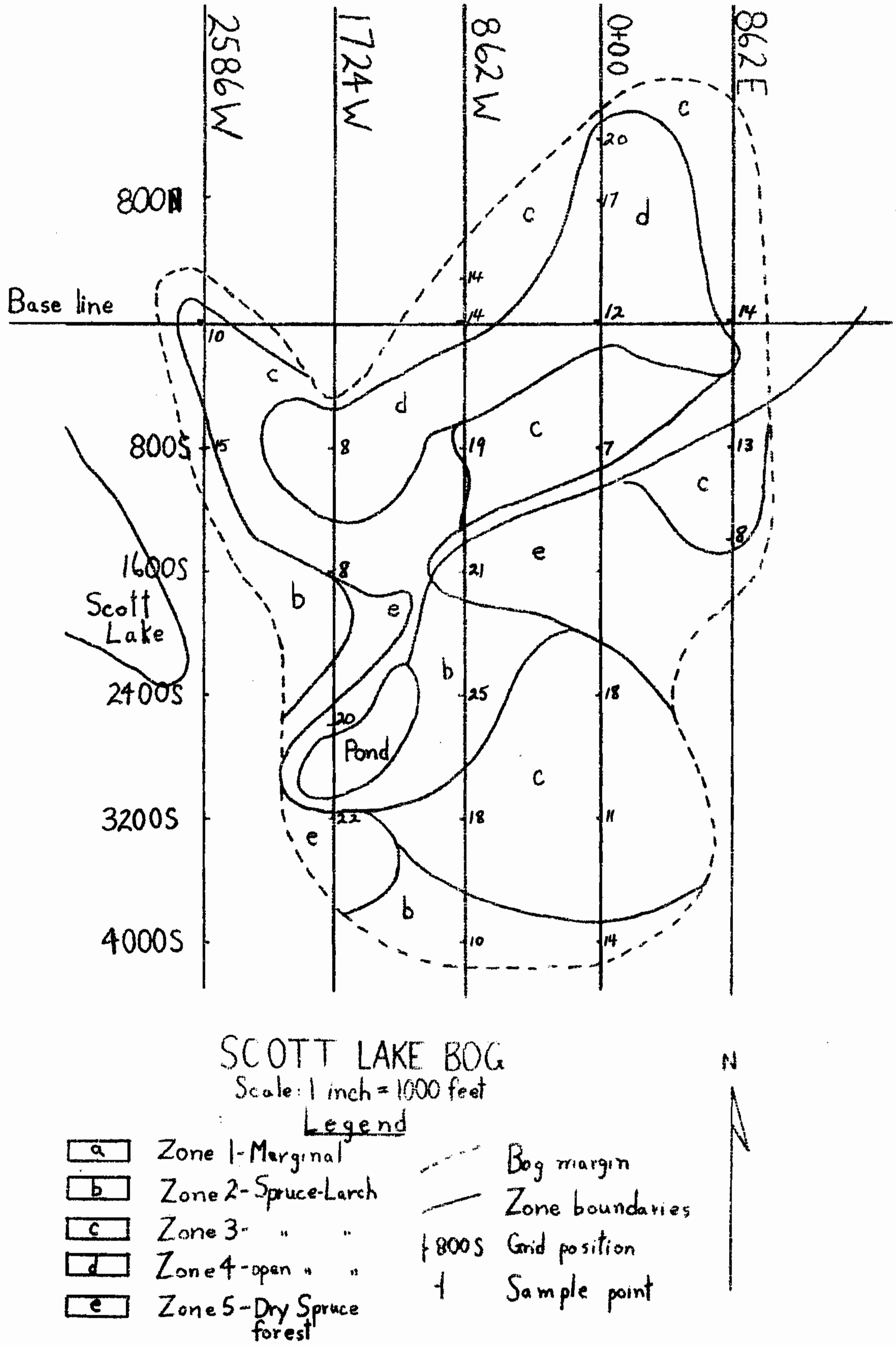


Figure 66. Zinc content of Leather-leaf leaves in ppm - dry wt.

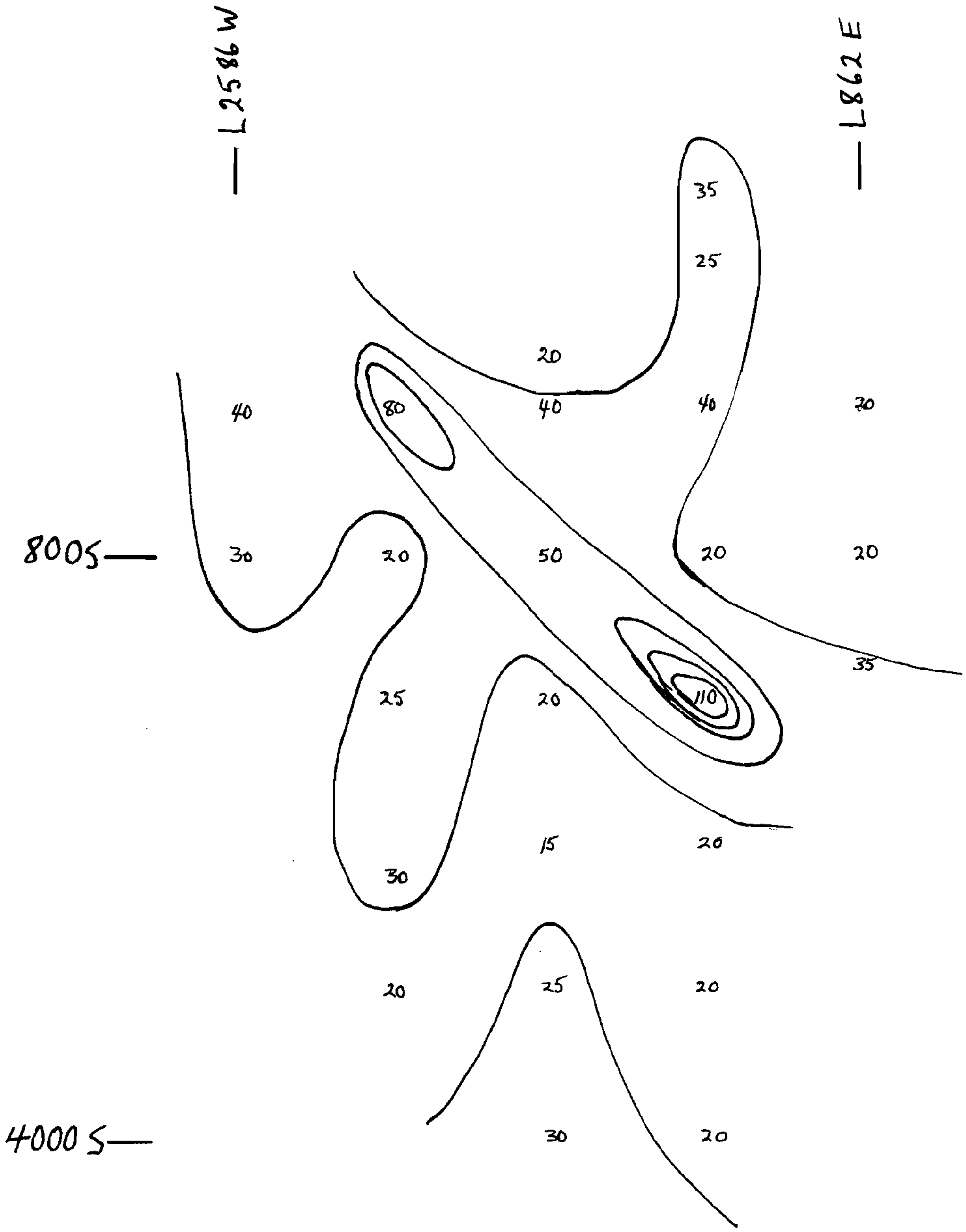


Figure 67. SCOTT LAKE BOG - Contour map
Contour interval - 20 ppm (21-40)
Zinc content of surface peats
in ppm - dry wt.

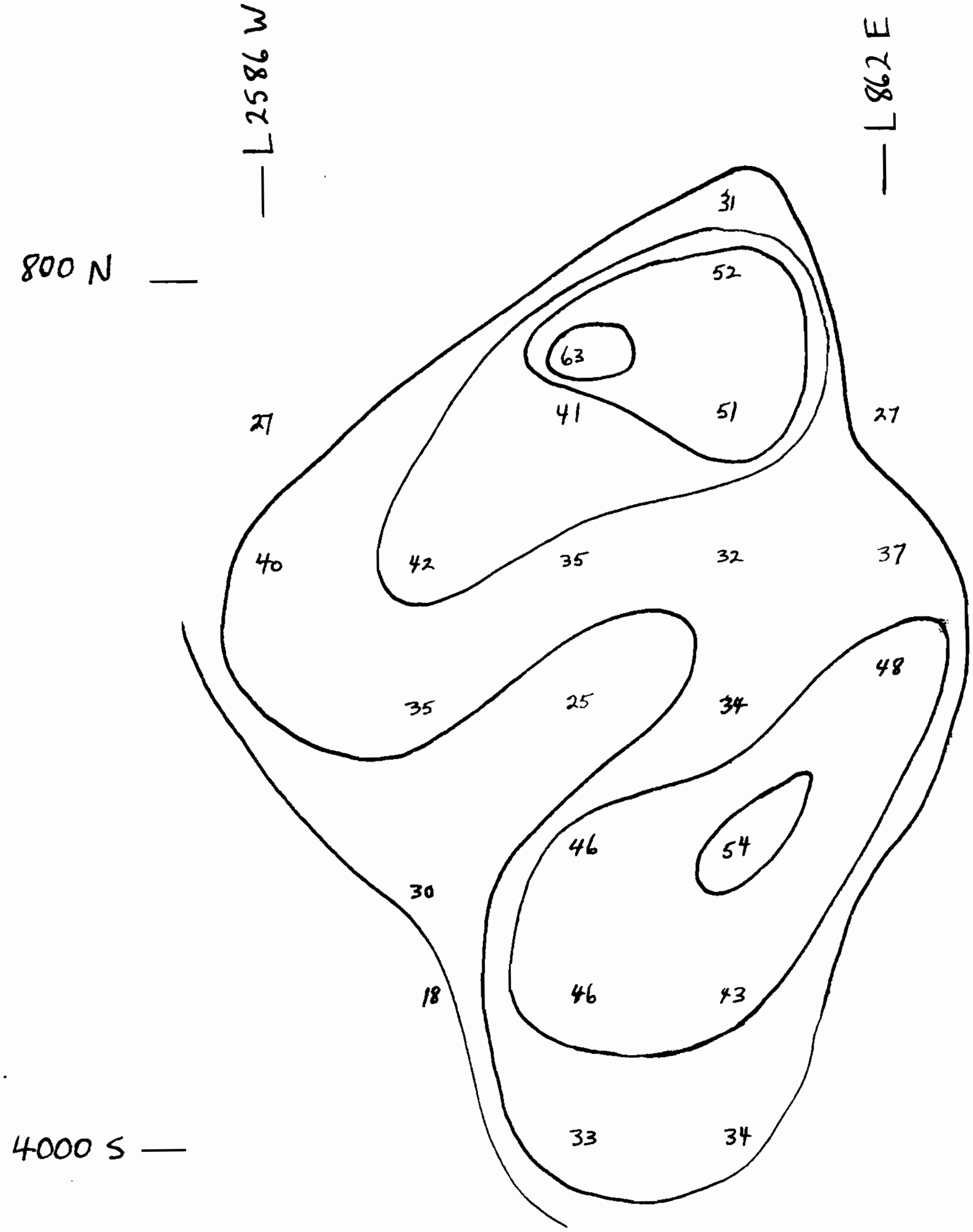


Figure 68. SCOTT LAKE BOG - Contour map

Contour interval 10 ppm (11-20)

Zinc content of Black Spruce

stems (2 yr. old) in ppm - dry wt.

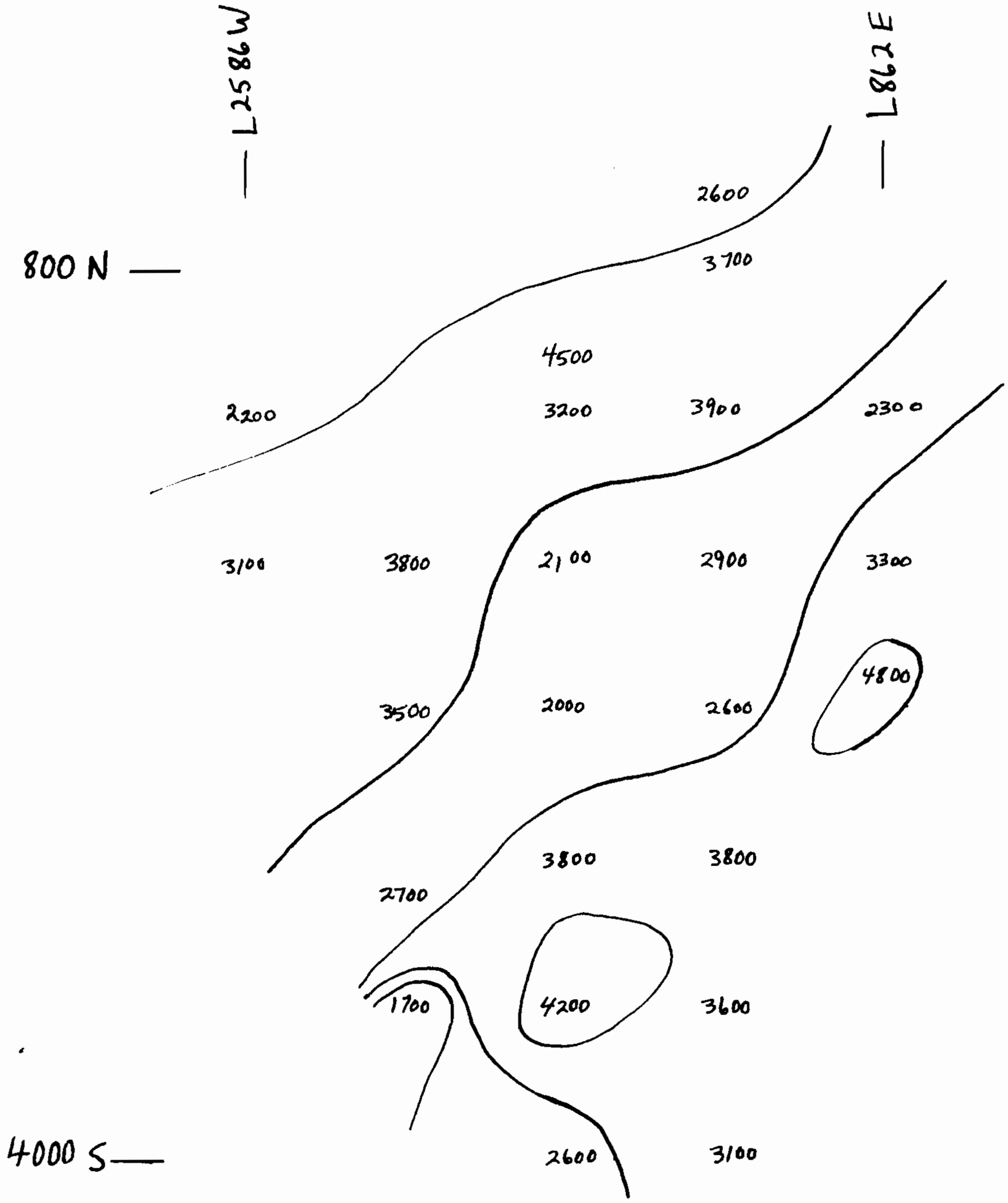


Figure 69. SCOTT LAKE BOG - Contour map
Contour interval - 1000 ppm (1001-2000)
Zinc content of Black Spruce
stems (2 yr. old) in ppm - ash.

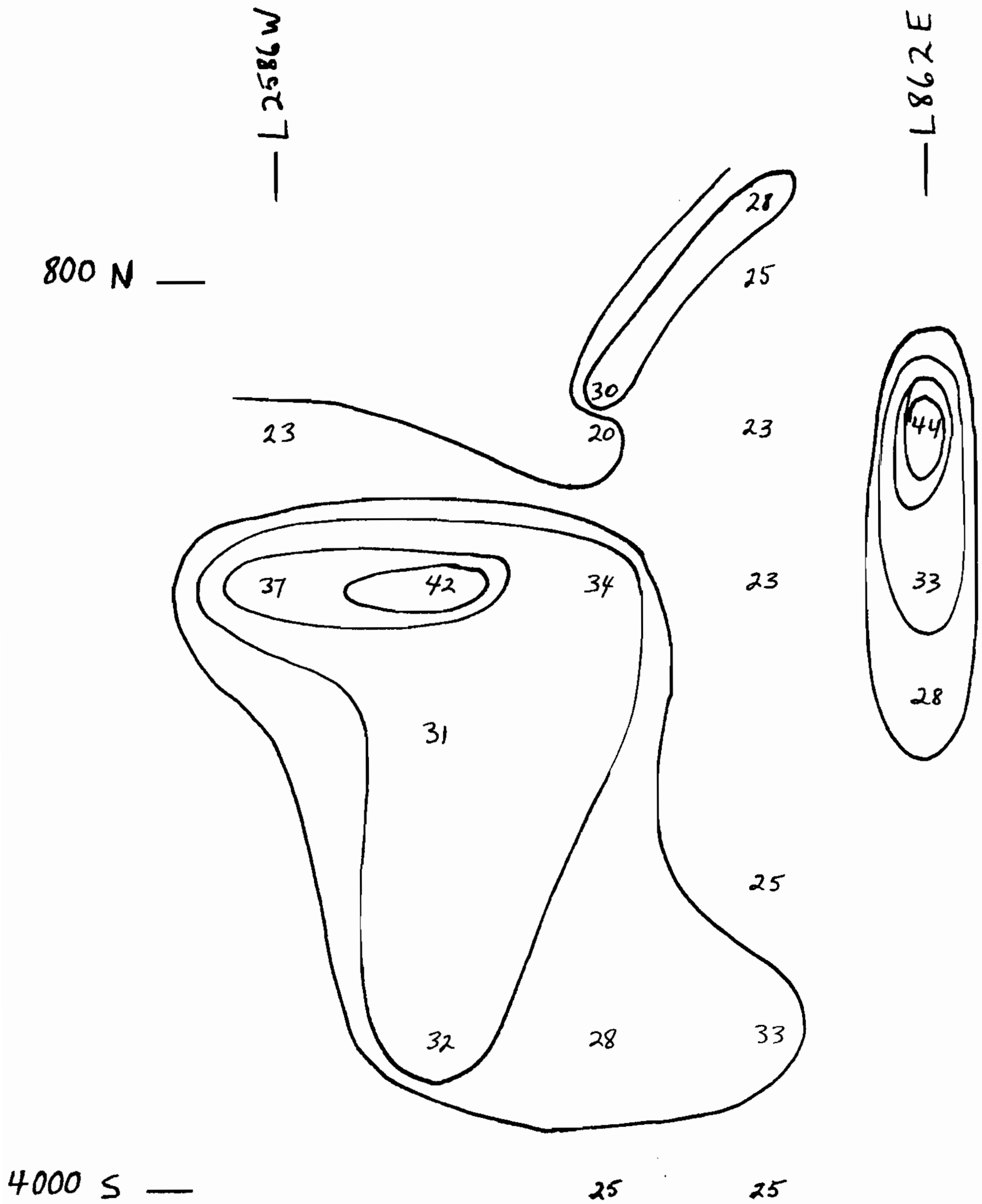


Figure 70. SCOTT LAKE BOG - Contour map

Contour interval - 5 ppm (21-25)

Zinc content of Larch stems

(2 - 4 yr. old) in ppm - dry wt.

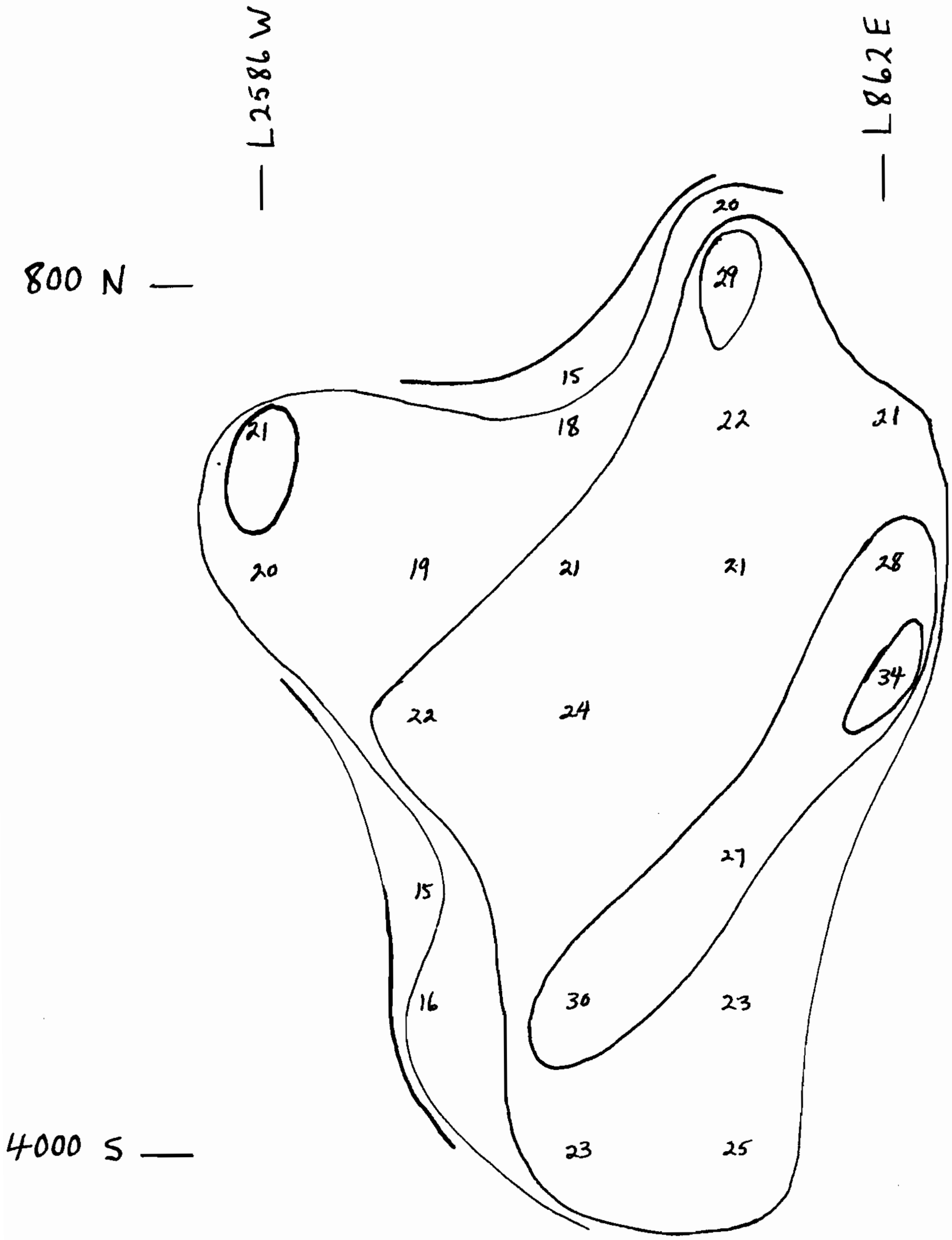


Figure 71. SCOTT LAKE BOG - Contour map

Contour interval - 5 ppm (21-25)

Zinc content of Leather-leaf

stems (2 yr. old) in ppm - dry wt.

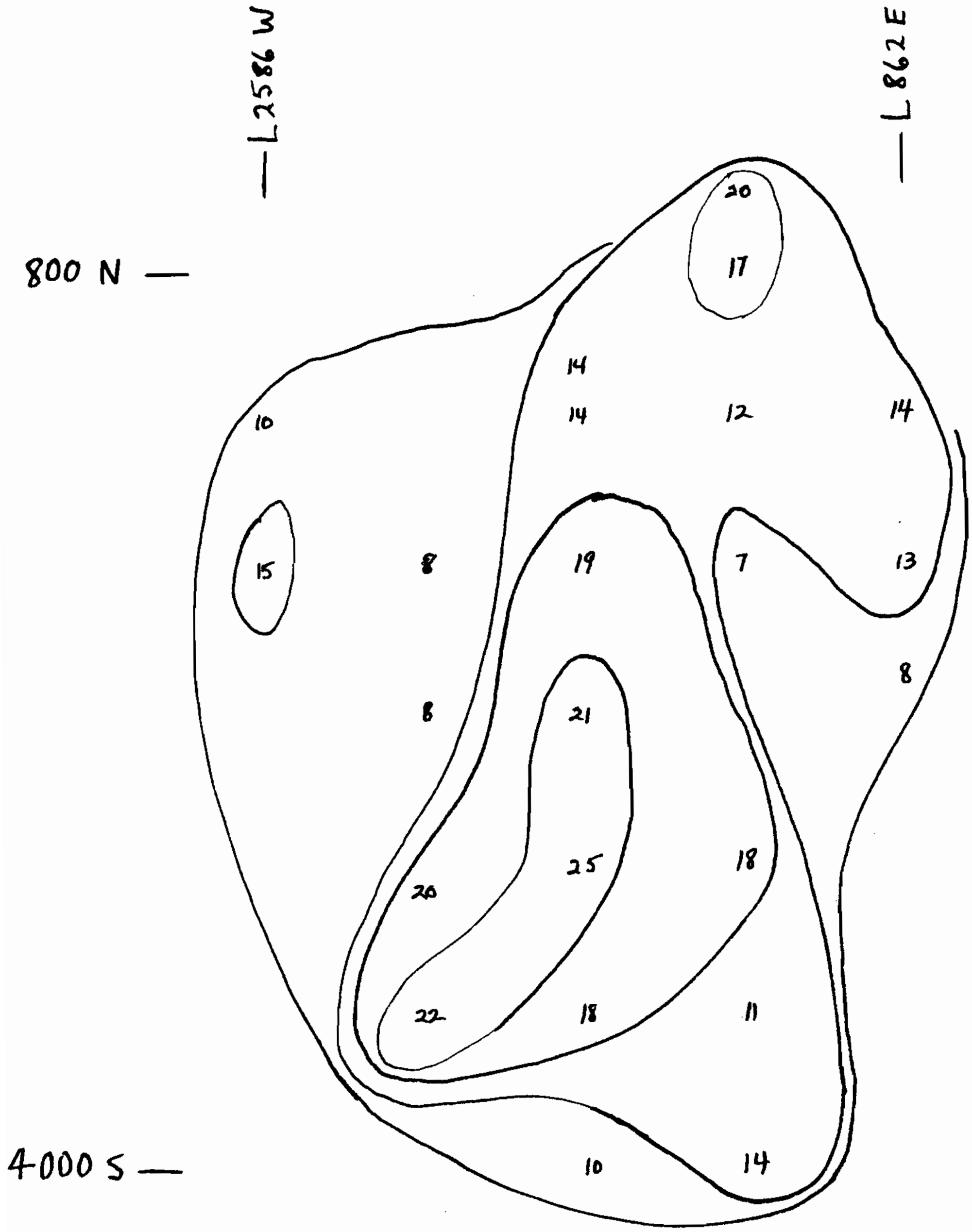


Figure 72. SCOTTLAKE BOG - Contour map
Contour interval - 5 ppm (21-25)
Zinc content of Leather-leaf
leaves in ppm - dry wt.

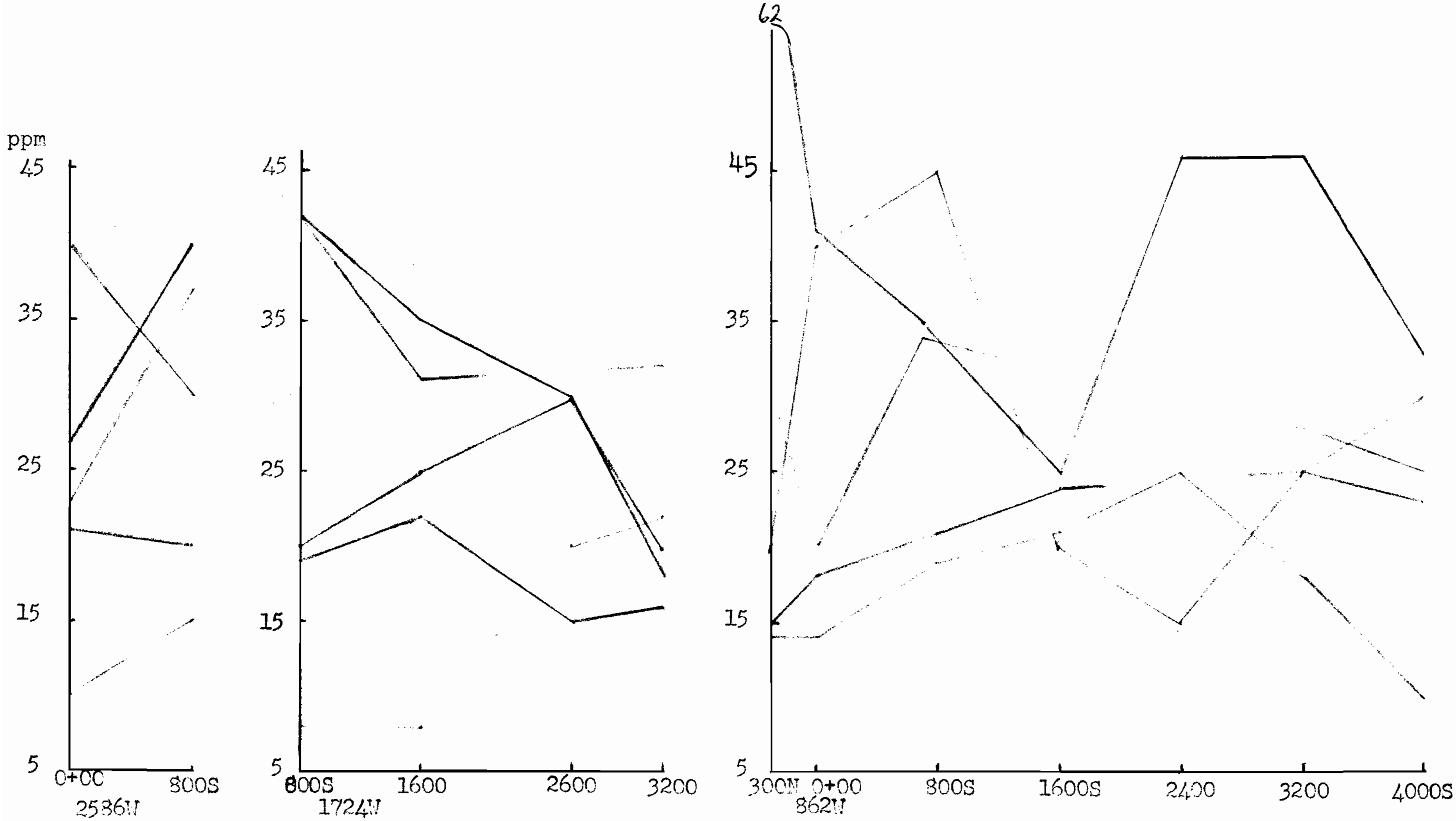


Figure 73. SCOTT LAKE BOG - Profile graphs - Lines 2586W, 1724W, and 862W
Zinc contents in ppm - dry wt.
Scales: Vertical 1 in.= 10 ppm; Horizontal 1 in.= 1000 feet

— Black Spruce stems (2 yr. old)
-- Larch stems (2 - 4 yr. old)
- Surface peats
— Leather-leaf leaves
— Leather-leaf stems (2 yr. old).

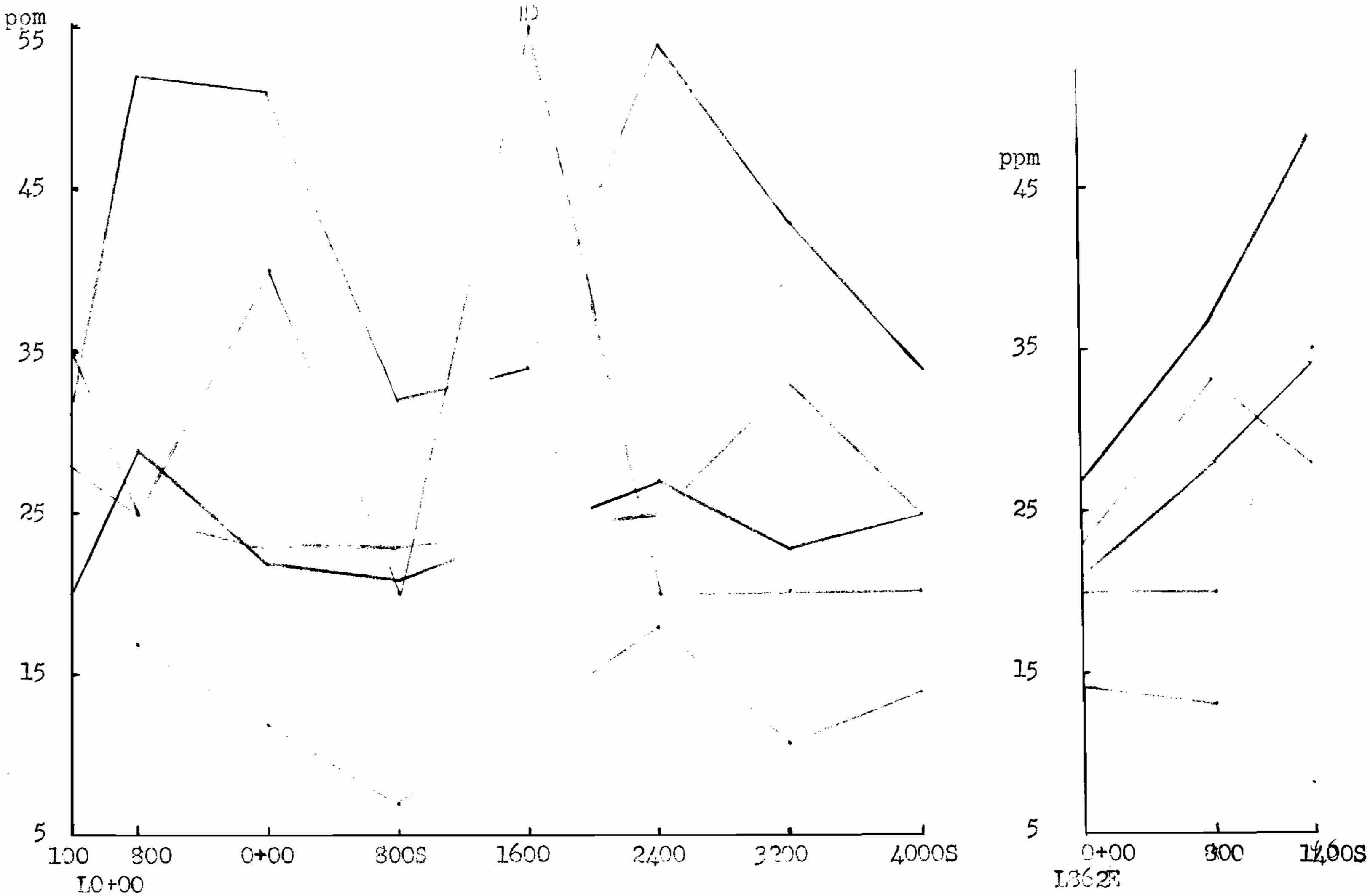


Figure 74. SCOTT LAKE BOG - Profile graphs - Lines 0+00 and 862E
Zinc contents in ppm - dry wt.
Scales: Vertical 1 in. = 10 ppm; Horizontal 1 in. = 1000 feet

— Black Spruce stems (2 yr. old)
— Larch stems (2 - 4 yr. old)
— Surface peats
— Leather-leaf leaves
— Leather-leaf stems (2 yr. old)

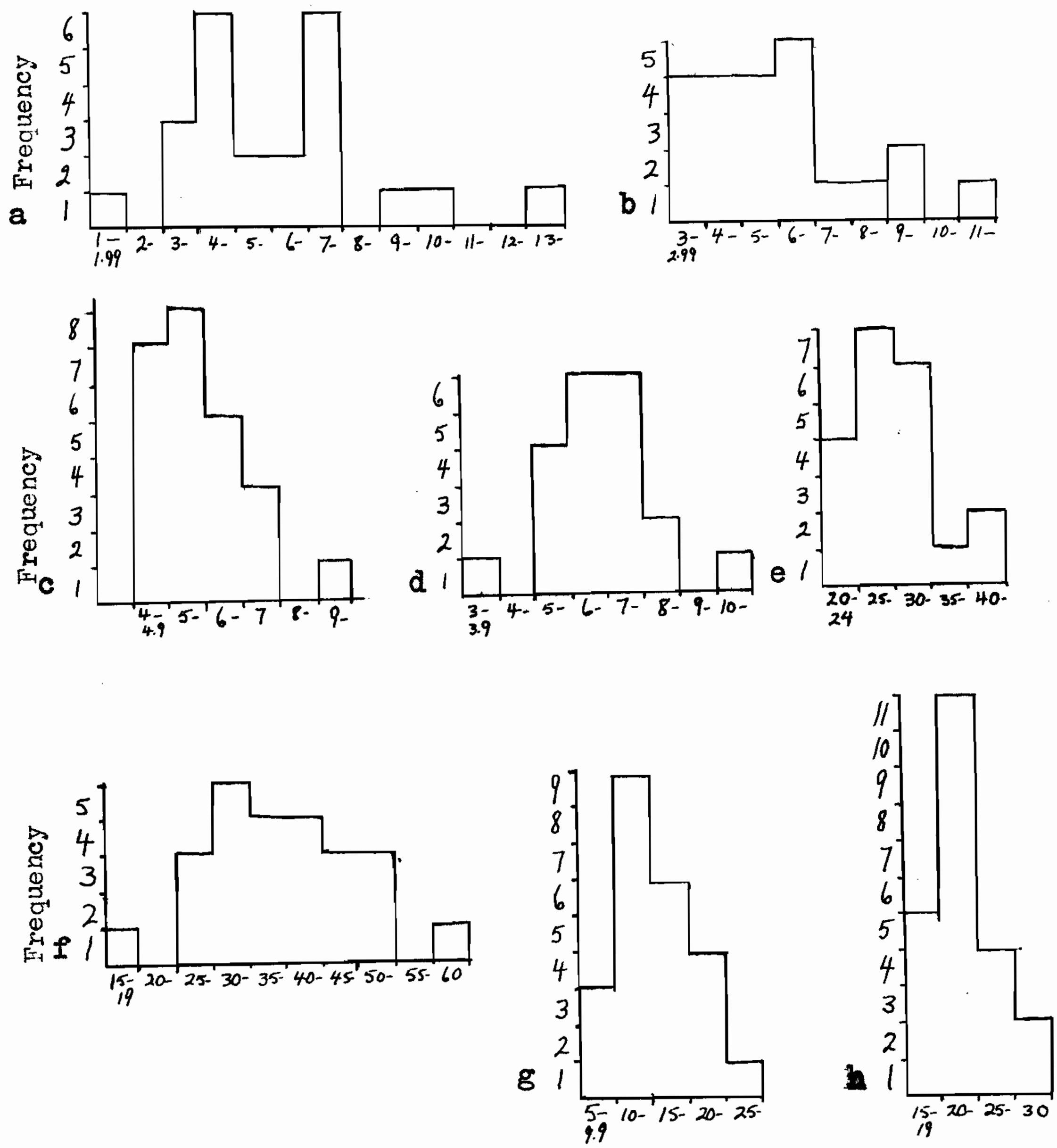


Figure 75. Histograms of Copper (a - d) and Zinc (e - h) contents (ppm - dry wt.) of plant samples from Scott Lake Bog.

	Interval
(a) Leather-leaf leaves	1 ppm
(b) Leather-leaf stems (2 yr. old)	1 ppm
(c) Black Spruce stems (2 yr. old)	1 ppm
(d) Larch stems (2-4 yr. old)	1 ppm
(e) Larch stems (2-4 yr. old)	5 ppm
(f) Black Spruce stems (2 yr. old)	5 ppm
(g) Leather-leaf leaves	5 ppm
(h) Leather-leaf stems (2 yr. old)	5 ppm

ash are given in figure 83. The correlation with ppm - dry wt. is not so obvious as with the zinc contents.

Figure 87 gives the profiles of the copper contents for each species. There is some correlation between species, particularly on lines 2586 W, 1724 W and 0+00.

The histograms of the copper contents of each species are given in figure 75, a to d. The shapes are all normal except that of Leather-leaf leaves which has two close peaks.

Cu:Zn ratio - The profile graphs of the Cu:Zn ratios for each species are plotted in figure 88. The values are similar at a few locations, such as L 1724 W, 800 S and 1600 S, L 862 W, 3200 S and 4000 S, L 0+00, 800 S, 3200 S and 4000 S.

The histograms of the Cu:Zn ratios in figure 89 are normal for each species except possibly the leaves of Leather-leaf. This histogram is similar to that for copper content (figure 75a).

Lead - The lead contents of each species are plotted on plant association maps in figures 91 to 94.

The lead contents of each species are contoured in figures 96 to 100. The lead contents of Black Spruce in ppm - dry wt. and ppm - ash are closely correlated (figures 96 and 97.) The contour maps show higher lead values for each species along the east side of the bog.

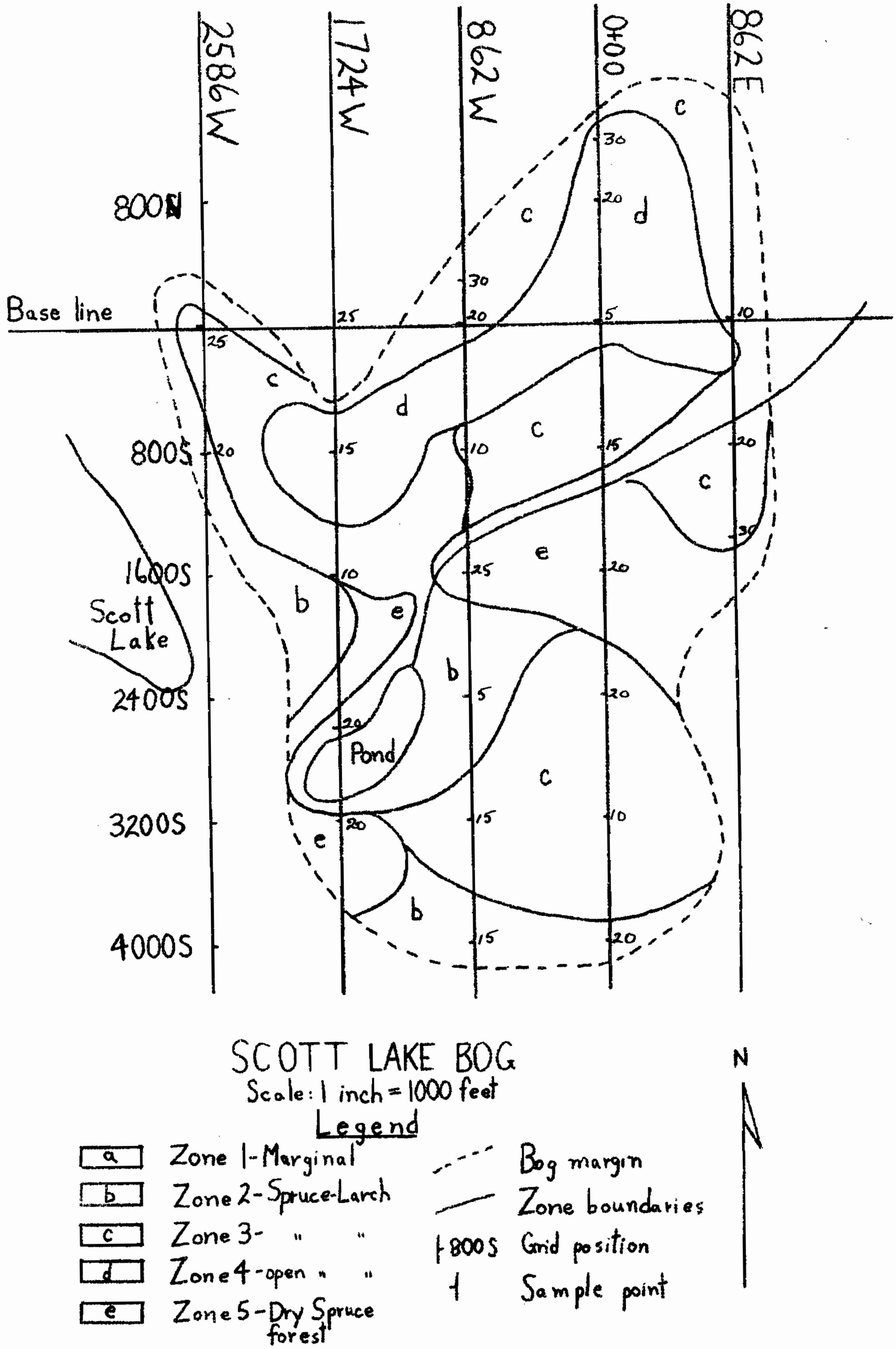


Figure 76. Copper content of surface peats

in ppm - dry wt.

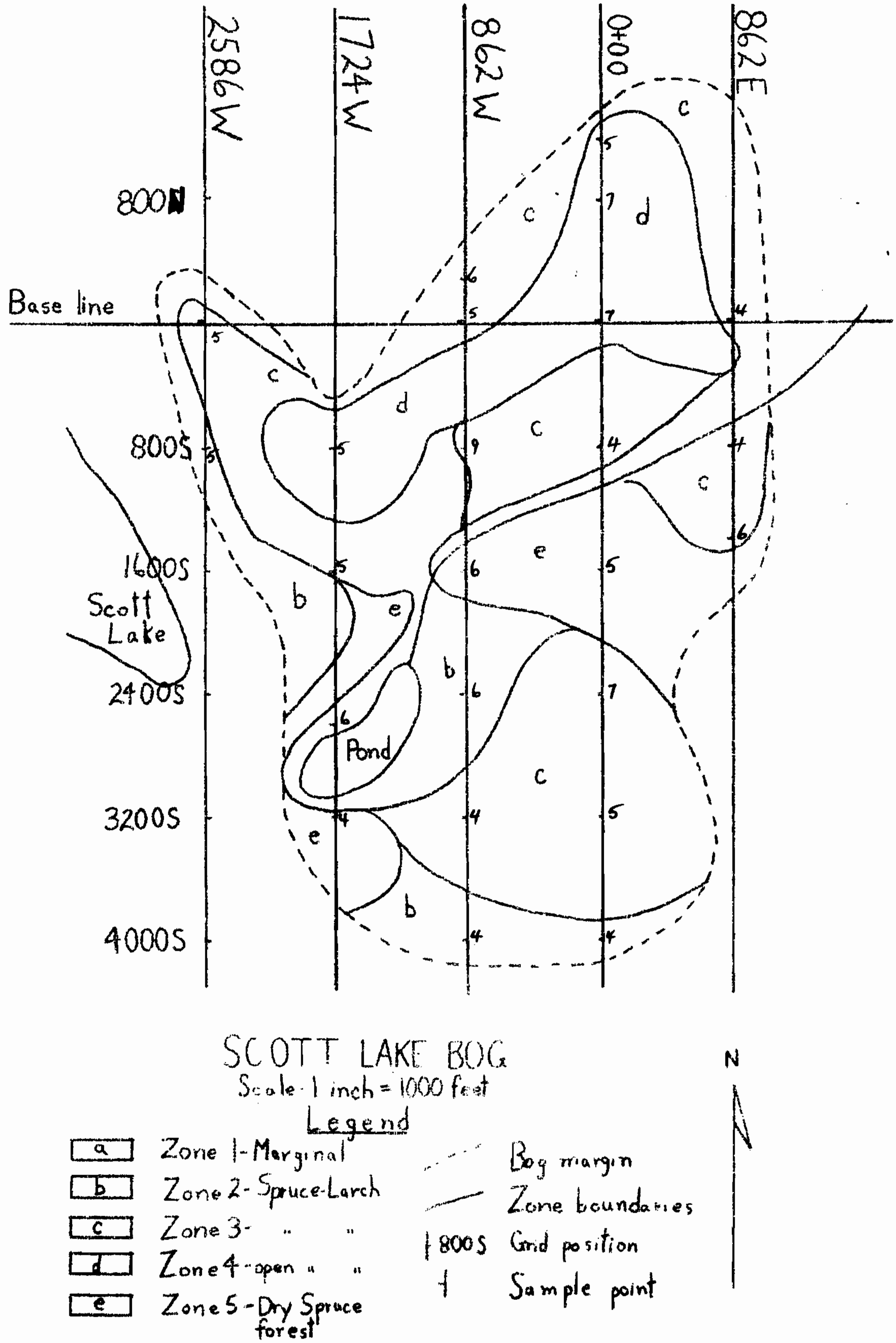


Figure 77. Copper content of Black Spruce stems (2 yr. old) in ppm - dry wt.

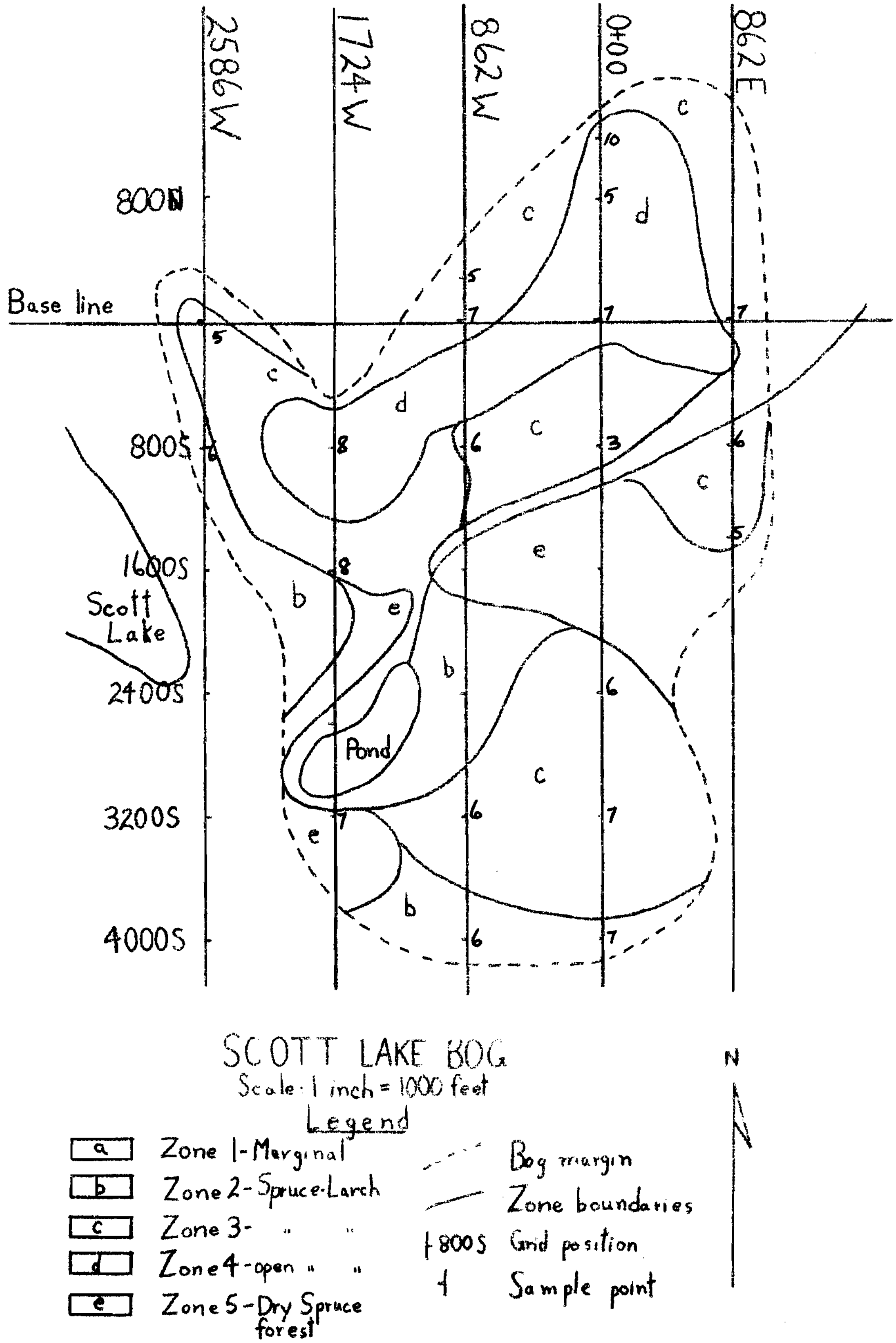


Figure 78. Copper content of Larch stems (2 - 4 yr. old) in ppm - dry wt.

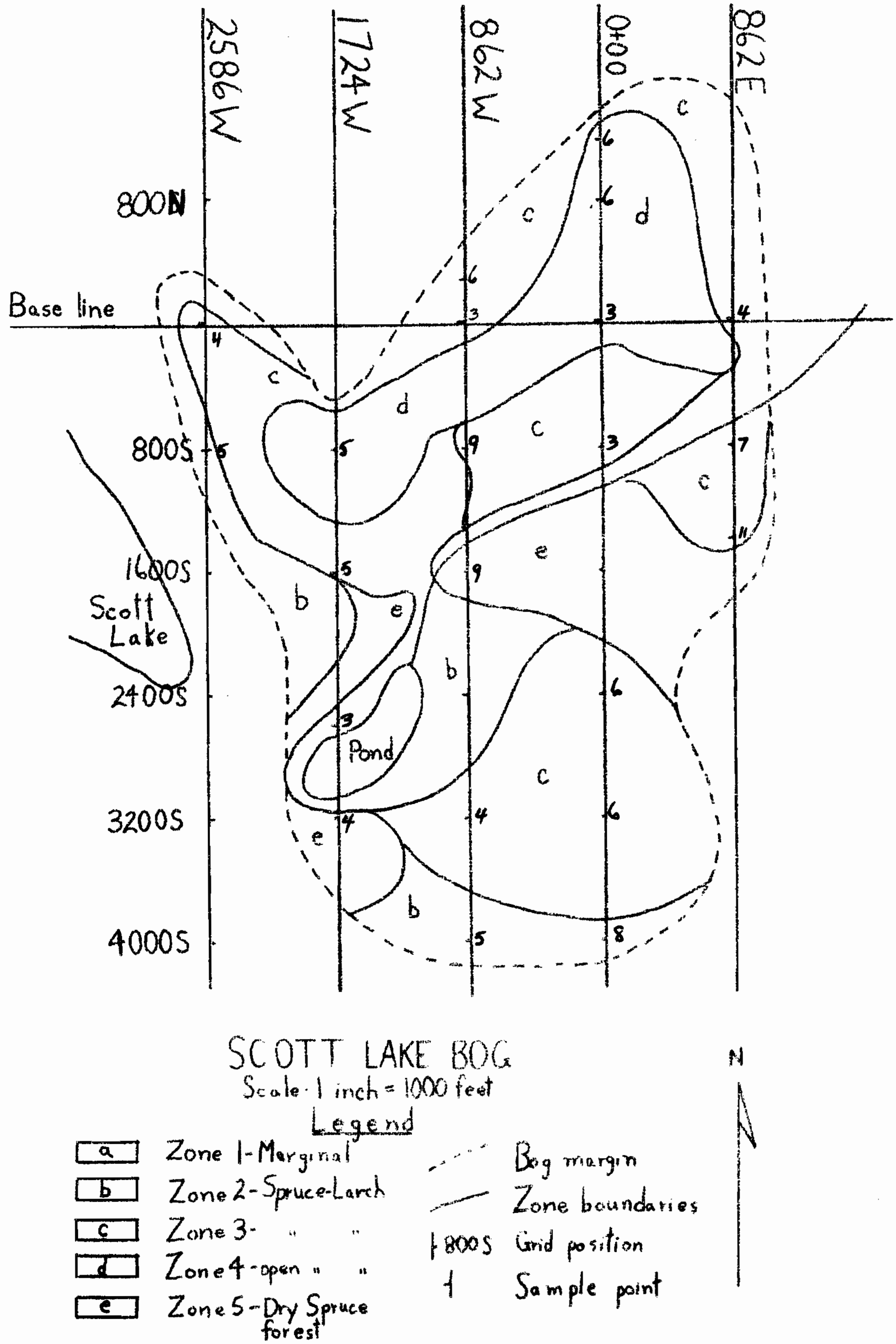


Figure 79. Copper content of Leather-leaf stems (2 yr. old) in ppm - dry wt.

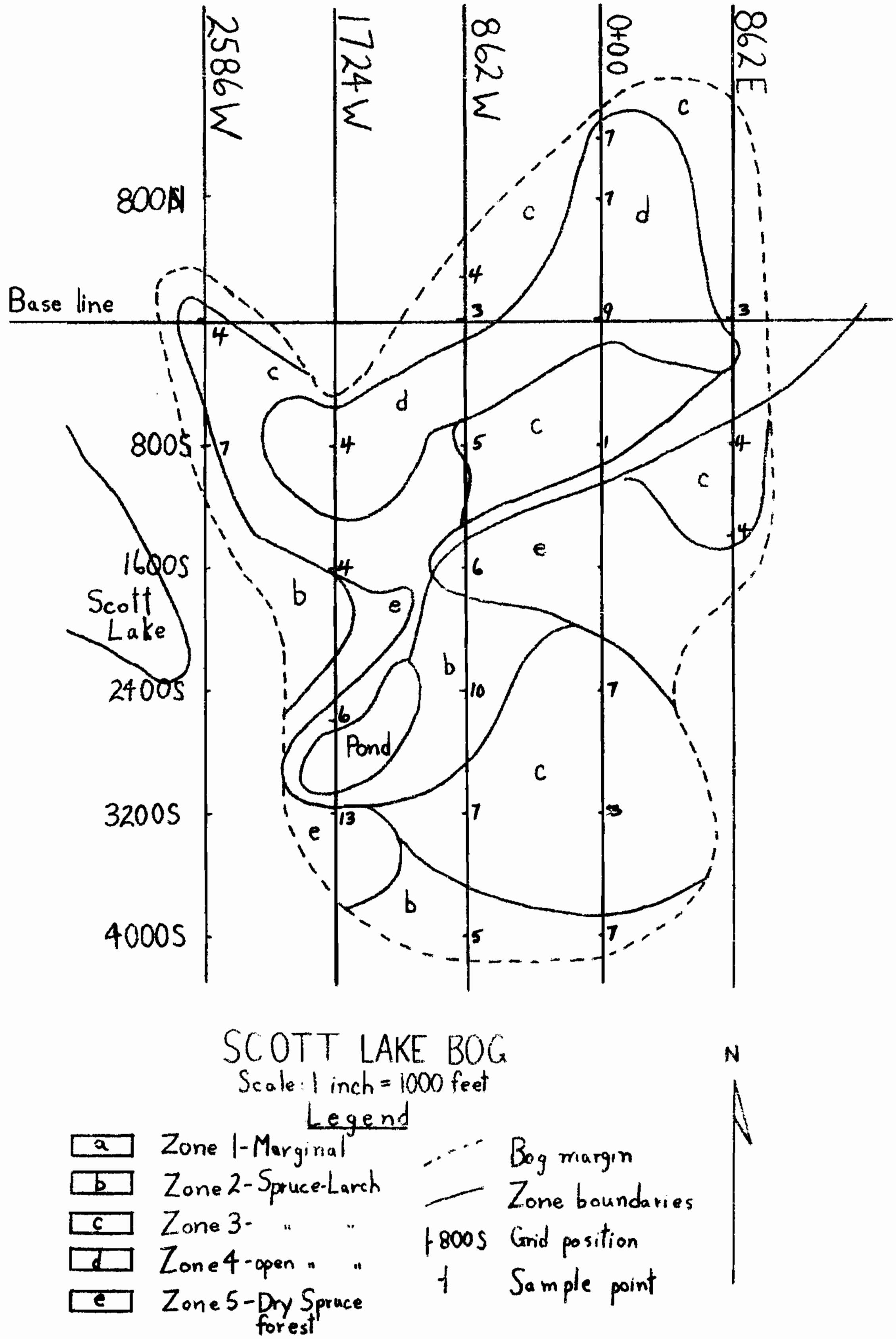


Figure 80. Copper content of Leather-leaf leaves in ppm - dry wt.

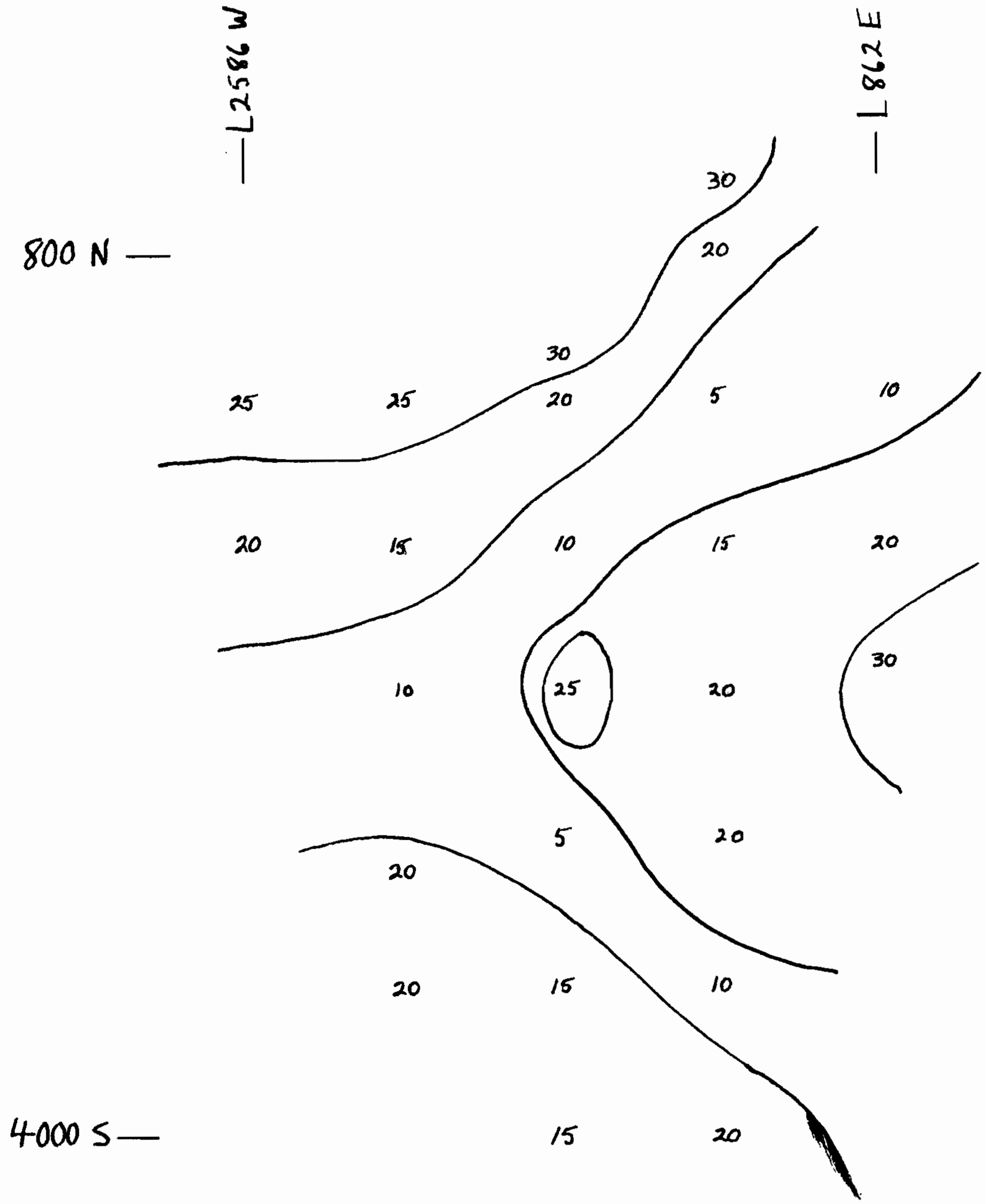


Figure 81. SCOTT LAKE BOG - Contour map
Contour interval - 10 ppm (11-20).
Copper content of surface peats
in ppm - dry wt.

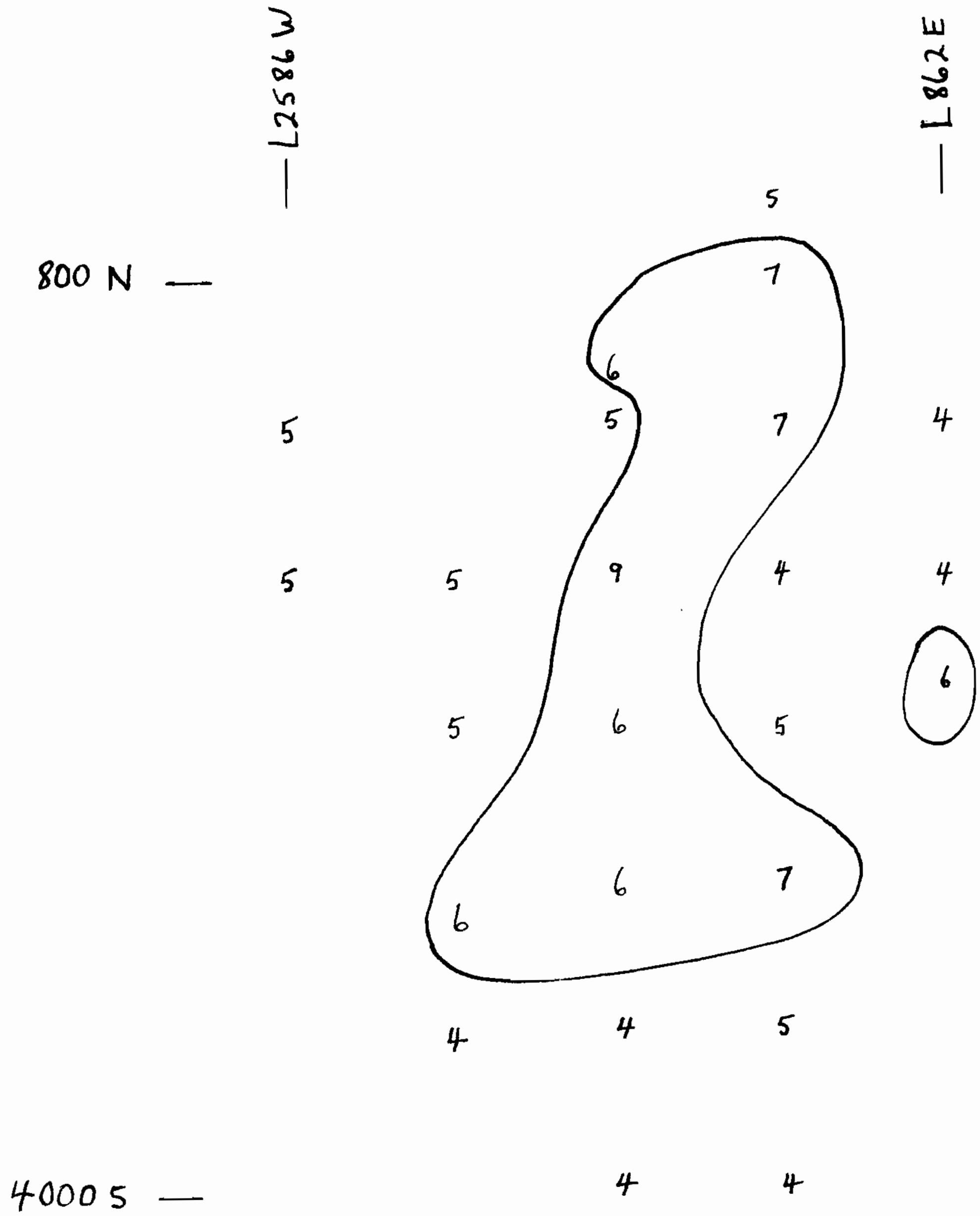


Figure 82. SCOTT LAKE BOG - Contour map
Contour interval - 5 ppm (6-10).
Copper content of Black Spruce
stems (2 yr. old) in ppm - dry wt.

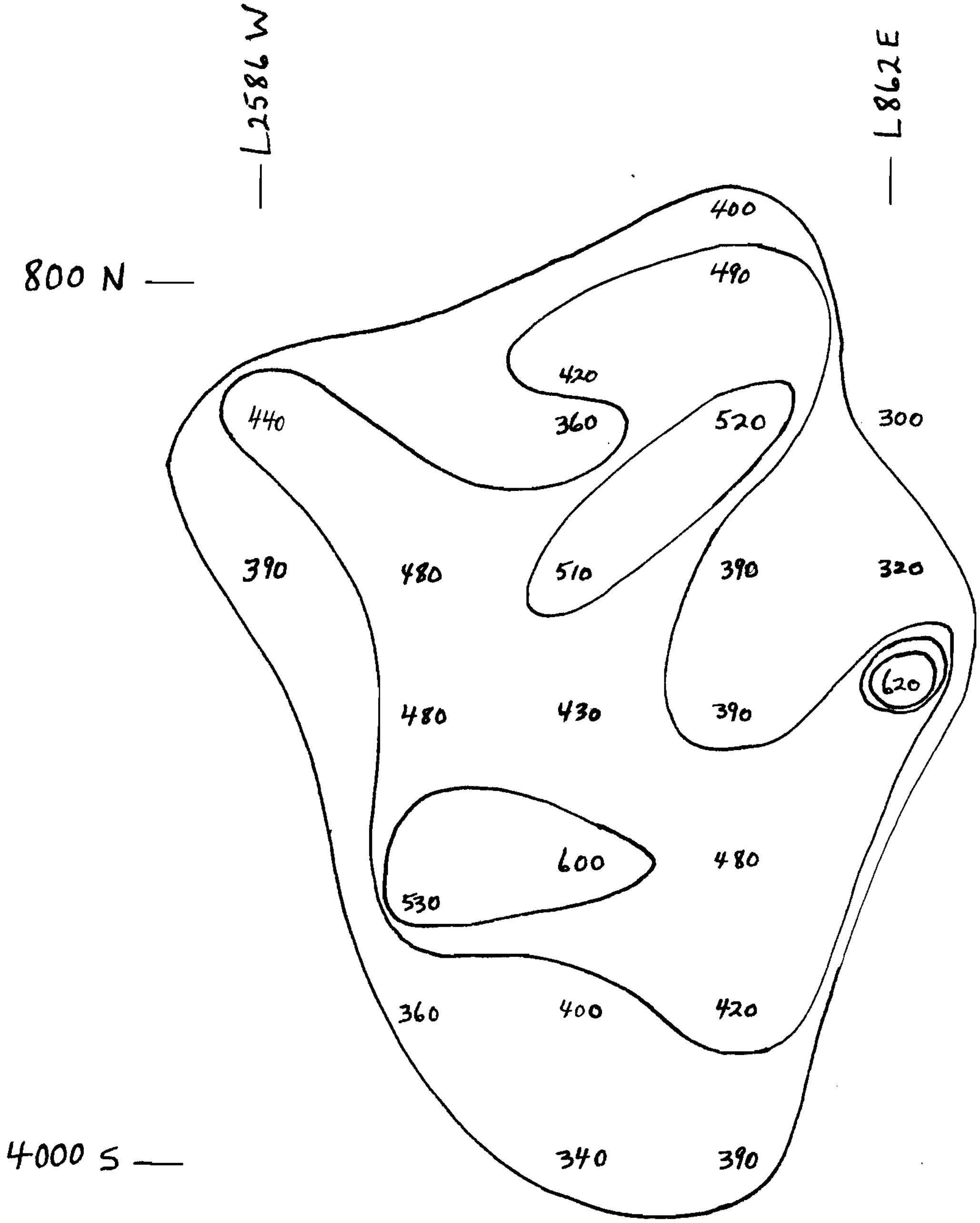


Figure 83. SCOTT LAKE BOG - Contour map
Contour interval - 100 ppm (101-200)
Copper content of Black Spruce
stems (2 yr. old) in ppm - ash.

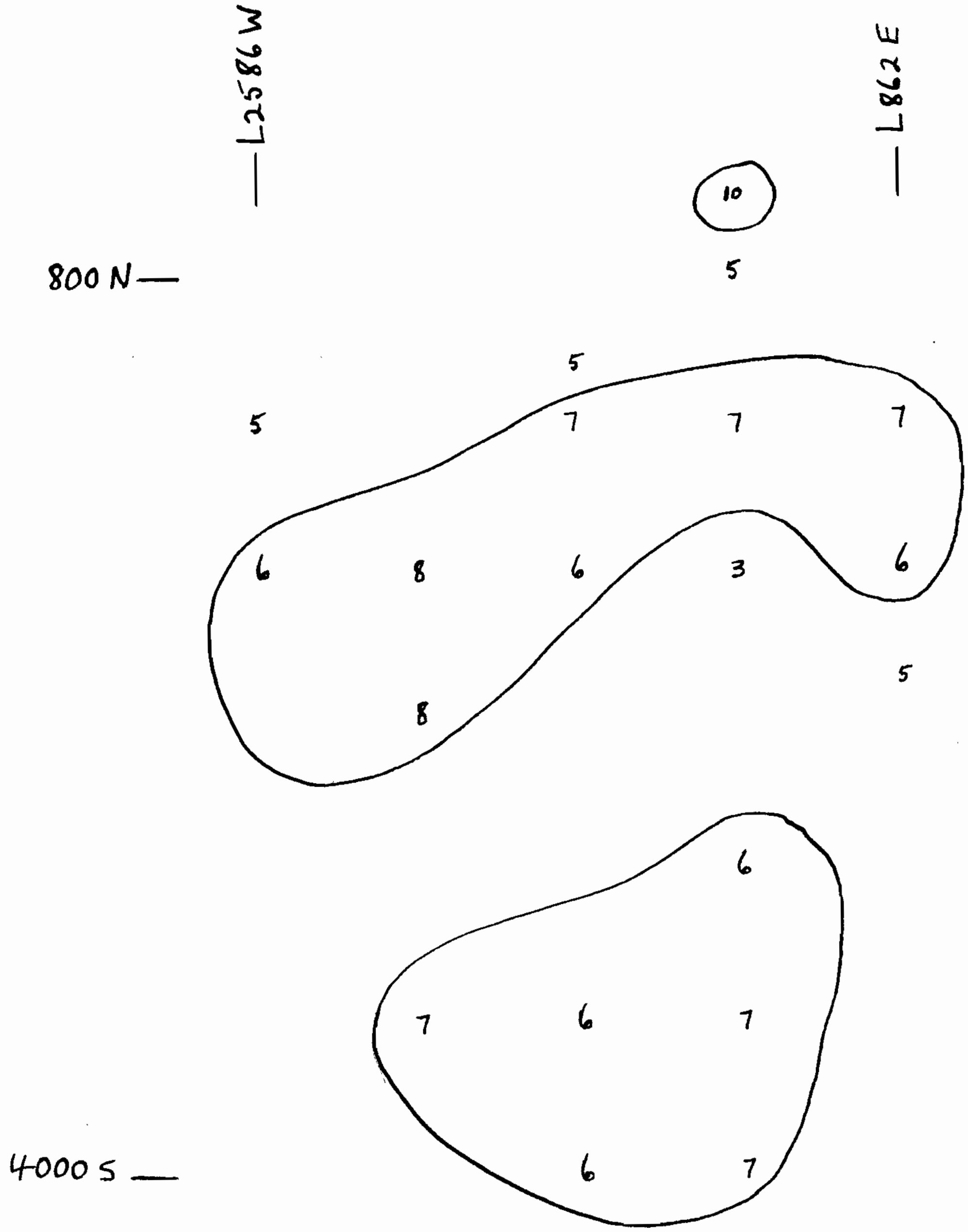


Figure 84. SCOTT LAKE BOG - Contour map
Contour interval - 5 ppm (6-10)
Copper content of Larch stems
(2 - 4 yr. old) in ppm - dry wt.

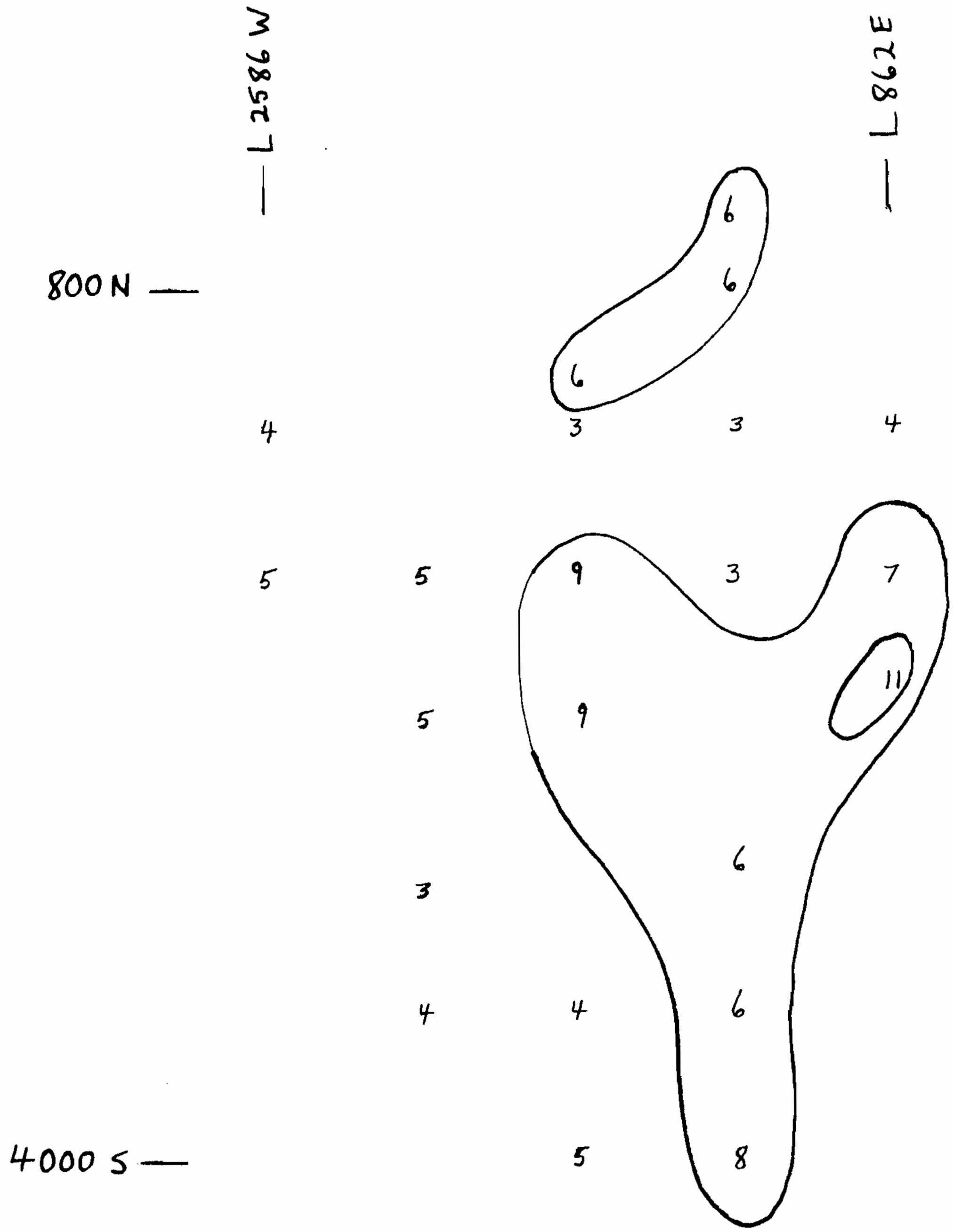


Figure 85. SCOTT LAKE BOG - Contour map
Contour interval - 5 ppm (6-10)
Copper content of Leather-leaf
stems (2 yr. old) in ppm - dry wt.

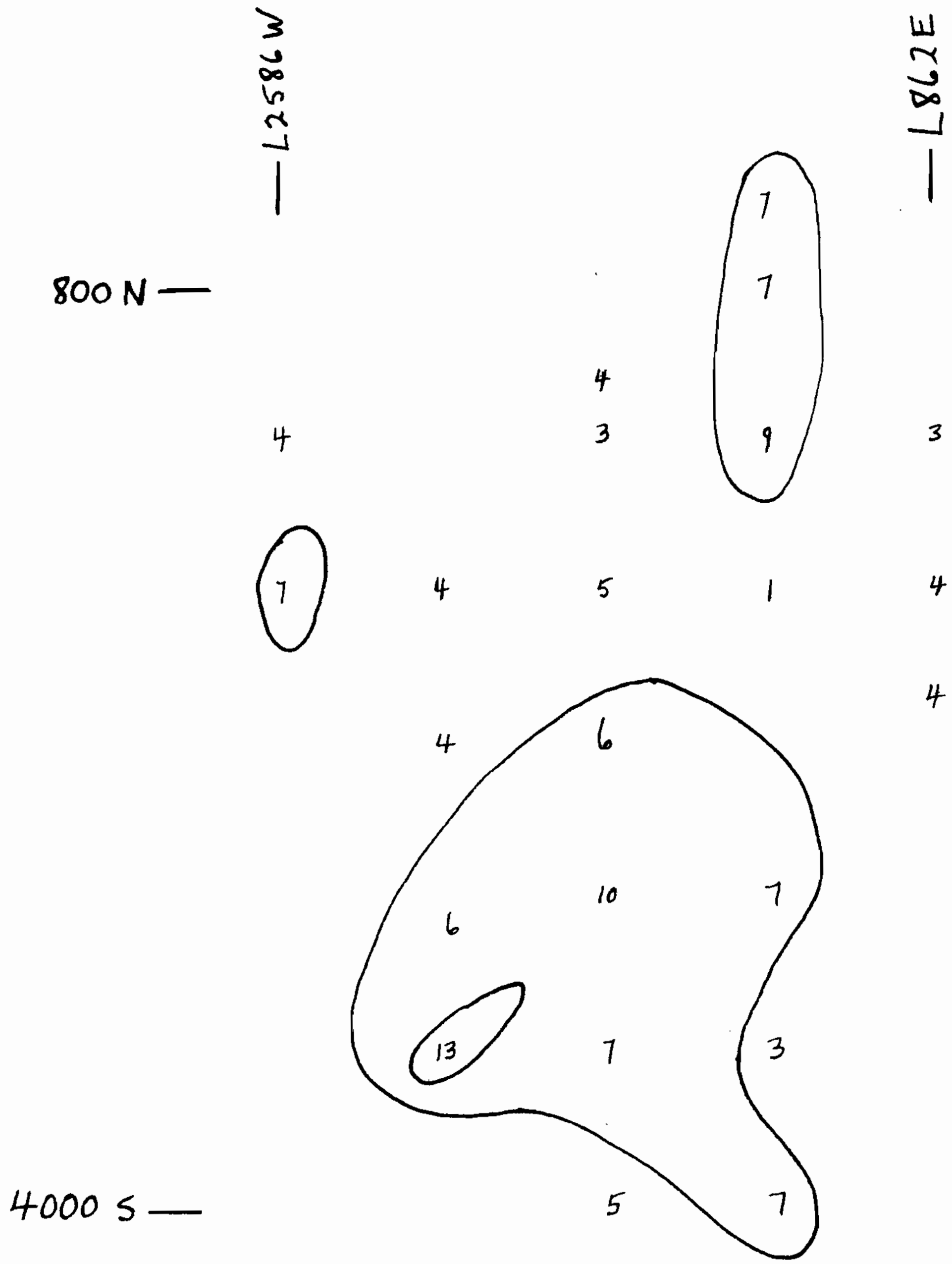


Figure 86. SCOTT LAKE BOG - Contour map

Contour interval - 5 ppm (6-10)

Copper content of Leather-leaf leaves

in ppm - dry wt.

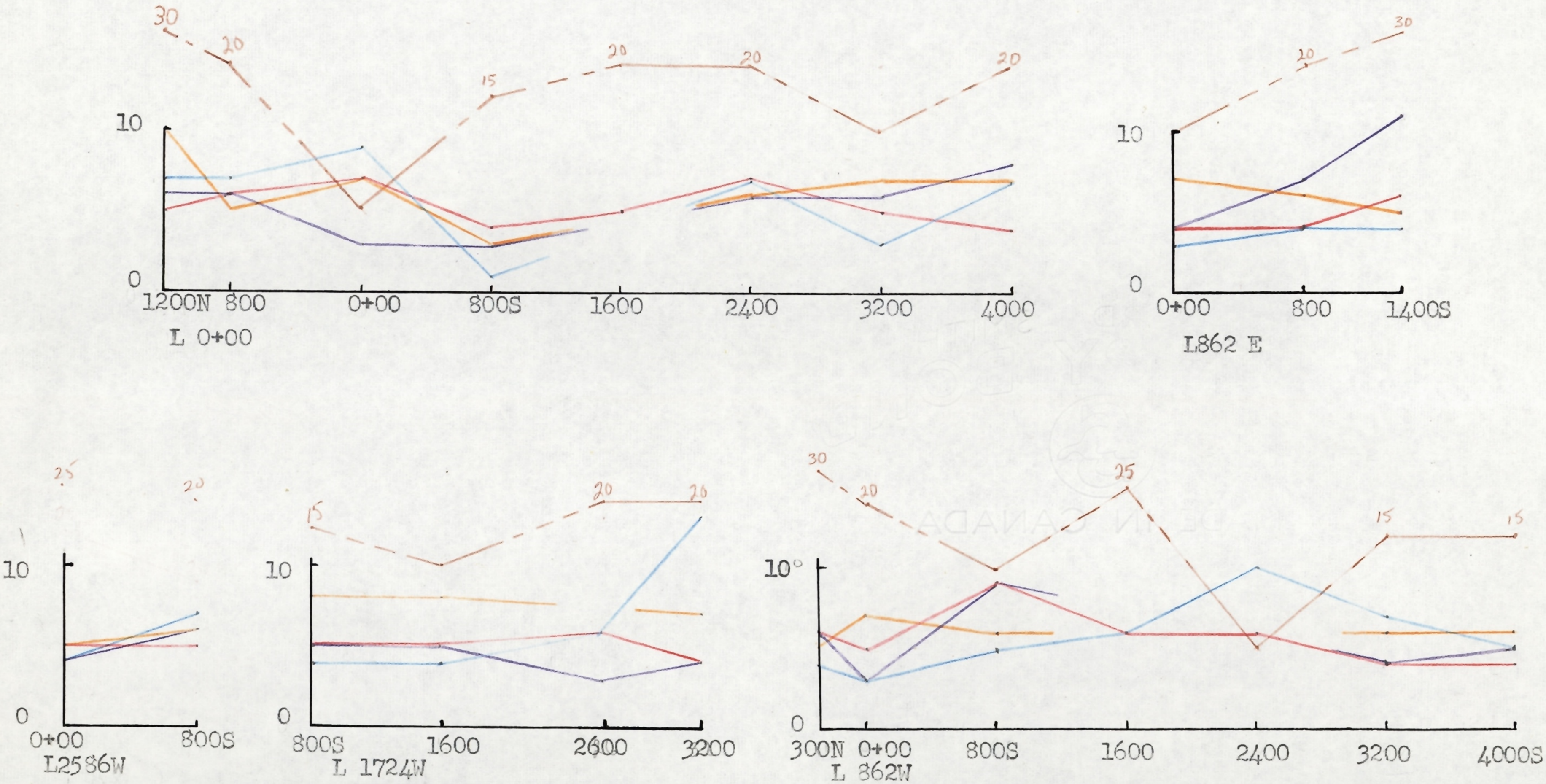


Figure 87. SCOTT LAKE BOG - Profile graphs - Lines 2586W, 1724W, 862W, 0+00, and 862E
Copper contents in ppm - dry wt.
Scales: Vertical 1 in = 10 ppm; Horizontal 1 in = 1000 feet

— Black Spruce stems (2 yr. old)
— Larch stems (2 - 4 yr. old)
— Surface peats
— Leather-leaf leaves
— Leather-leaf stems (2 yr. old)

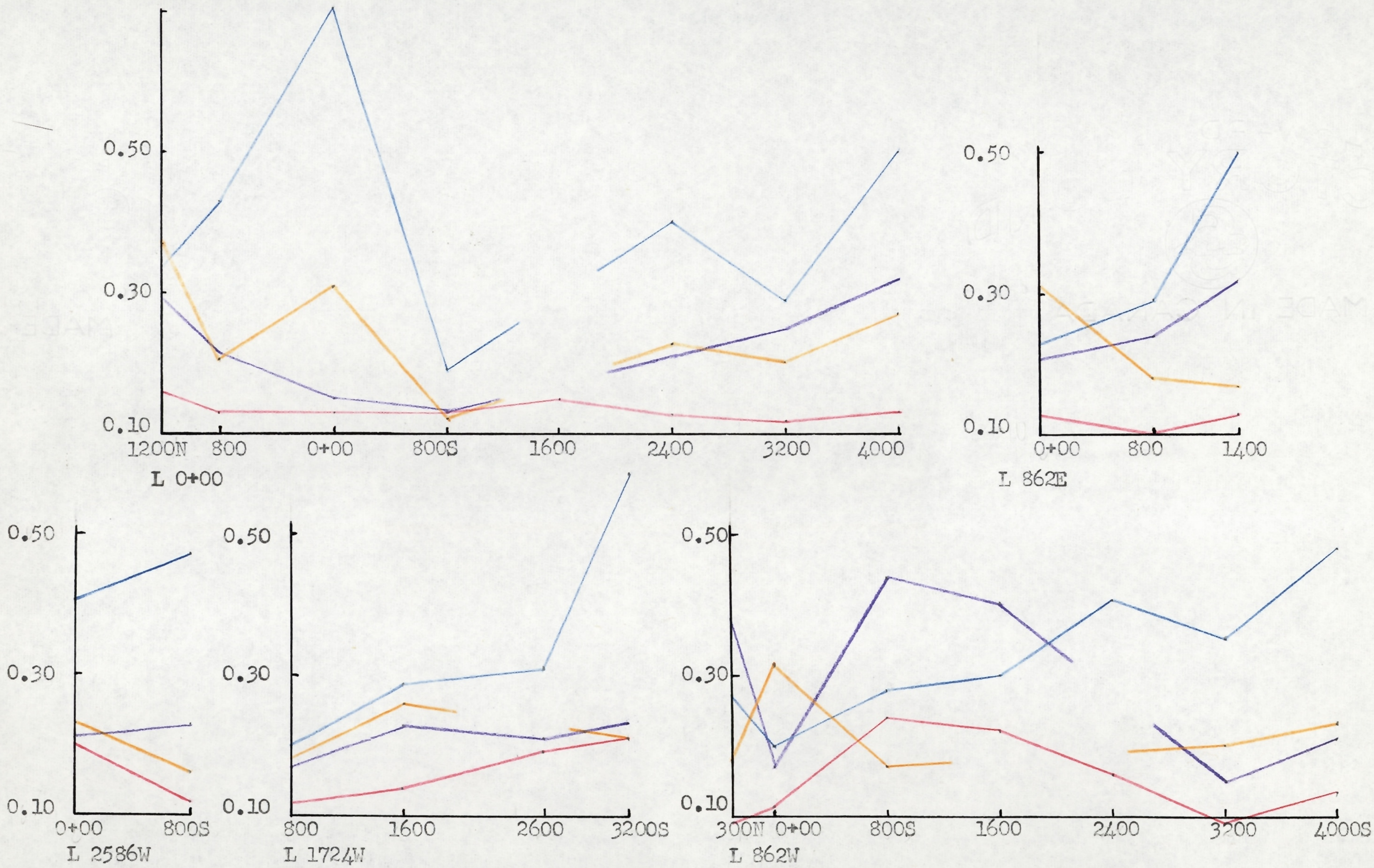


Figure 88. SCOTT LAKE BOG - Profile graphs - Lines 2586W, 1724W, 862W, 0+00 and 862E
Copper ; Zinc ratios
Scales: Vertical 1 in = 0.20 Horizontal i in. = 1000 feet

— Black Spruce stems (2 yr. old)
— Larch stems (2 - 4 yr. old)
— Leather-leaf leaves
— Leather-leaf stems (2 yr. old)

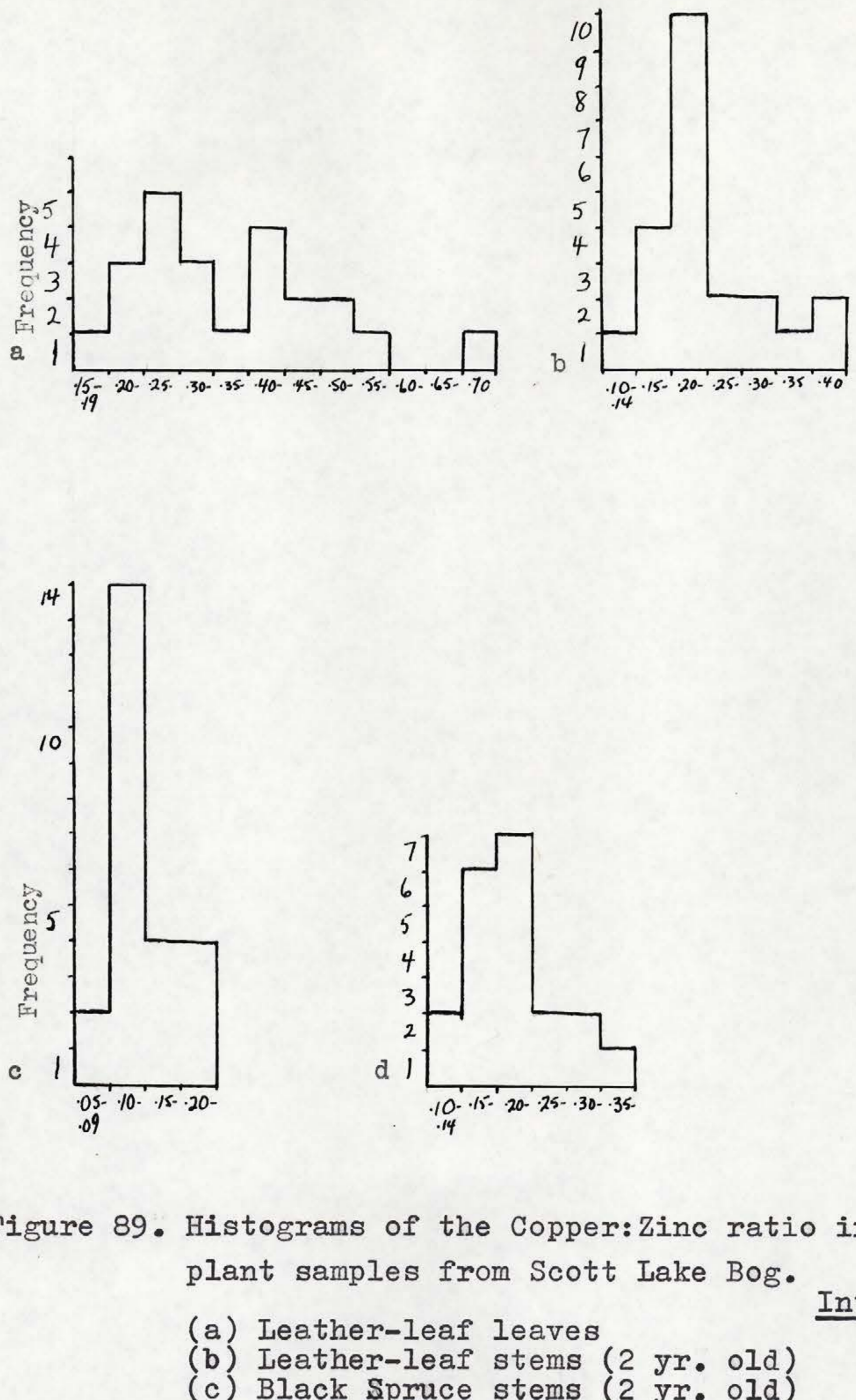


Figure 89. Histograms of the Copper:Zinc ratio in plant samples from Scott Lake Bog.

	Interval
(a) Leather-leaf leaves	0.05
(b) Leather-leaf stems (2 yr. old)	0.05
(c) Black Spruce stems (2 yr. old)	0.05
(d) Larch stems (2 - 4 yr. old)	0.05

Profiles of the lead contents of each species are given in figure 101.

Histograms of the lead contents of each species are given in figure 102, a to d. The histograms of Larch, Spruce, and Leather-leaf leaves show some values on the high side.

Nickel - The nickel contents of each species are plotted on plant association maps in figures 102 to 105.

The nickel contents of each species are contoured in figures 107 to 111. The nickel contents of Black Spruce in ppm - dry wt. and ppm - ash are closely correlated (see figures 107 and 108).

Profiles of the nickel contents of the different species are given in figure 112.

Histograms of the nickel contents are given in figure 100, e to h. The histograms of Larch, Spruce, and Leather-leaf leaves show some values on the high side.

Ash content - The ash contents (expressed as a percentage of the air - dried weight) of the plant samples from Scott Lake Bog are graphed in the profiles in figure 113. The percentage ash has a definite range for each species and plant part. There is some correlation between the ash contents of different species at the same sampling point.

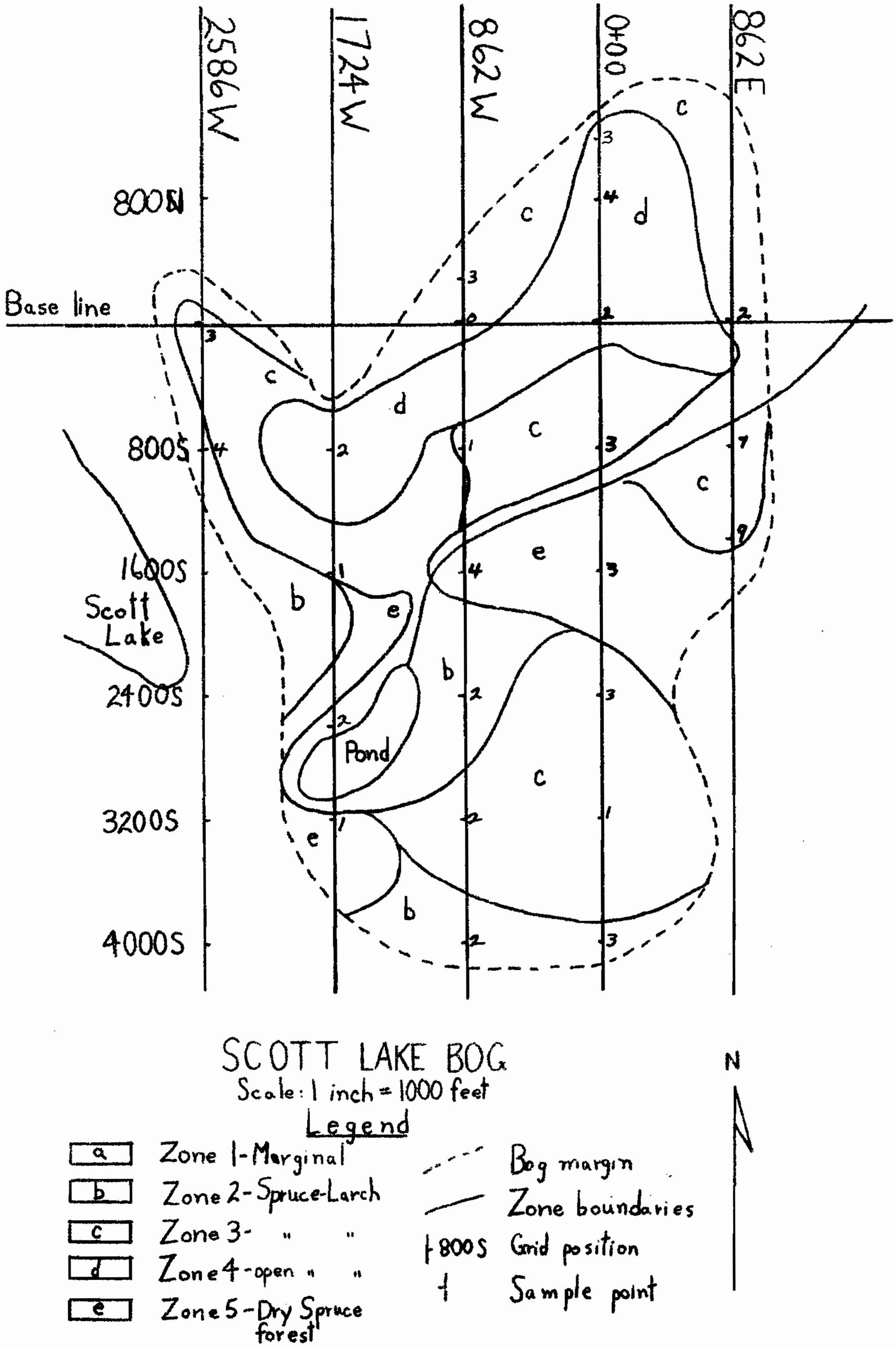


Figure 90. Lead contents of Black Spruce stems (2 yr. old) in ppm - dry wt.

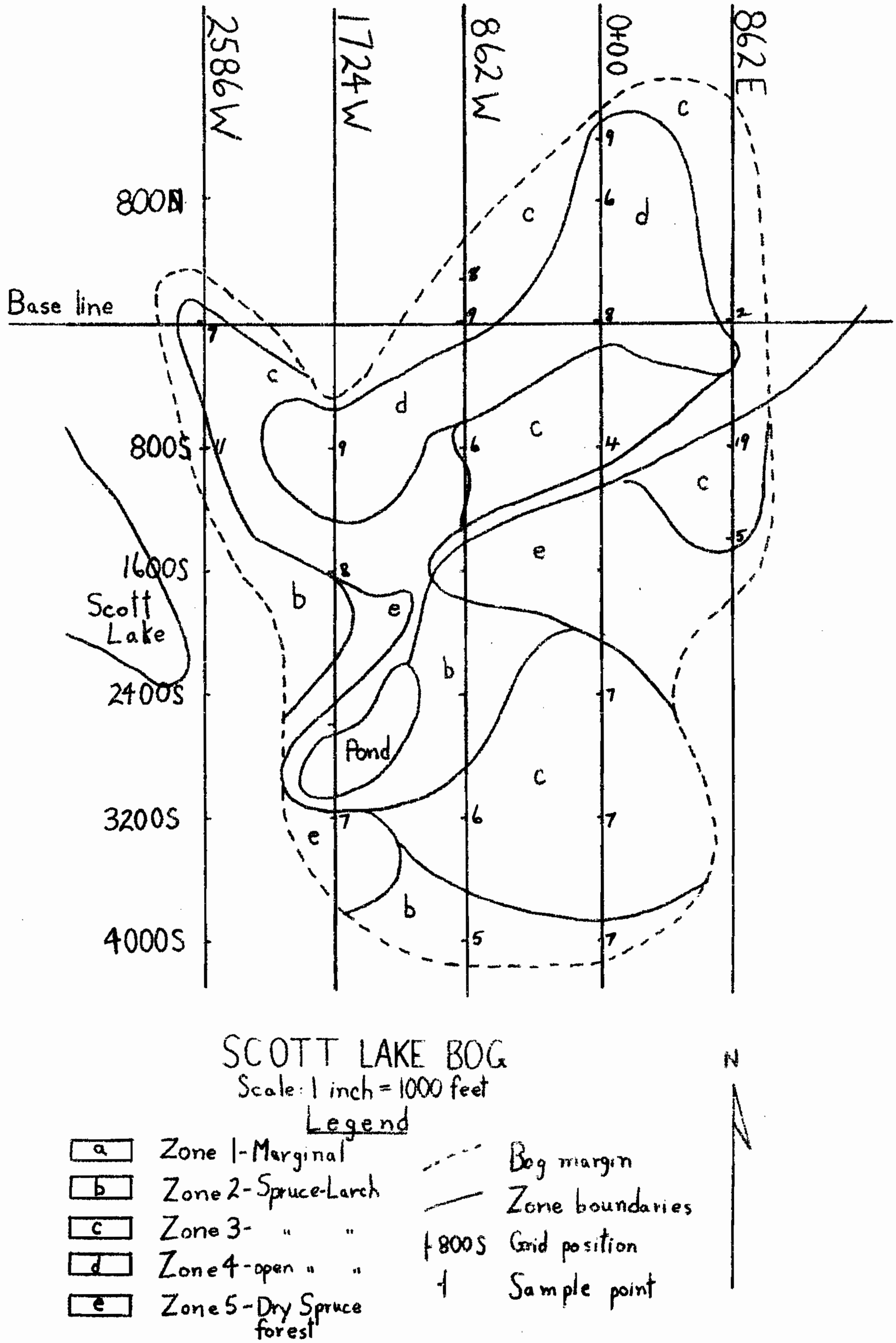


Figure 91. Lead contents of Larch stems (2-4 yr. old) in ppm - dry wt.

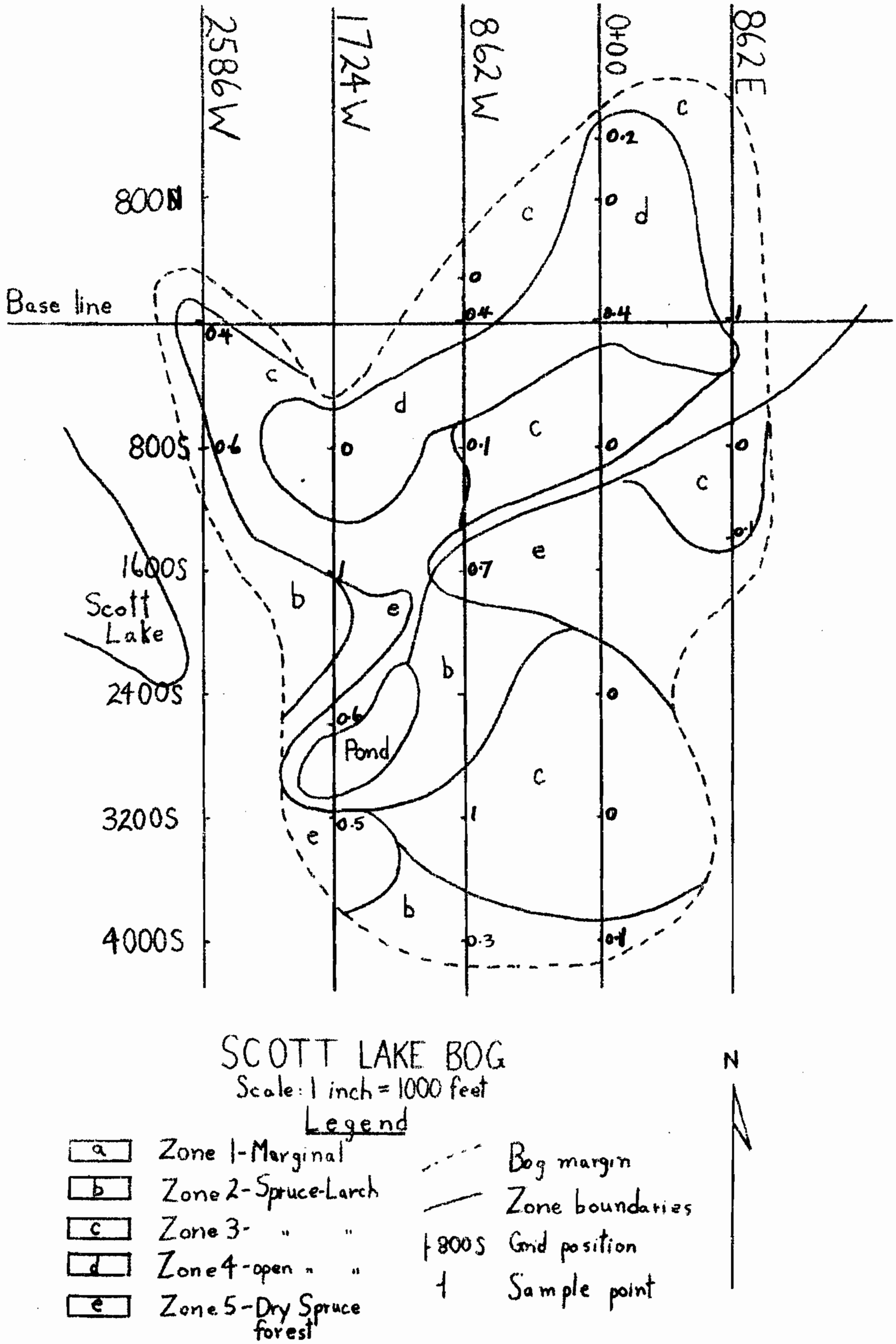


Figure 92. Lead contents of Leather-leaf stems (2 yr. old) in ppm - dry wt.

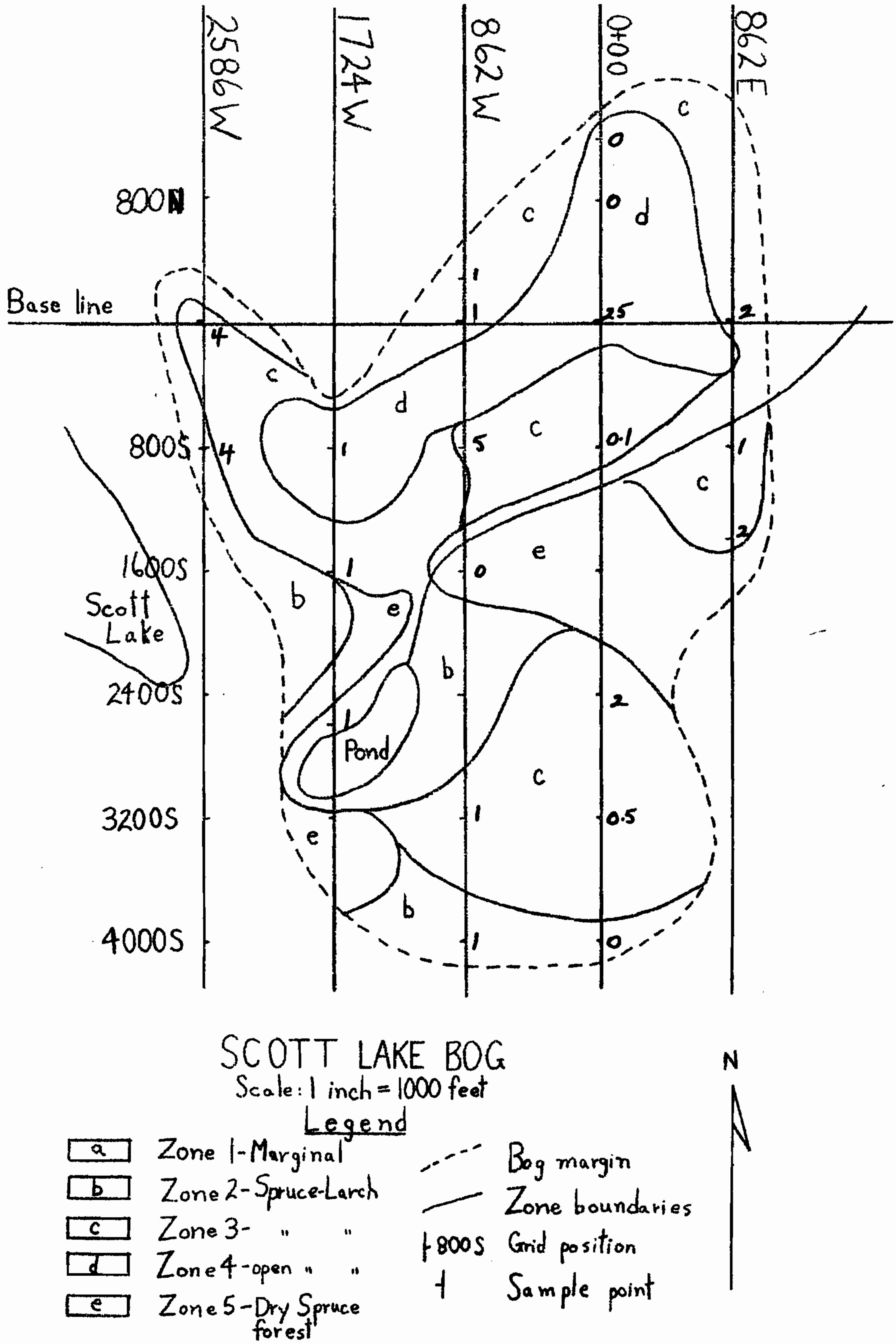


Figure 93. Lead contents of Leather-leaf leaves in ppm - dry wt.

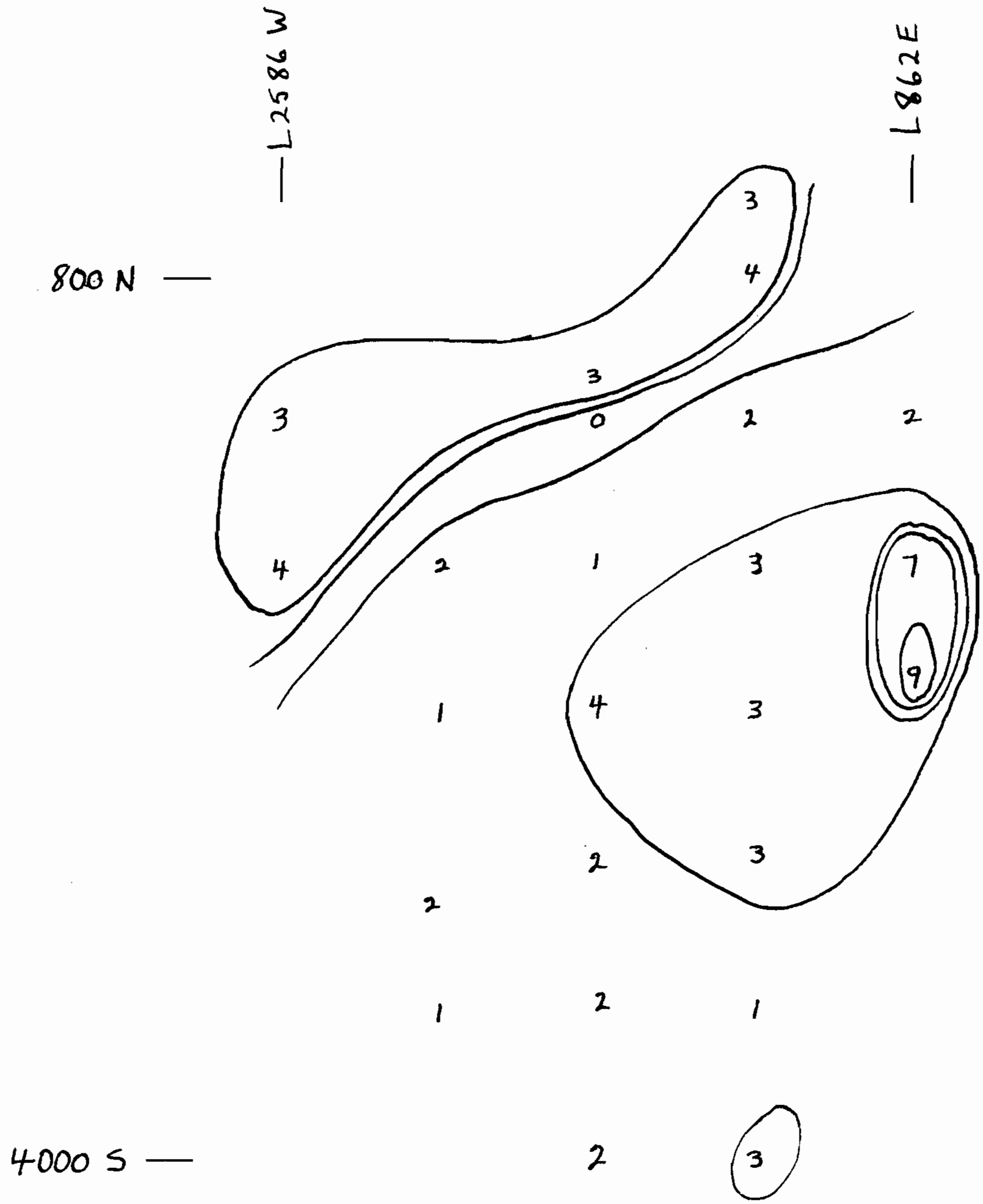


Figure 94. SCOTT LAKE BOG - Contour map
Contour interval - 2 ppm (3-4)
Lead contents of Black Spruce
stems (2 yr. old) in ppm - dry wt.

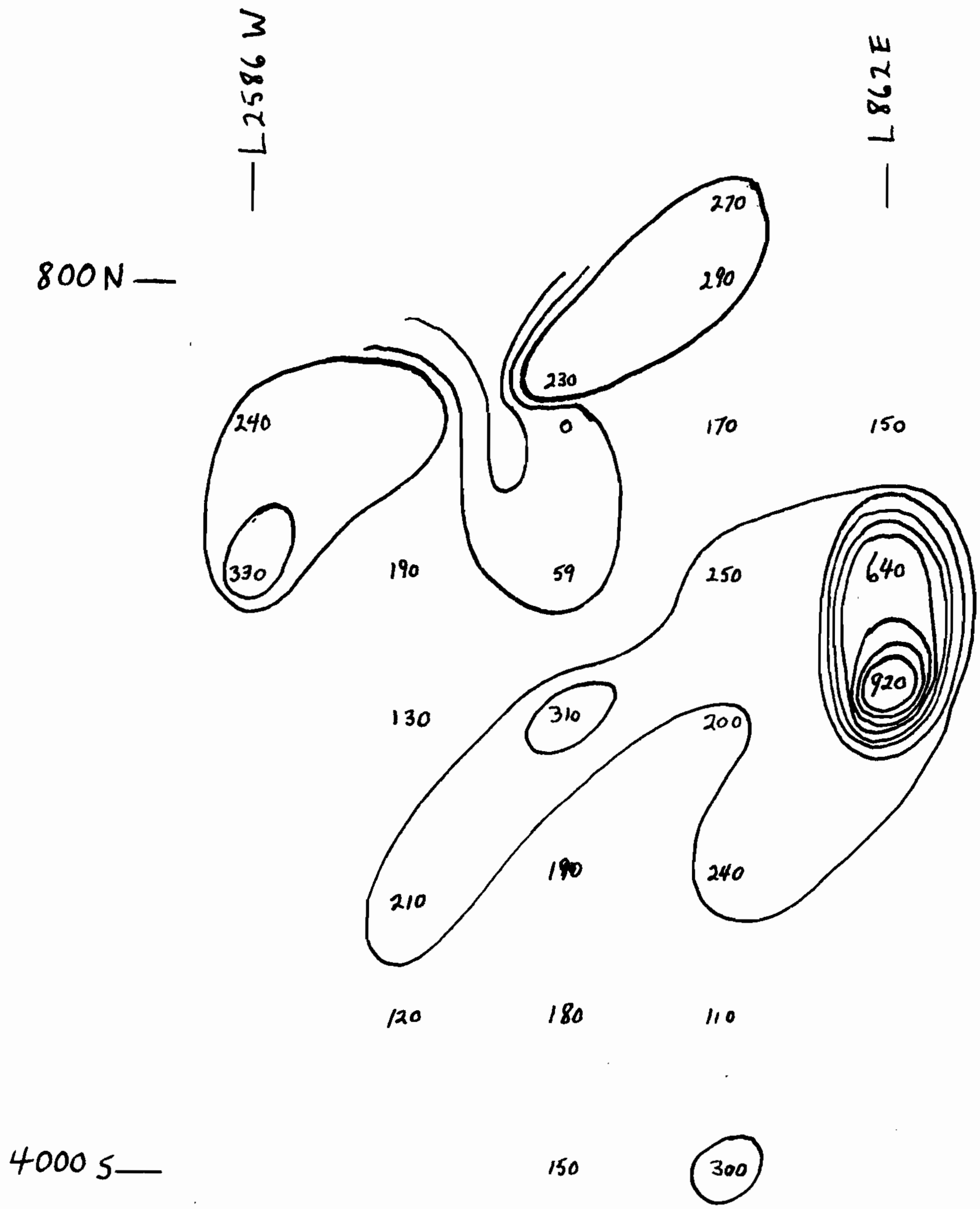


Figure 95. SCOTT LAKE BOG - Contour map
Contour interval - 100 ppm (101-200)

Lead contents of Black Spruce

stems (2 yr. old) in ppm - ash.

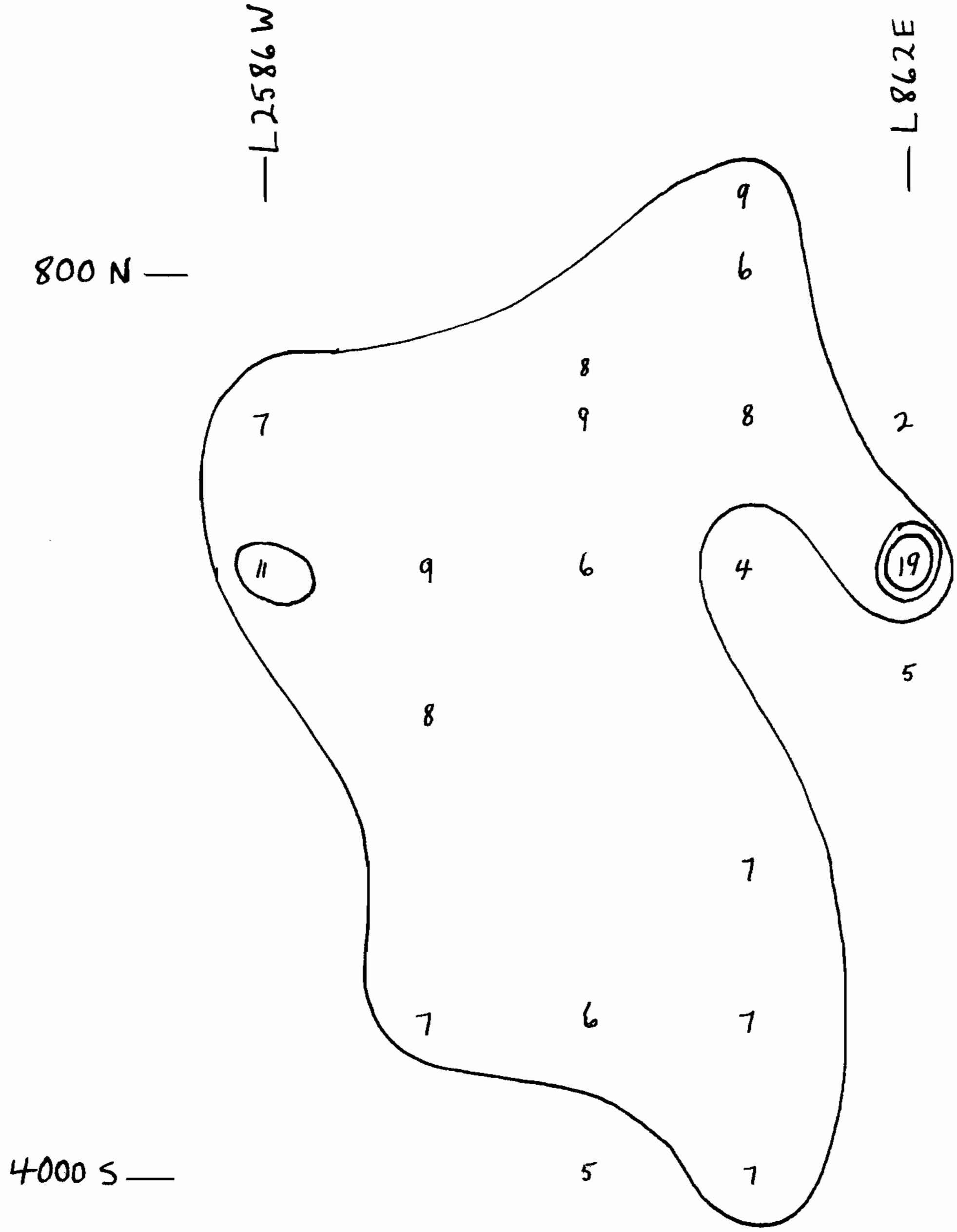


Figure 96. SCOTT LAKE BOG - Contour map

Contour interval - 5 ppm (6-10)

Lead contents of Larch stems (2-4 yr. old) in ppm - dry wt.

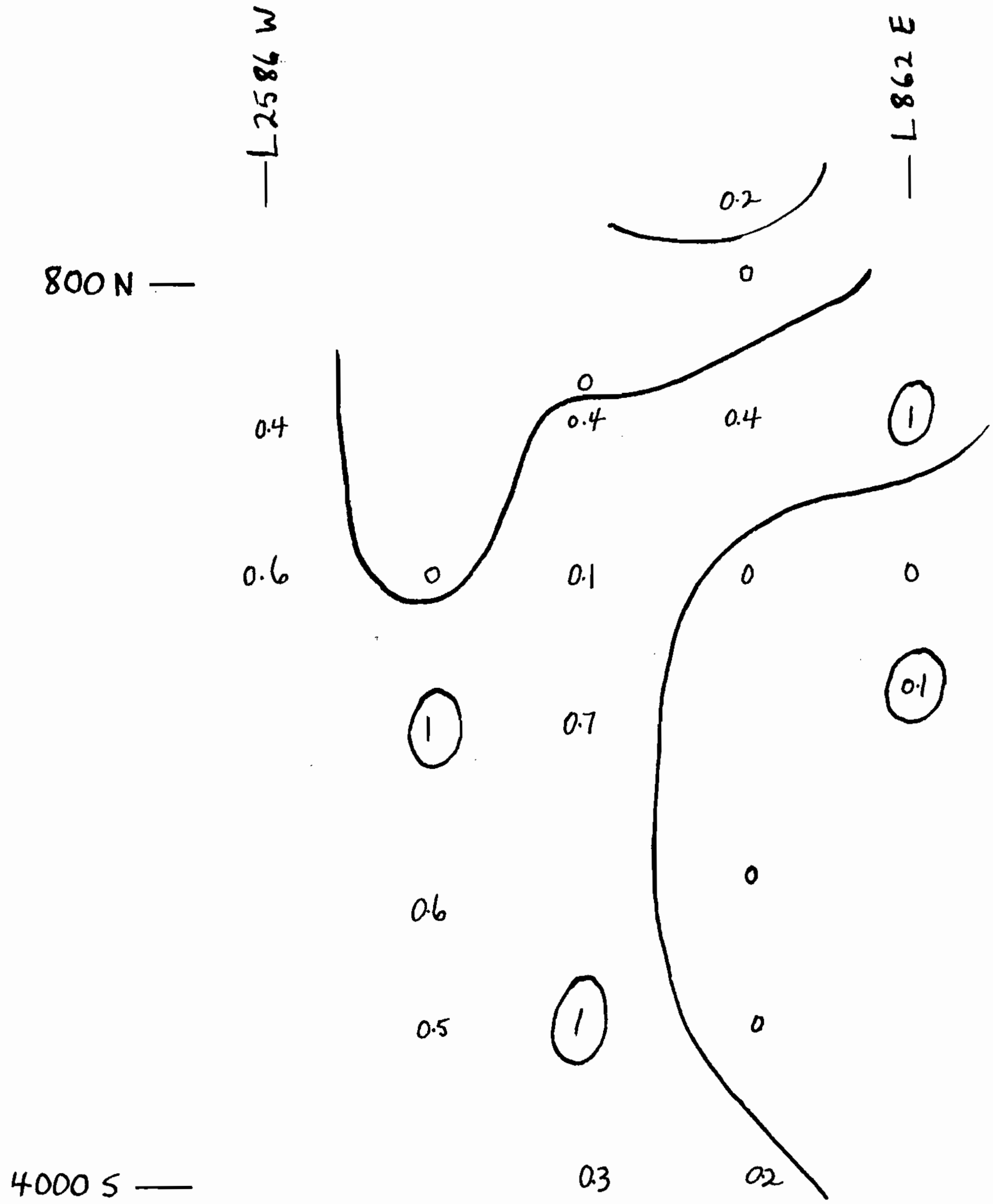


Figure 97. SCOTT LAKE BOG - Contour map
Contour interval - 1 ppm (0.1-0.9,1-1.9)
Lead contents of Leather-leaf
stems (2 yr. old) in ppm - dry wt.

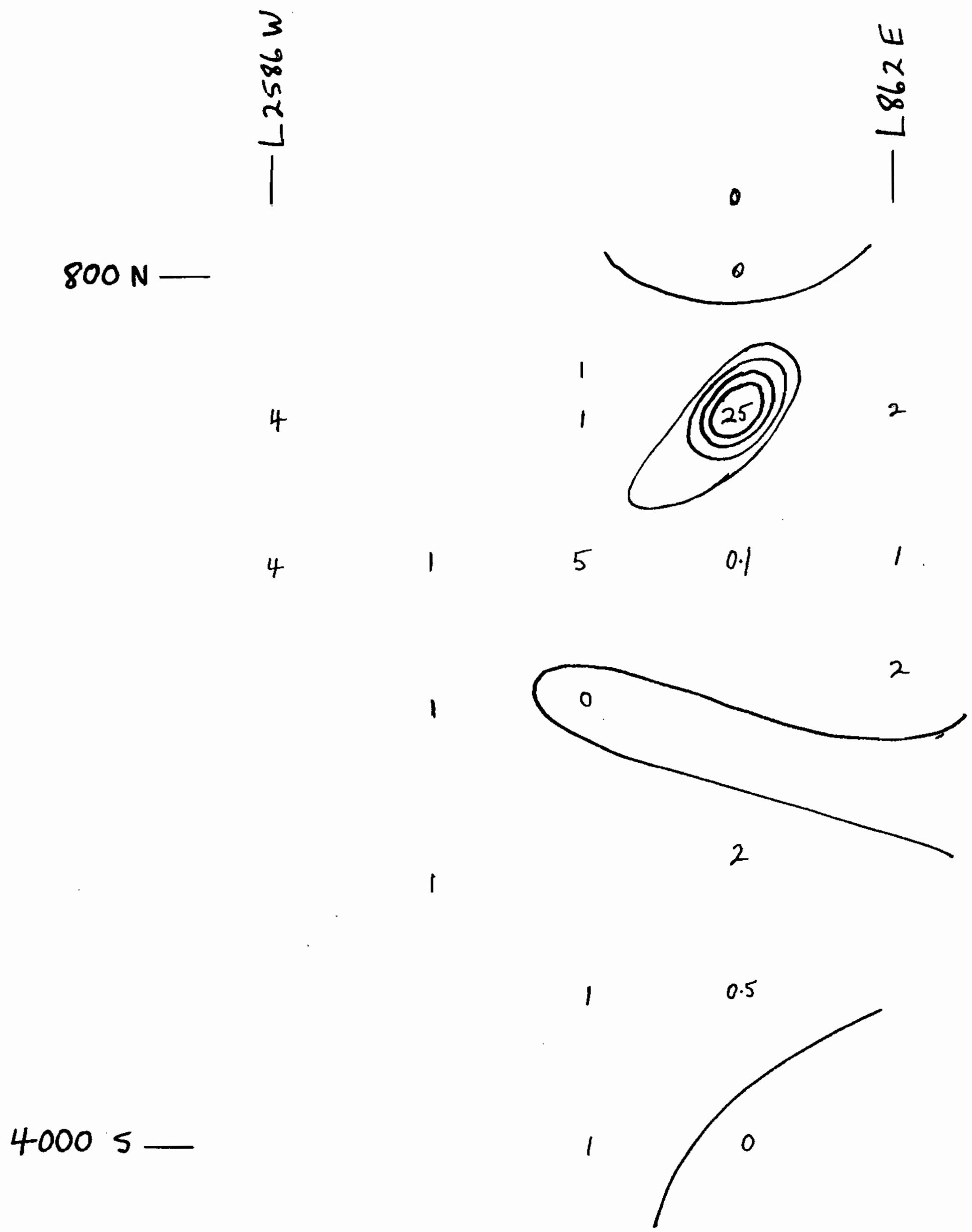


Figure 98. SCOTT LAKE BOG - Contour map

Contour interval - 5 ppm (0.5-5,6-10)

Lead contents of Leather-leaf leaves
in ppm-dry wt.

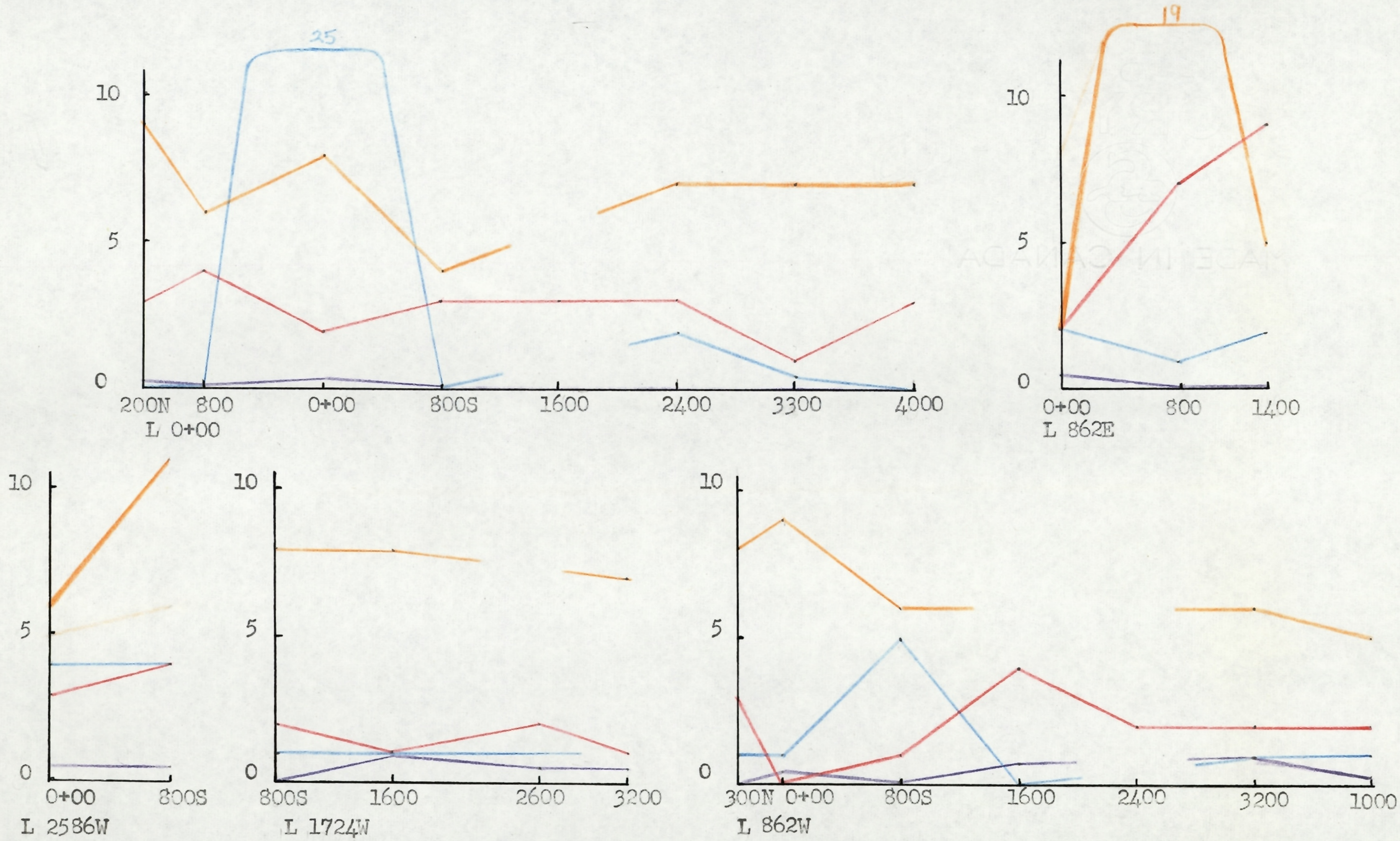


Figure 99. SCOTT LAKE BOG - Profile graphs - Lines 2586W, 1724W, 862W, 0+00, and 862E
Lead contents in ppm - dry wt.
Scales: Vertical 1 in = 5 ppm; Horizontal 1 in. = 1000 feet.

— Black Spruce stems (2 yr. old)
— Larch stems (2 - 4 yr. old)
— Leather-leaf leaves
— Leather-leaf stems (2 yr. old)

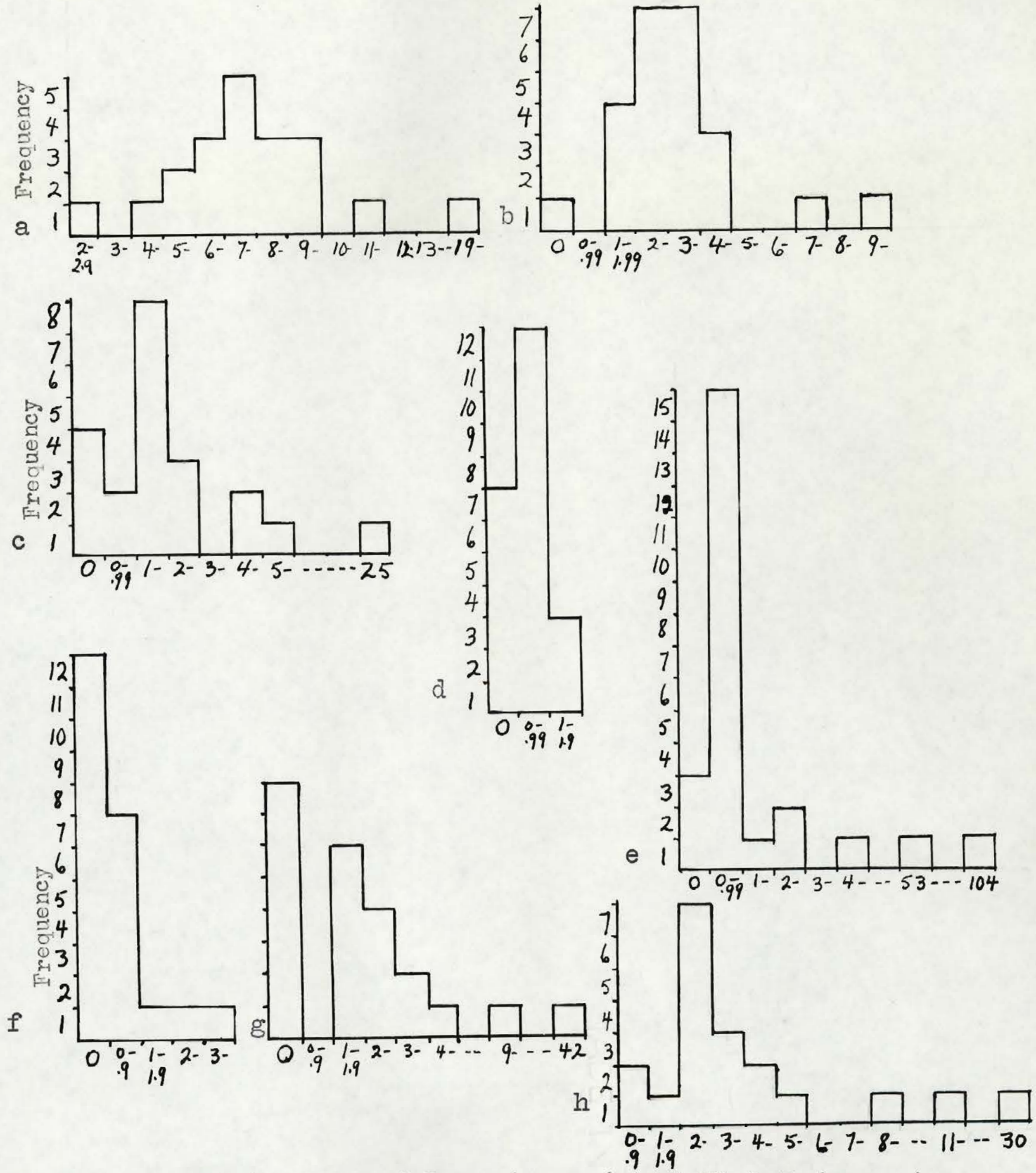


Figure 100. Histograms of Lead (a - d) and Nickel (e - h) contents (ppm - dry wt.) of plant samples from Scott Lake Bog.

	Interval
(a) Larch stems (2-4 yr. old)	1 ppm
(b) Black Spruce stems (2 yr. old)	1 ppm
(c) Leather-leaf leaves	1 ppm
(d) Leather-leaf stems (2 yr. old)	1 ppm
(e) Black Spruce stems (2 yr. old)	1 ppm
(f) Leather-leaf leaves	1 ppm
(g) Leather-leaf stems (2 yr. old)	1 ppm
(h) Larch stems (2 - 4 yr. old0	1 ppm

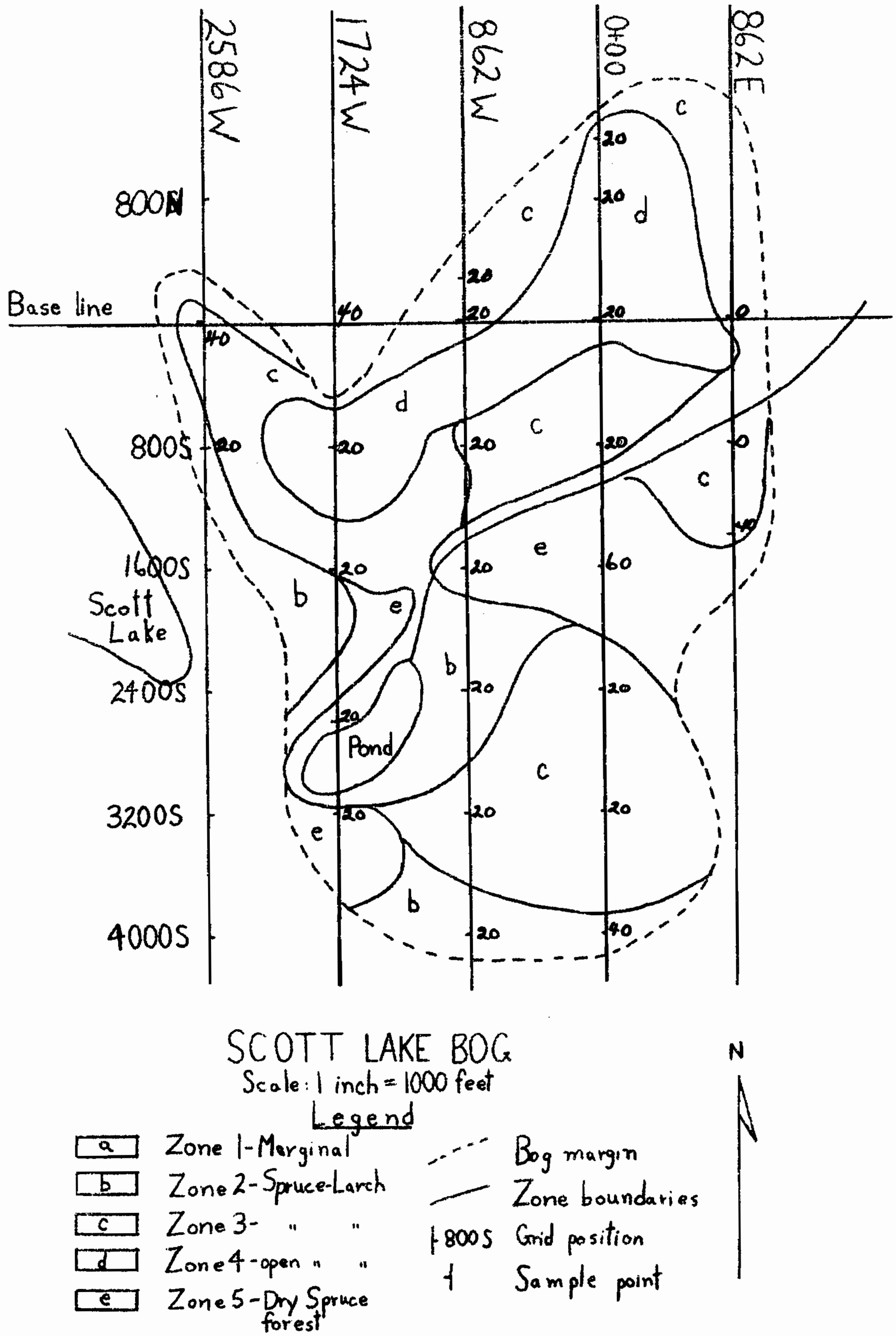


Figure 101. Nickel contents of surface peats in ppm - dry wt.

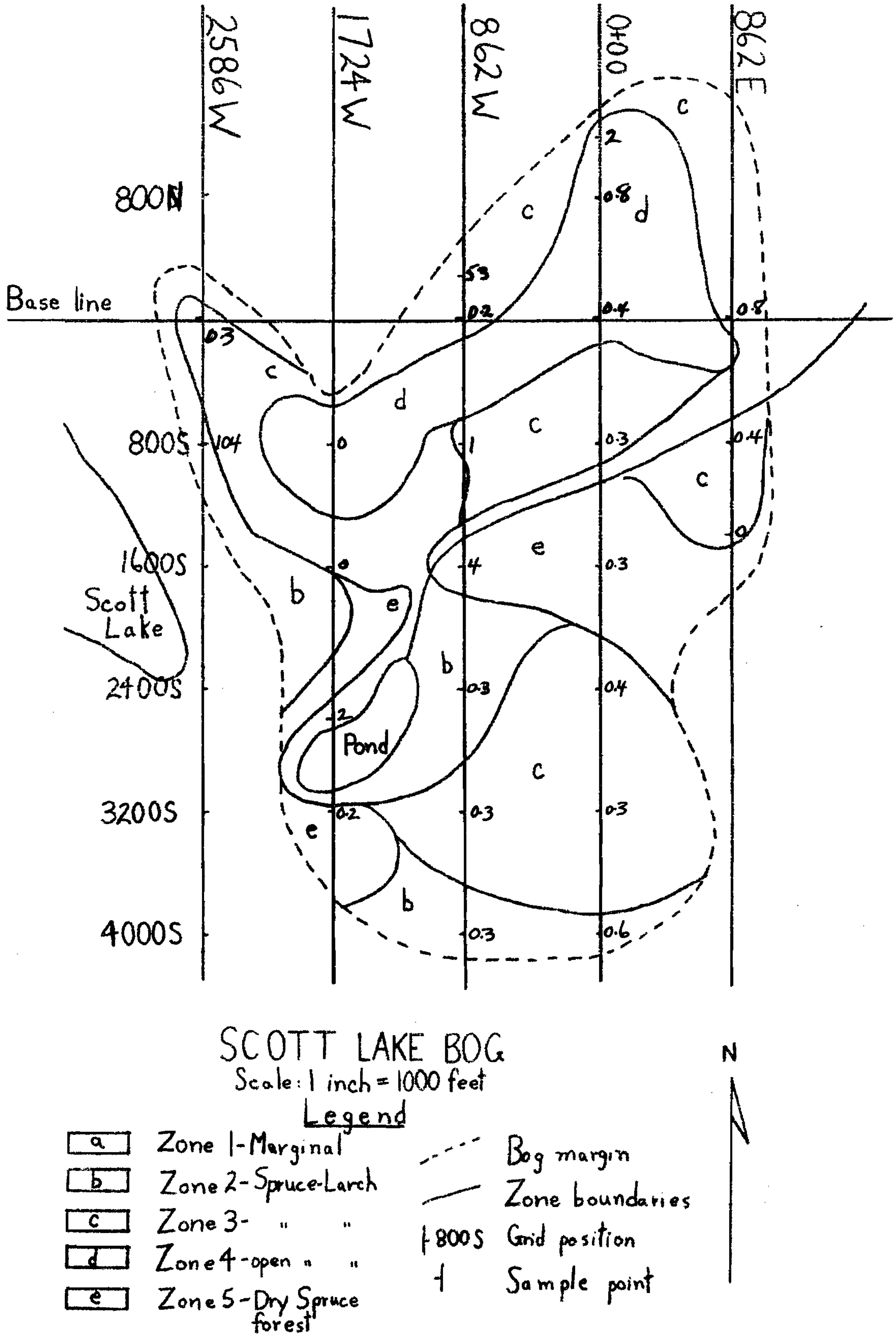


Figure 102. Nickel contents of Black Spruce stems (2 yr. old) in ppm - dry wt.

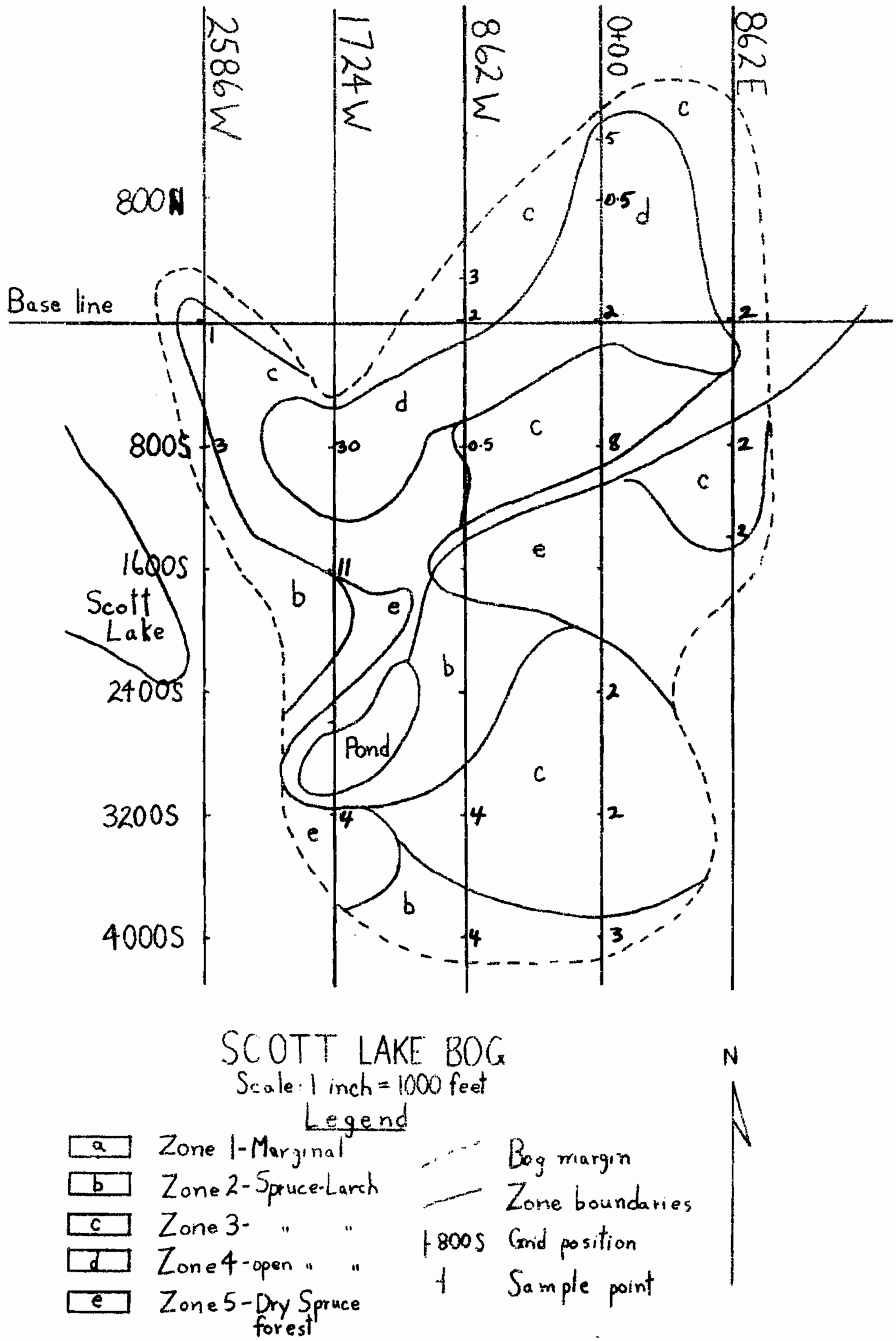


Figure 103. Nickel contents of Larch stems
(2 - 4 yr. old) in ppm - dry wt.

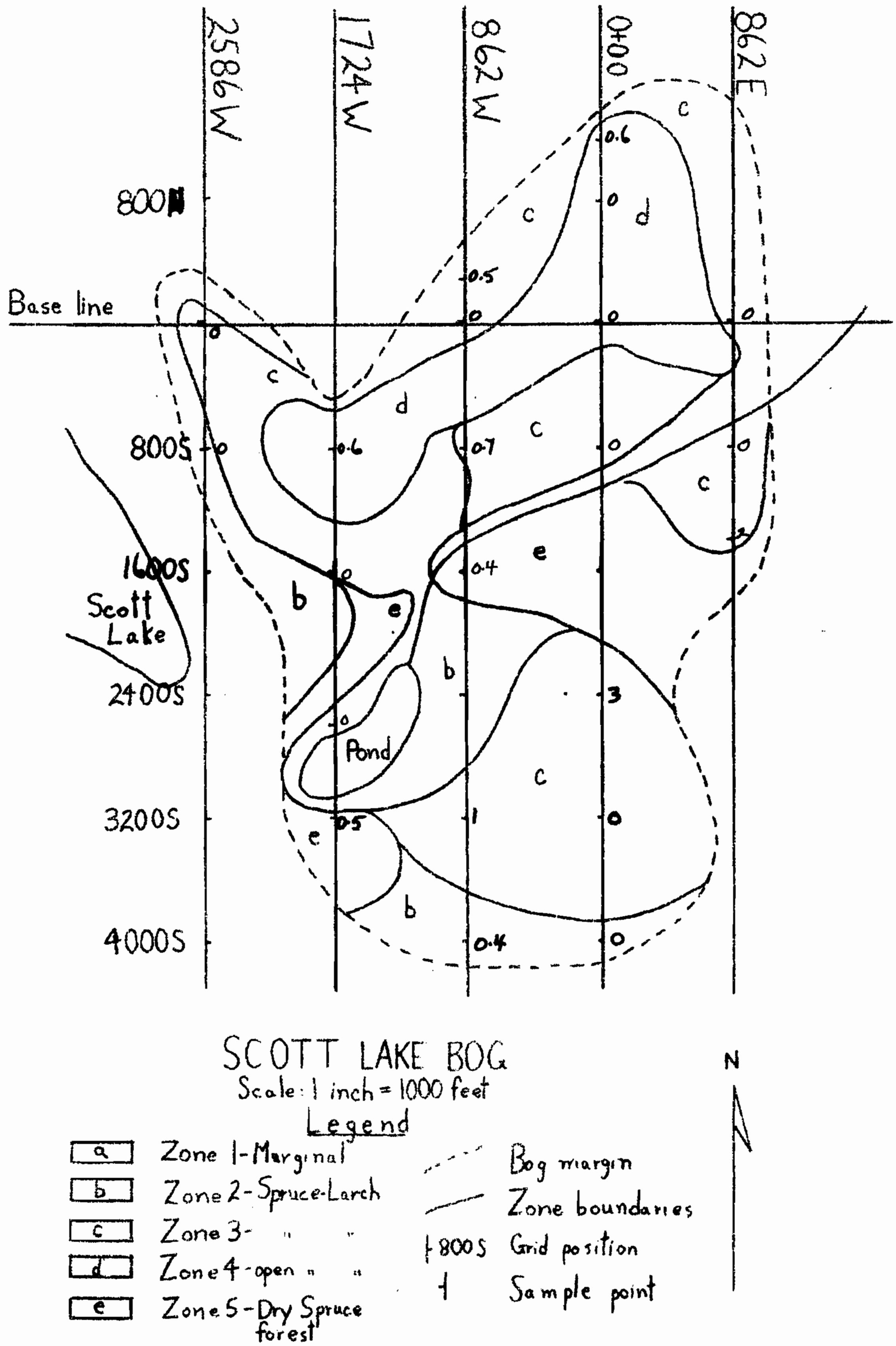


Figure 104. Nickel contents of Leather-leaf stems (2 yr. old) in ppm - dry wt.

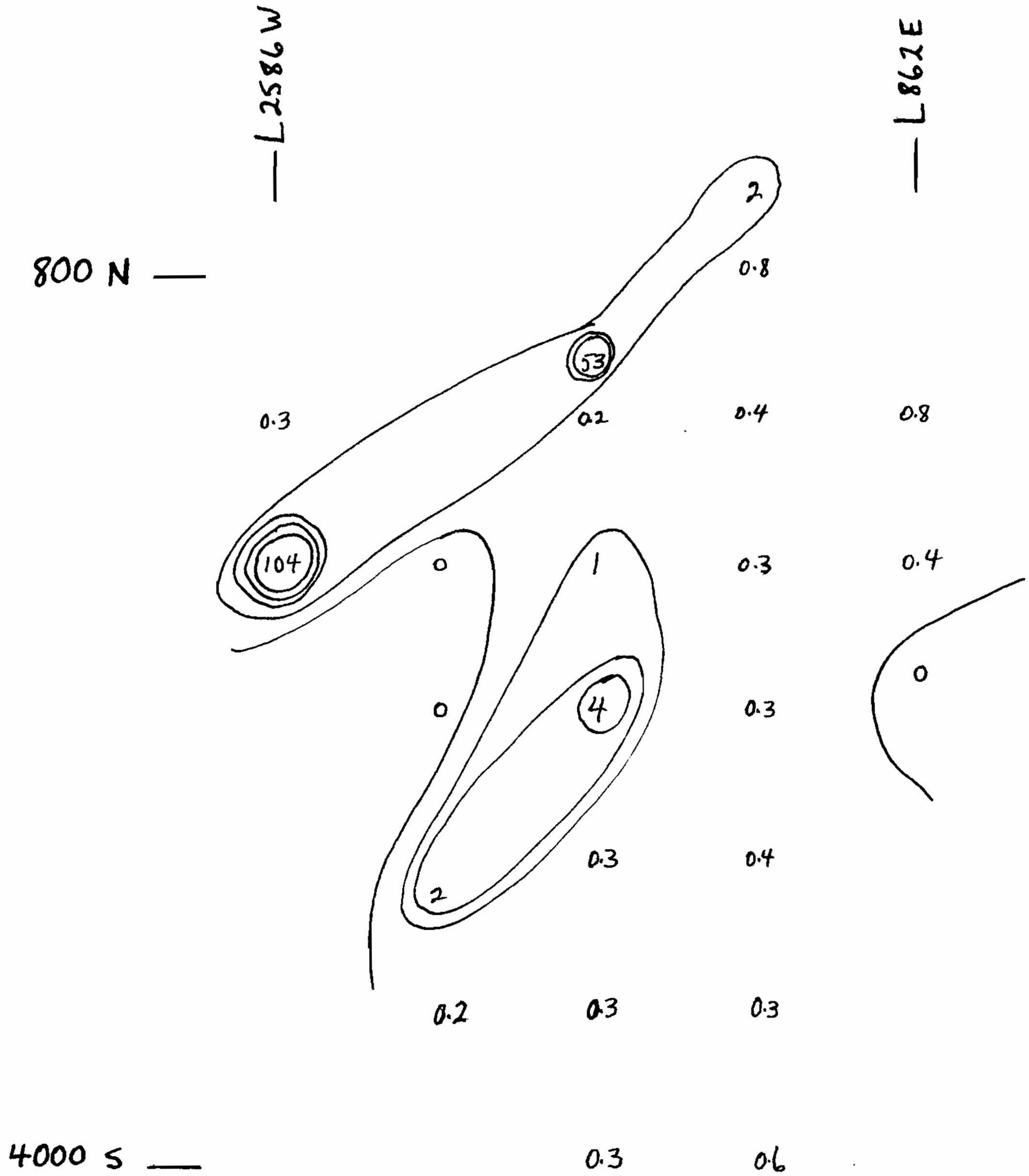


Figure 107. SCOTT LAKE BOG - Contour map

Contour interval - 1 ppm with exc.

Nickel contents of Black Spruce

stems (2 yr. old) in ppm - ash.

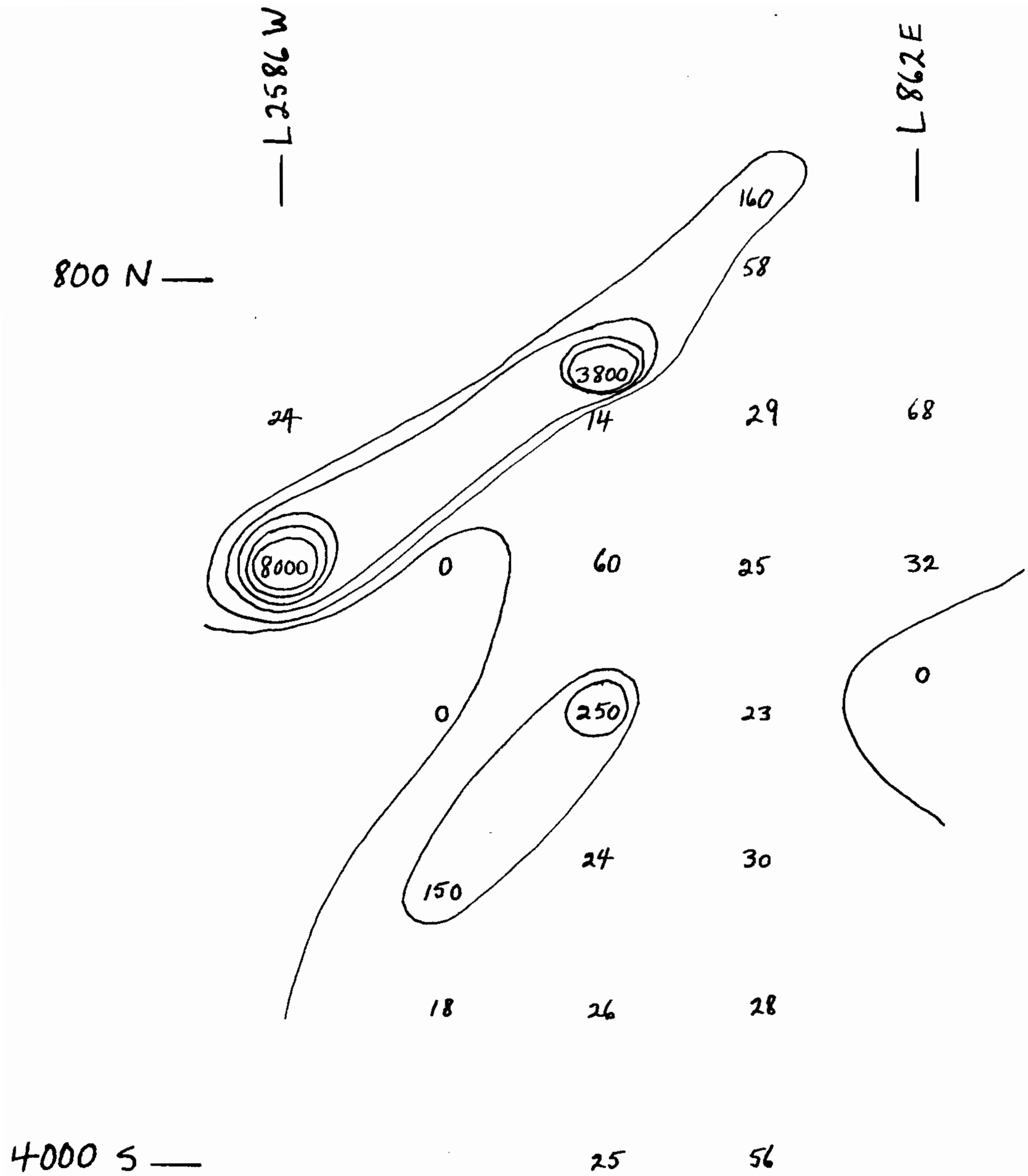


Figure 108. SCOTT LAKE BOG - Contour map

Contour interval - 100 ppm with exc.

Nickel contents of Black Spruce

stems (2 yr. old) in ppm - ash.

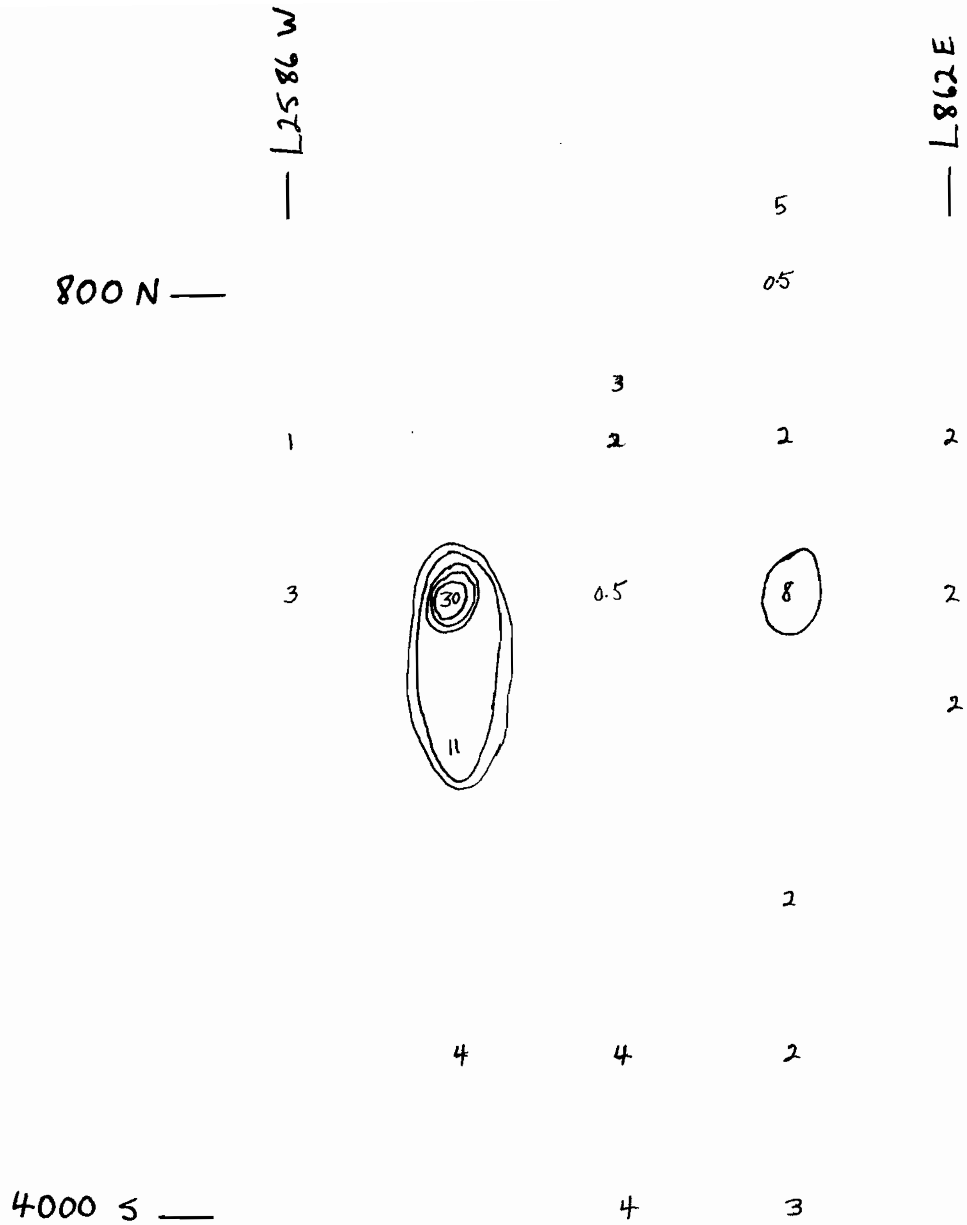


Figure 109. SCOTT LAKE BOG - Contour map

Contour interval - 5 ppm (6-10)

Nickel contents of Larch stems

(2 - 4 yr. old) in ppm - dry wt.

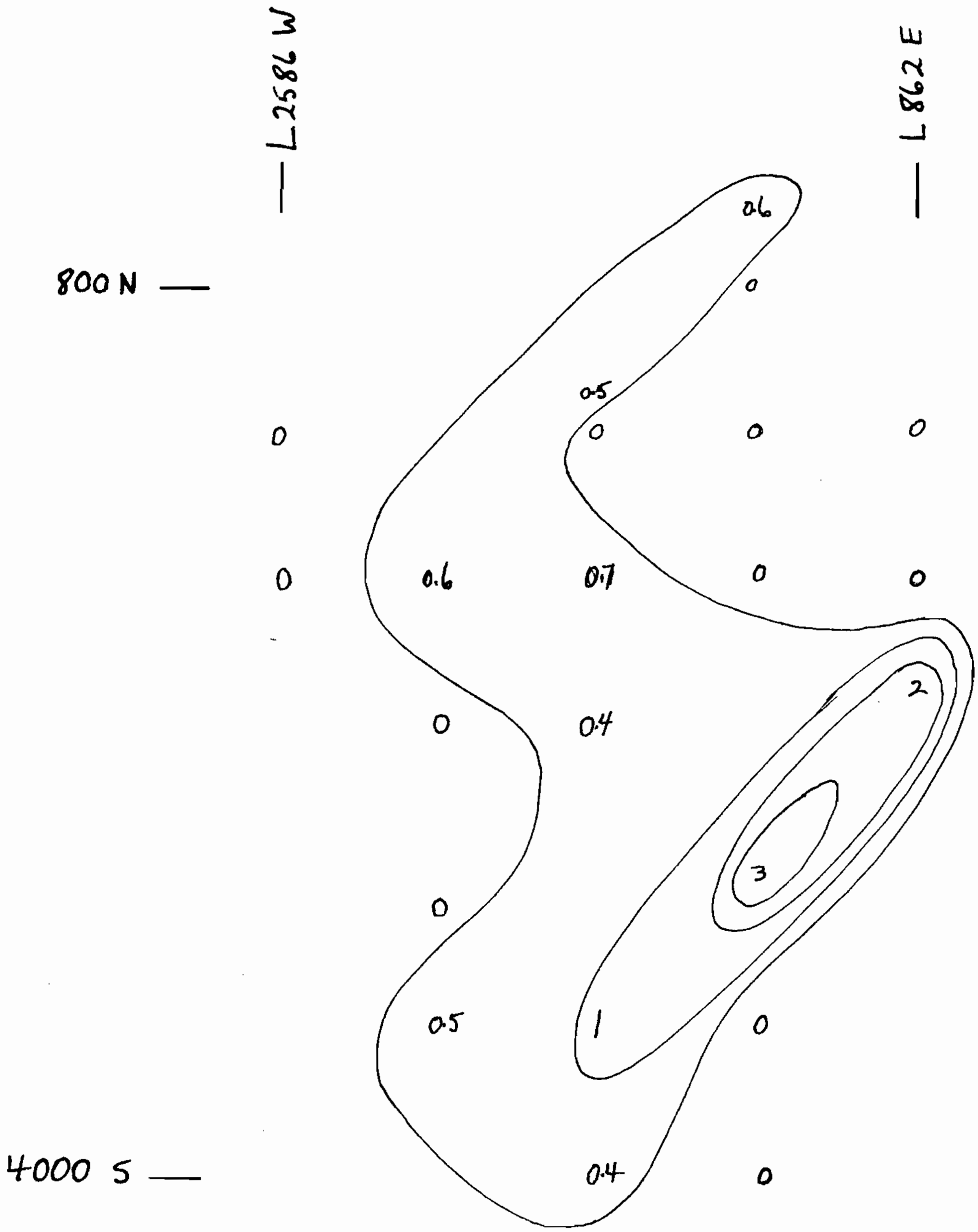


Figure 110. SCOTT LAKE BOG - Contour map

Contour interval - 1 ppm

Nickel contents of Leather-leaf

stems (2 yr. old) in ppm - dry wt.

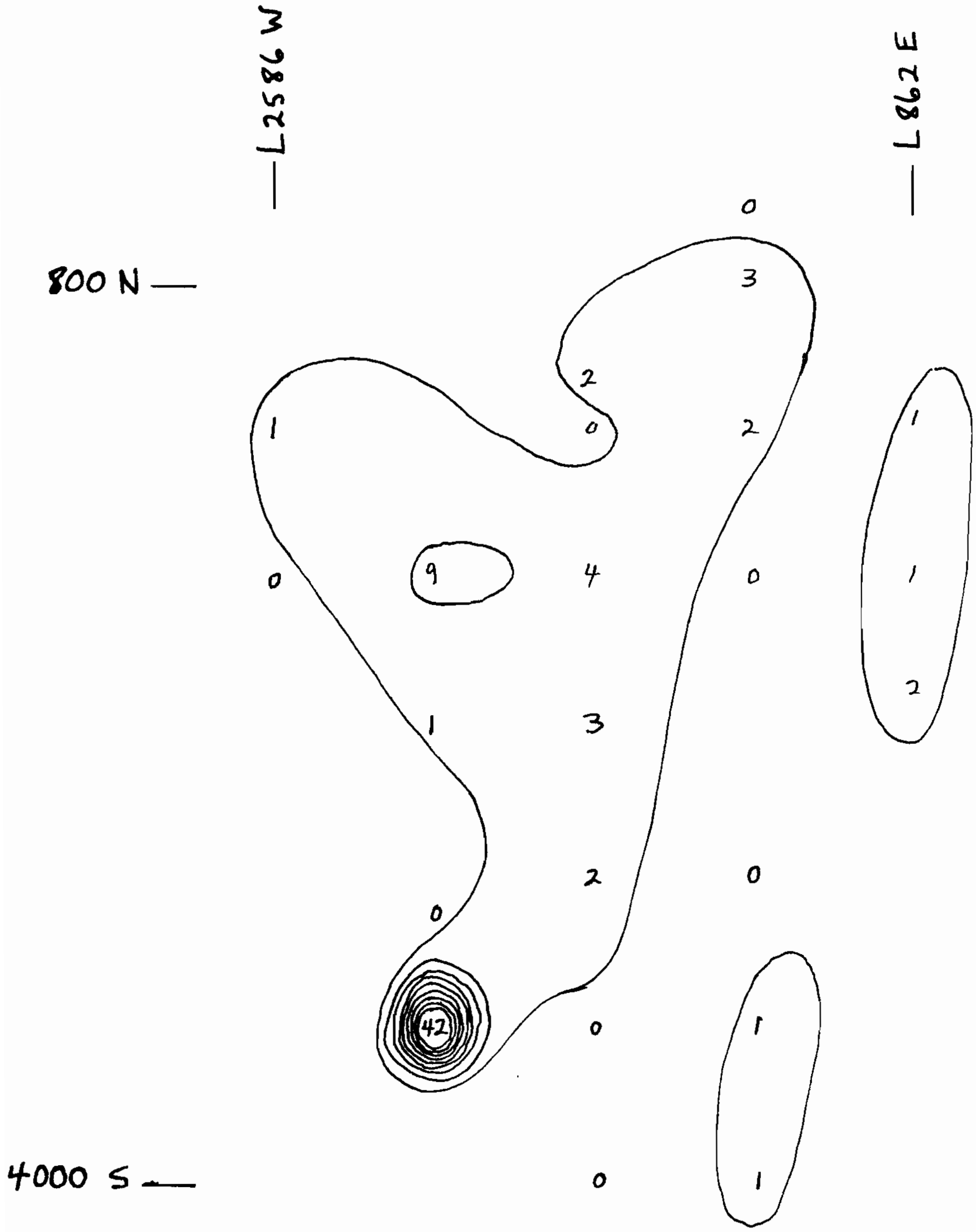


Figure 111. SCOTT LAKE BOG - Contour map

Contour interval - 5 ppm (6-10)

Nickel contents of Leather-leaf

leaves in ppm - dry wt.

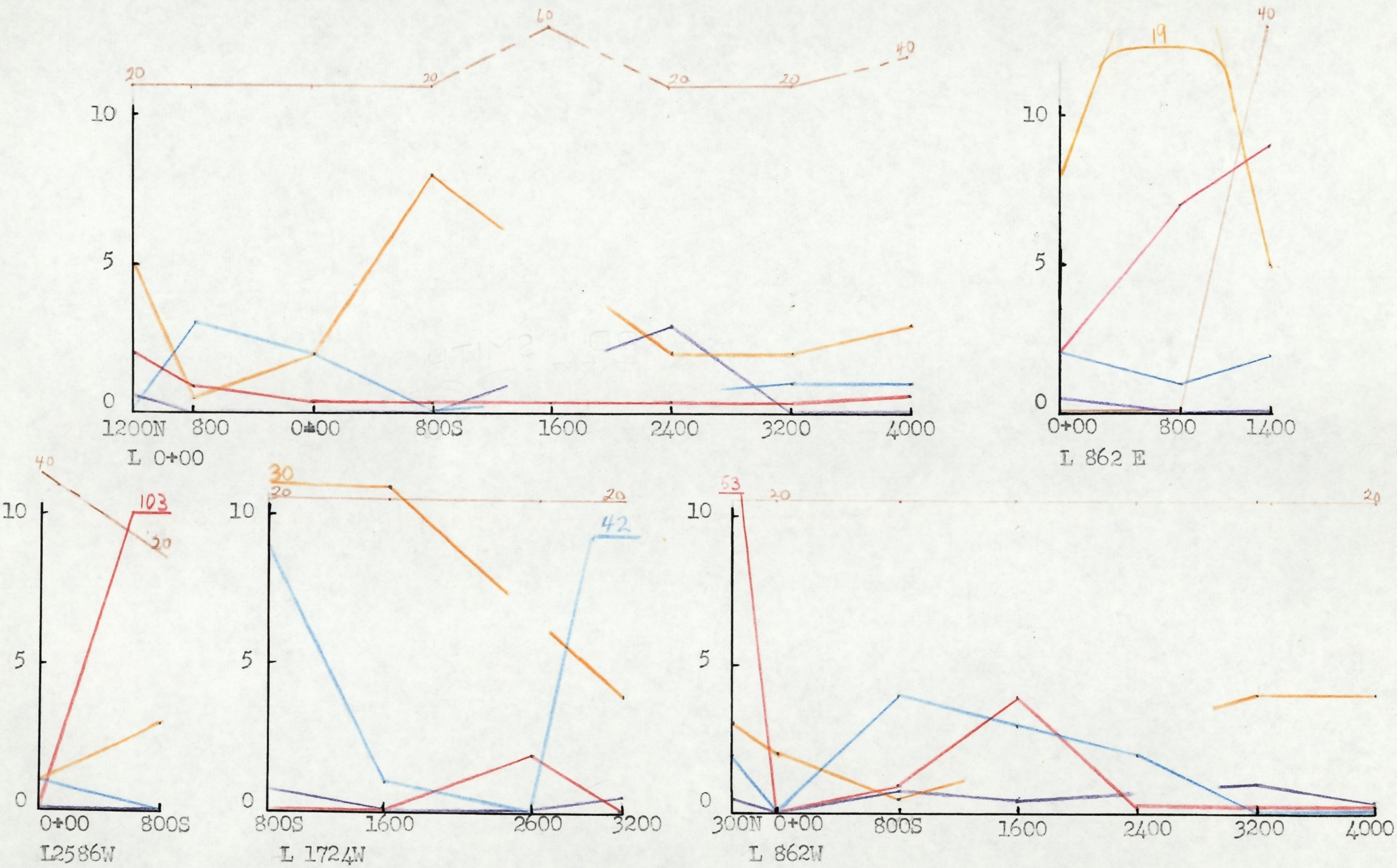


Figure 112. SCOTT LAKE BOG - Profile graphs - Lines 2586W, 1724W, 862W, 0+00, and 862E.
Nickel contents in ppm - dry wt.
Scales: Vertical 1 in = 5 ppm; Horizontal 1 in. = 1000 feet.

- Black Spruce stems (2 yr. old)
- Larch stems (2 - 4 yr. old)
- Surface peats
- Leather-leaf leaves
- Leather-leaf stems (2 yr. old)

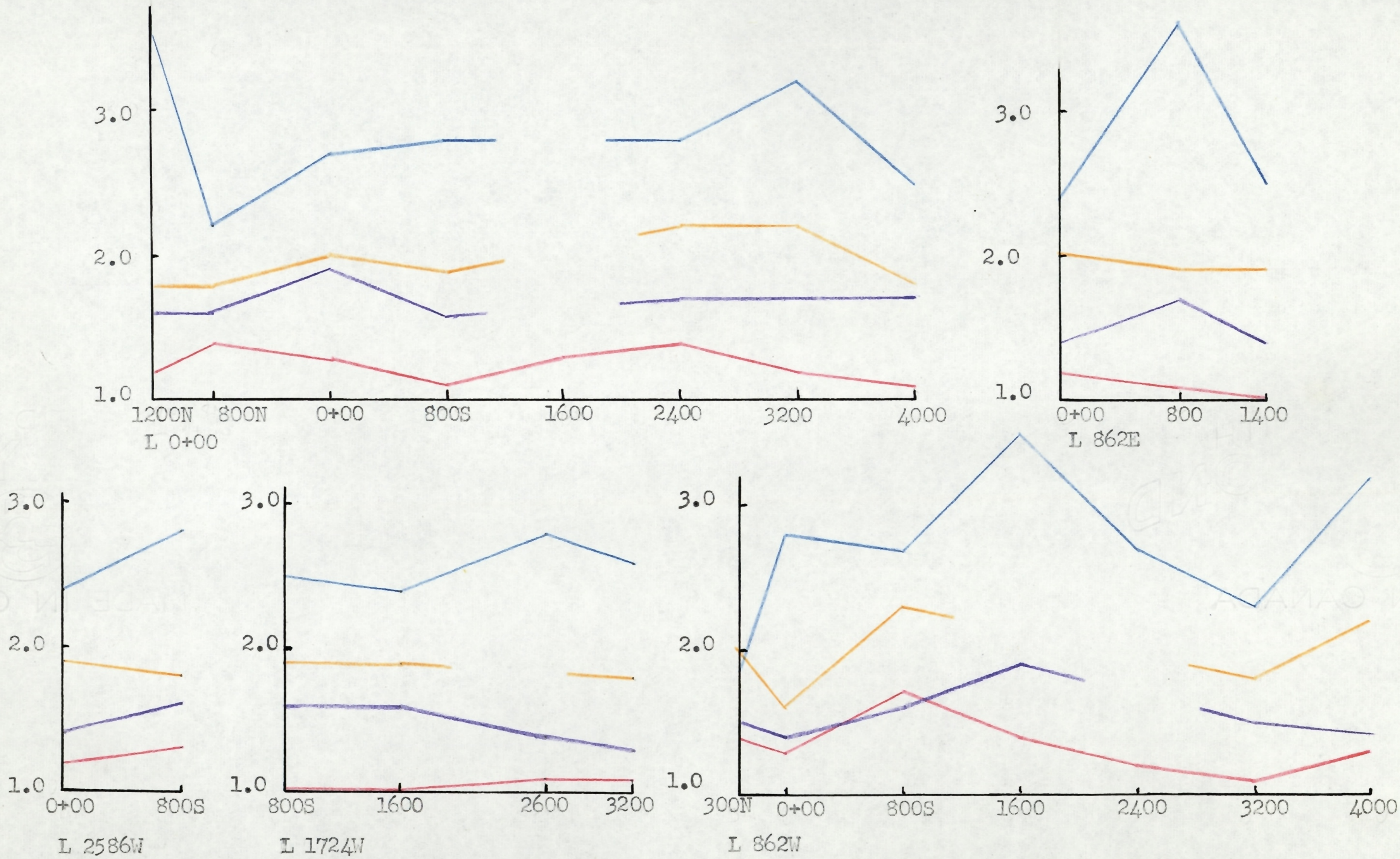


Figure 113. SCOTT LAKE BOG - Profile graphs - Lines 2586W, 1724W, 862W, 0+00, and 862E
Percentage ash of plant samples
Scales: Vertical 1 in. = 1 percent; Horizontal 1 in. = 1000 feet

— Black Spruce stems (2 yr. old)
— Larch stems (2 - 4 yr. old)
— Leather-leaf stems (2 yr. old)
— Leather-leaf leaves

MATTAGAMI LAKE MINES

Introduction

Sample area - This area was not a peat bog even though humus up to two feet deep had developed from Sphagnum moss, thus, the data presented in this section cannot be compared to the data in the two previous sections on an equal basis.

Sampling points - The sampling of plants for metal analysis on the Mattagami Lake Mines Property took place at a total of 62 points on the grid. The Sampling points occurred at 200 foot and 400 foot intervals on alternate lines 200 feet apart. These sampling points are marked on figure 115. Nearly all samples were taken north of the base line. The terrain and the drainage channels sloped gently to the north.

Species collected and analyzed - Black Spruce was the only tree species present. Twigs were collected and the 2 year - old stems analyzed. Twigs of the shrub, Speckled Alder (*Alnus rugosa* (DuRoi) Spreng. var. *americana* (Regel) Fern.) were collected when present. Stems 2 - 5 years old were analyzed. Twigs of the ever-present Labrador-tea were also collected and the 2 year - old stems analyzed. Whole plants of the herb, Wood-Horsetail (*Equisetum sylvaticum* L.) and the moss (*Sphagnum* spp.) were collected and analyzed. The Horsetail was collected whenever present.

All samples were analyzed for copper, zinc, lead and nickel. The metal contents are expressed in parts per million on the basis of the air-dried weight (ppm - dry wt.), and in parts per million on the basis of the ash weight (ppm - ash). The copper:zinc ratio and the percentage ash of each sample were calculated. Only the ppm - dry wt. figures are used here.

Zinc - The zinc contents of each species are plotted on plant association maps in figures 115 to 119. There is some correlation between the zinc contents and the forest associations as shown in Table VIII. The first three species are positively correlated with the Spruce - Labrador-tea Association and the last two species are positively correlated with the Spruce - Fir - Alder Association.

TABLE VIII

Average zinc contents (ppm - dry wt.) in Forest Associations

Sample species	(a) Spruce - Labrador-tea	(b) Spruce-Fir-Alder
Black Spruce	41 (14)	36 (11)
Speckled Alder	77 (11)	69 (20)
Labrador-tea	29 (27)	26 (29)
Wood-Horsetail	61 (8)	67 (19)
Sphagnum Moss	39 (19)	44 (20)

* No. of samples in brackets

The zinc contents of the surface clays are contoured in figure 120.

The zinc contents of each species are contoured in figures 121 to 125. The contour maps show several areas of high values over and about the ore body outlines. The high areas of each species are usually independent of each other, however, there is some overlap between high areas in Alder and Labrador-tea, and Alder and Horsetail.

The histograms of the zinc contents in figure 126 show some extensions on the sides of the high values. The histograms of Spruce and Alder show some high values on a normal shape. The histograms of Horsetail and Sphagnum show two peaks.

Copper - The copper contents of each species are plotted on plant association maps in figures 128 to 132.

The copper contents of each species are contoured in figures 134 to 138. The contour map of Labrador-tea shows a high area directly over the ore body.

The histograms of the copper contents are in figure 139. Those of Horsetail and Sphagnum moss are symmetrical in shape. The Alder histogram has two peaks and the Spruce and Labrador-tea histograms have some high values.

Cu:Zn ratio - The Cu:Zn ratios of each species are contoured in figures 140 to 144. Several high values occur within the outlines of the ore bodies.

The histograms of the Cu:Zn ratios in figure 145 all have some higher values.

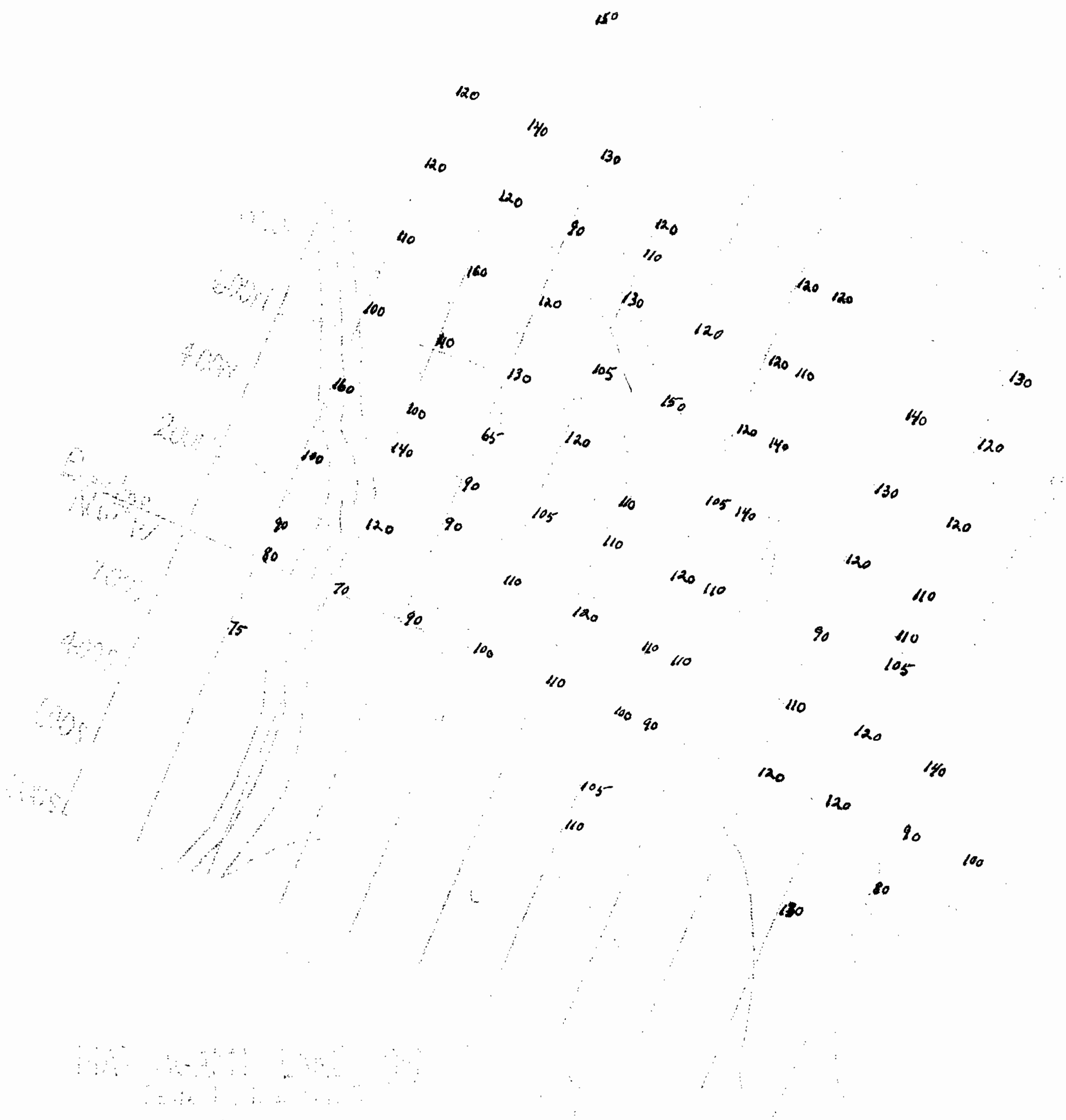


Figure 114

Zinc contents of surface clays in ppm - dry wt.

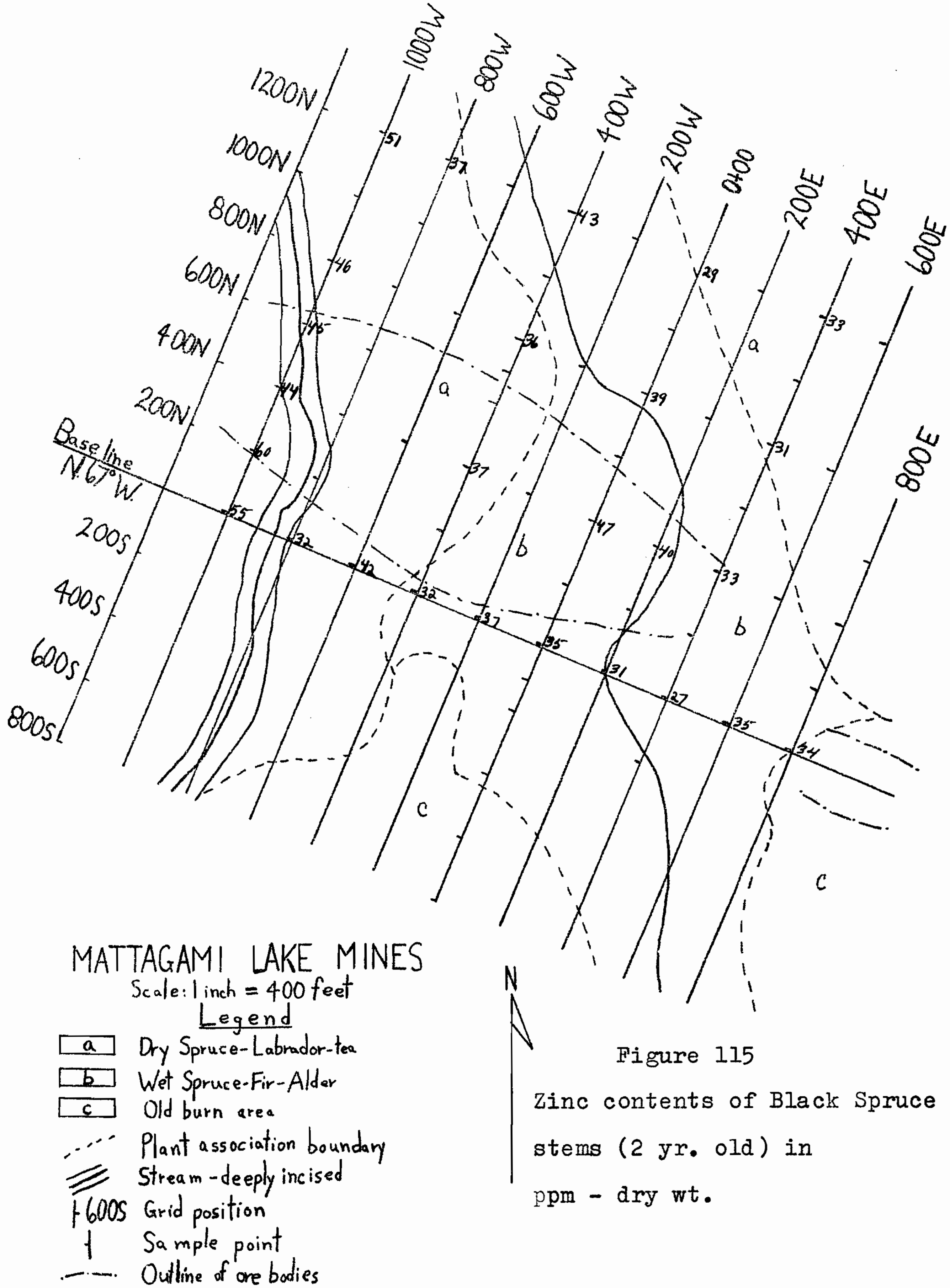


Figure 115

Zinc contents of Black Spruce stems (2 yr. old) in ppm - dry wt.

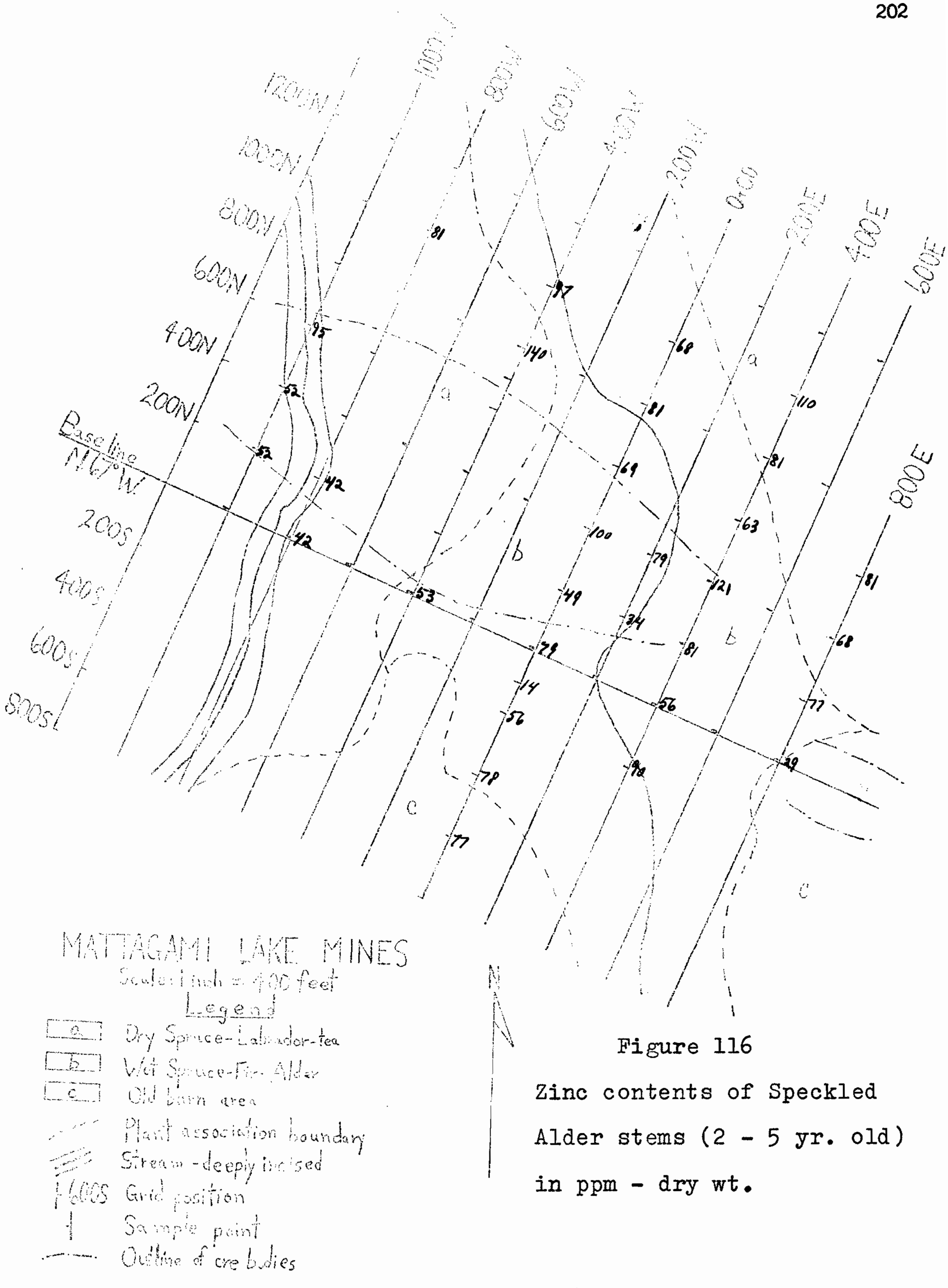


Figure 116

Zinc contents of Speckled Alder stems (2 - 5 yr. old) in ppm - dry wt.

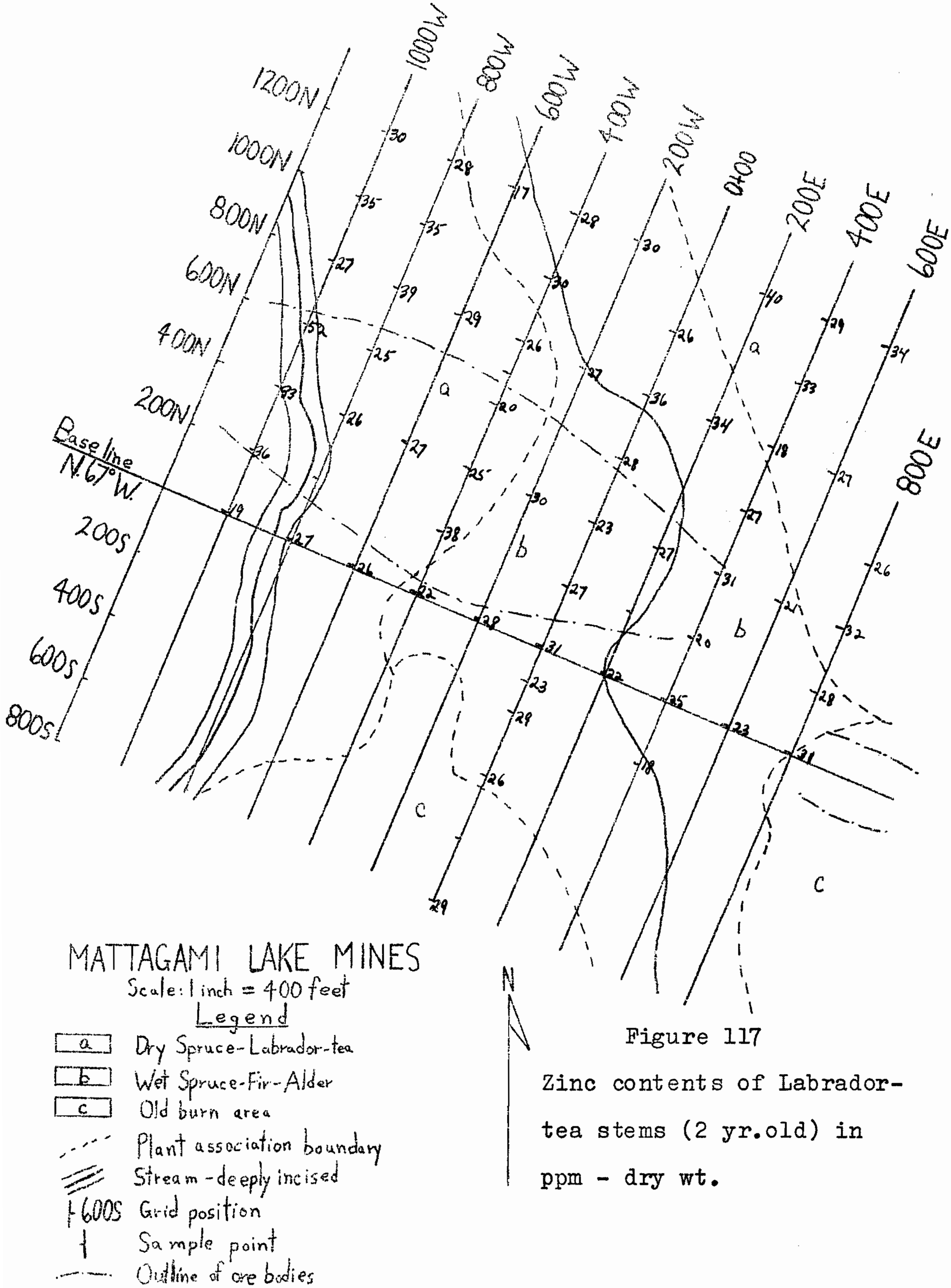


Figure 117

Zinc contents of Labrador-tea stems (2 yr.old) in ppm - dry wt.

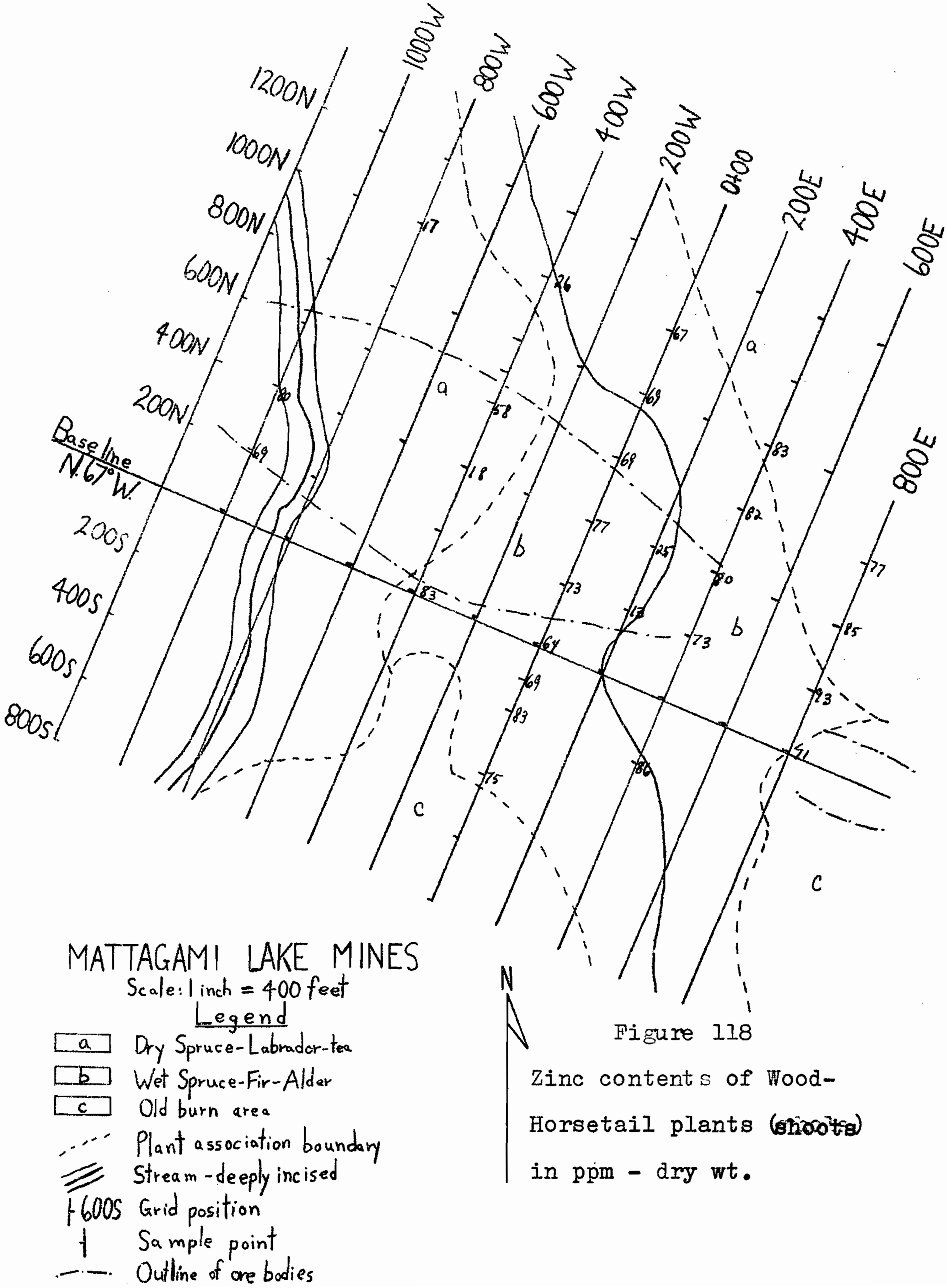


Figure 118

Zinc contents of Wood-Horsetail plants (shoots) in ppm - dry wt.

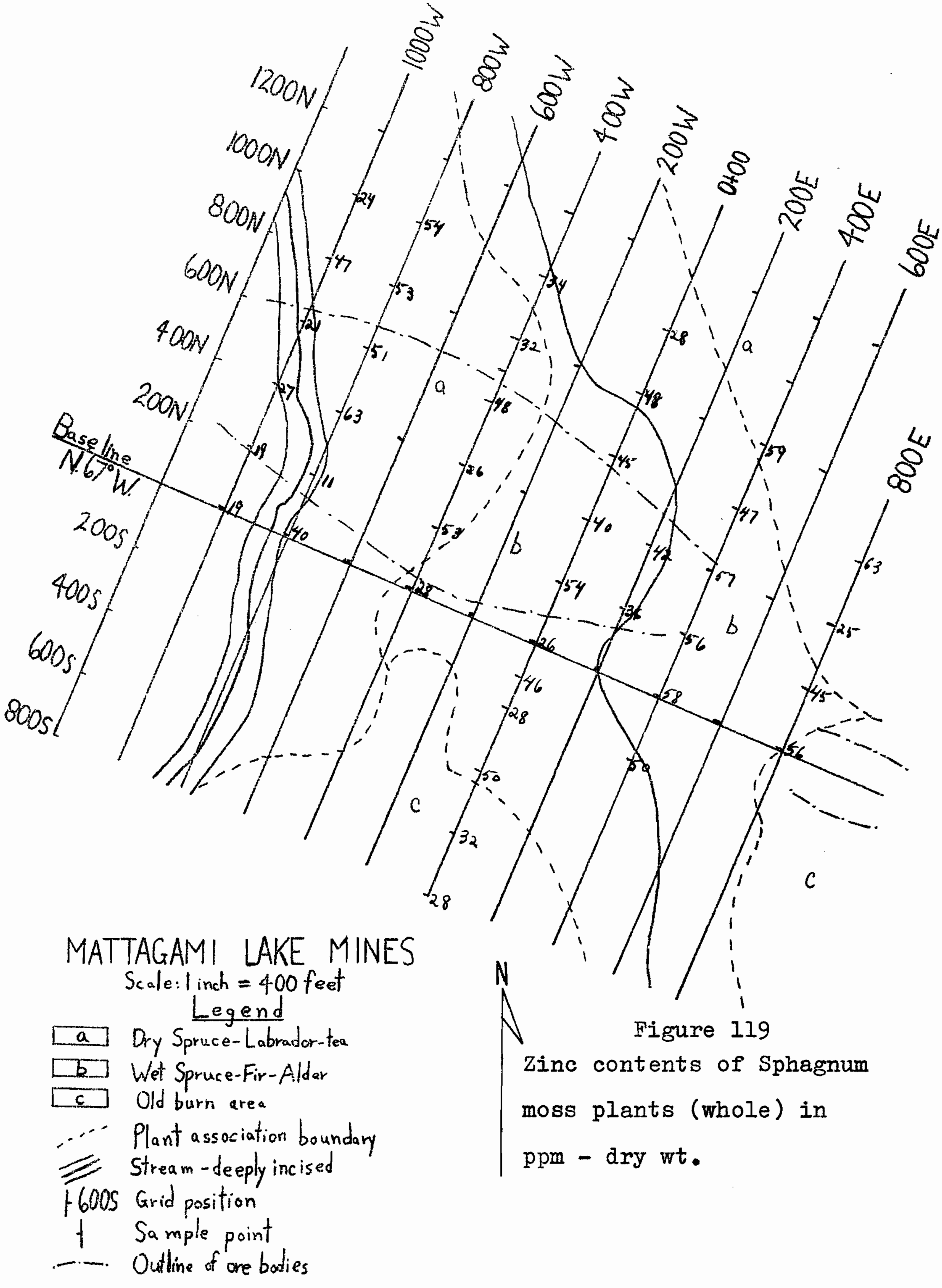


Figure 119

Zinc contents of Sphagnum moss plants (whole) in ppm - dry wt.

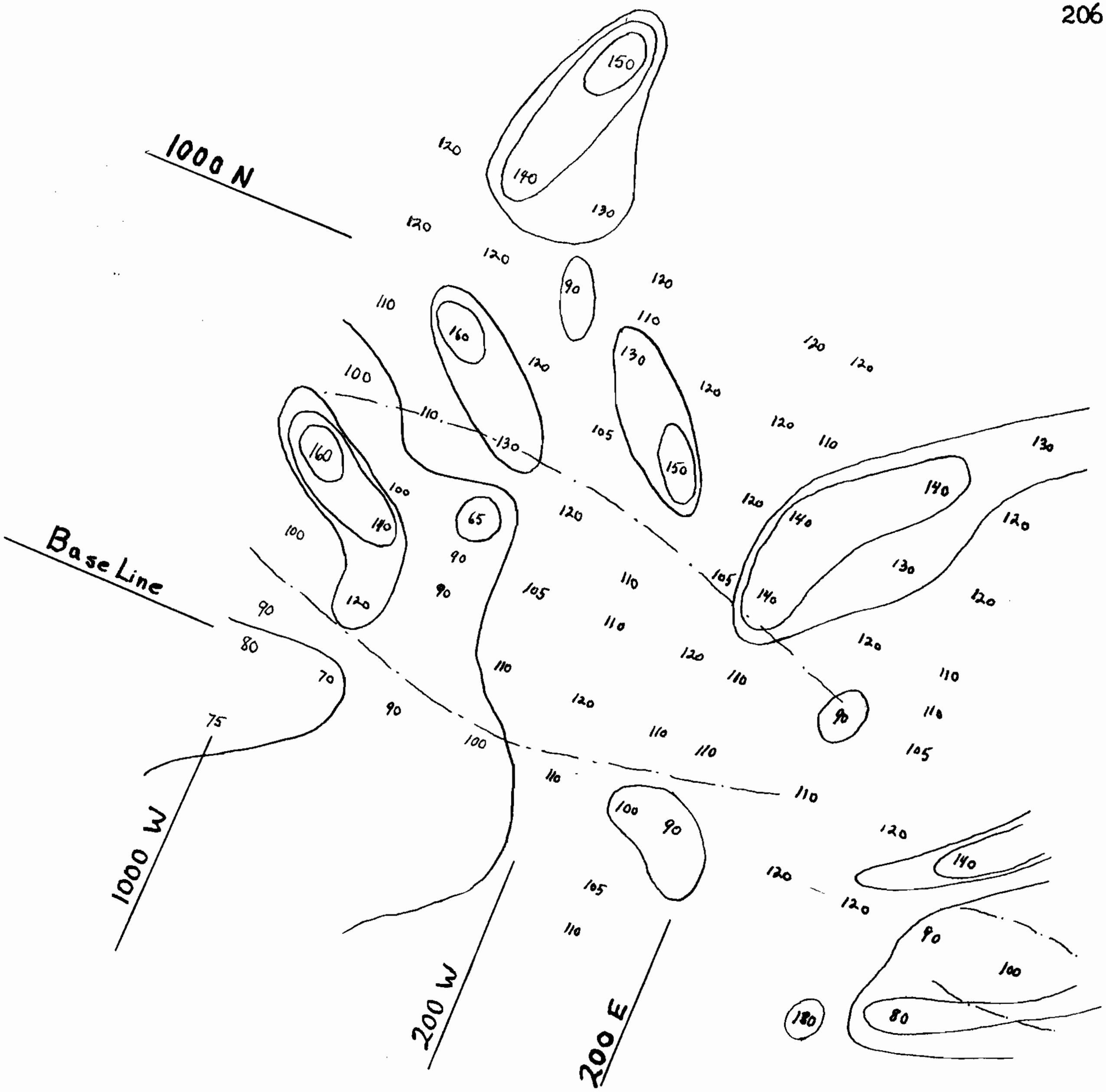


Figure 120 - MATTAGAMI LAKE MINES - Contour map

Contour interval - 20 ppm (61-80)

Zinc contents of surface clays

in ppm - dry wt.

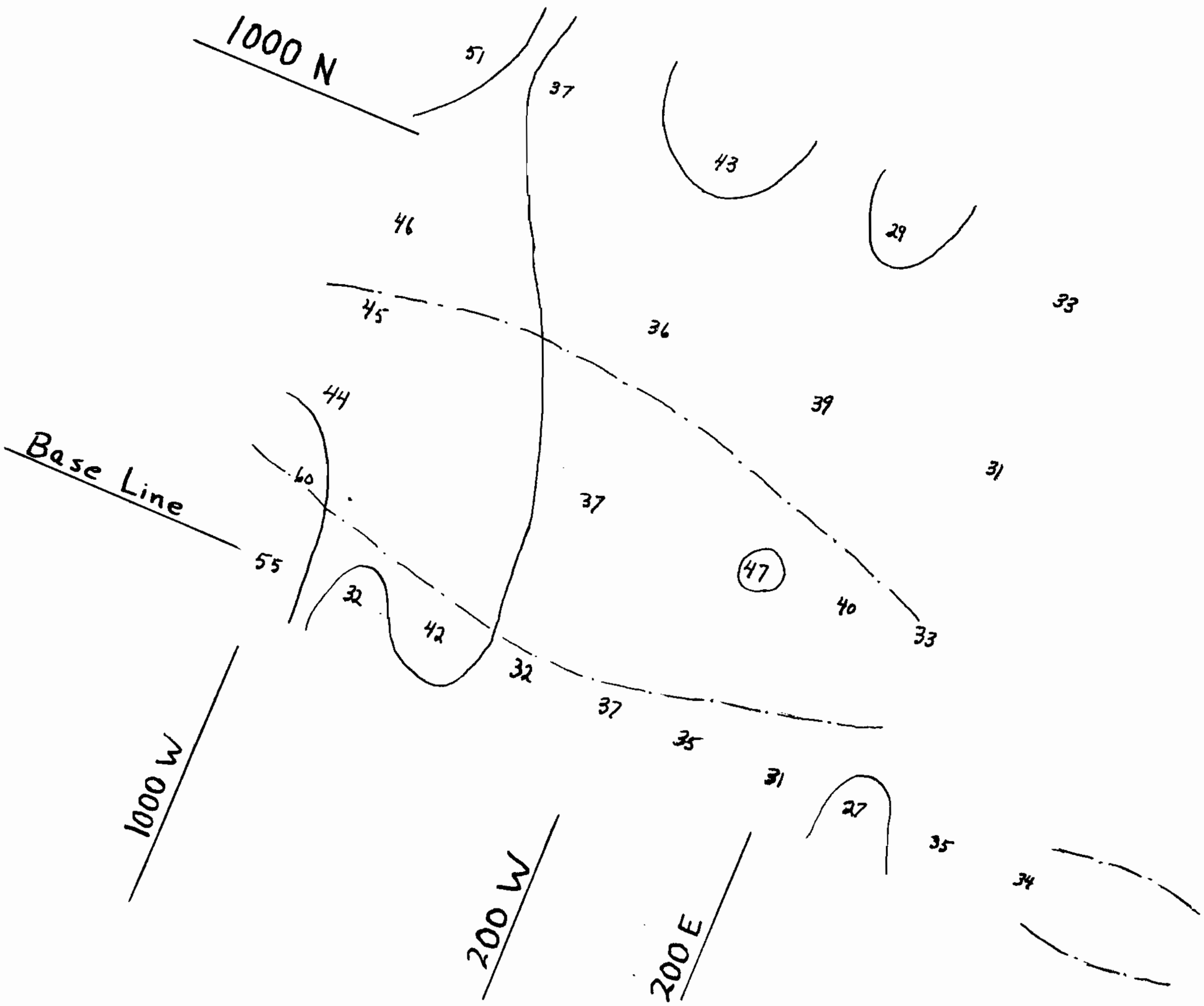


Figure 121. MATTAGAMI LAKE MINES - Contour map

Contour interval - 10 ppm (21-40)

Zinc contents of Black Spruce

stems (2 yr. old) in ppm - dry wt.

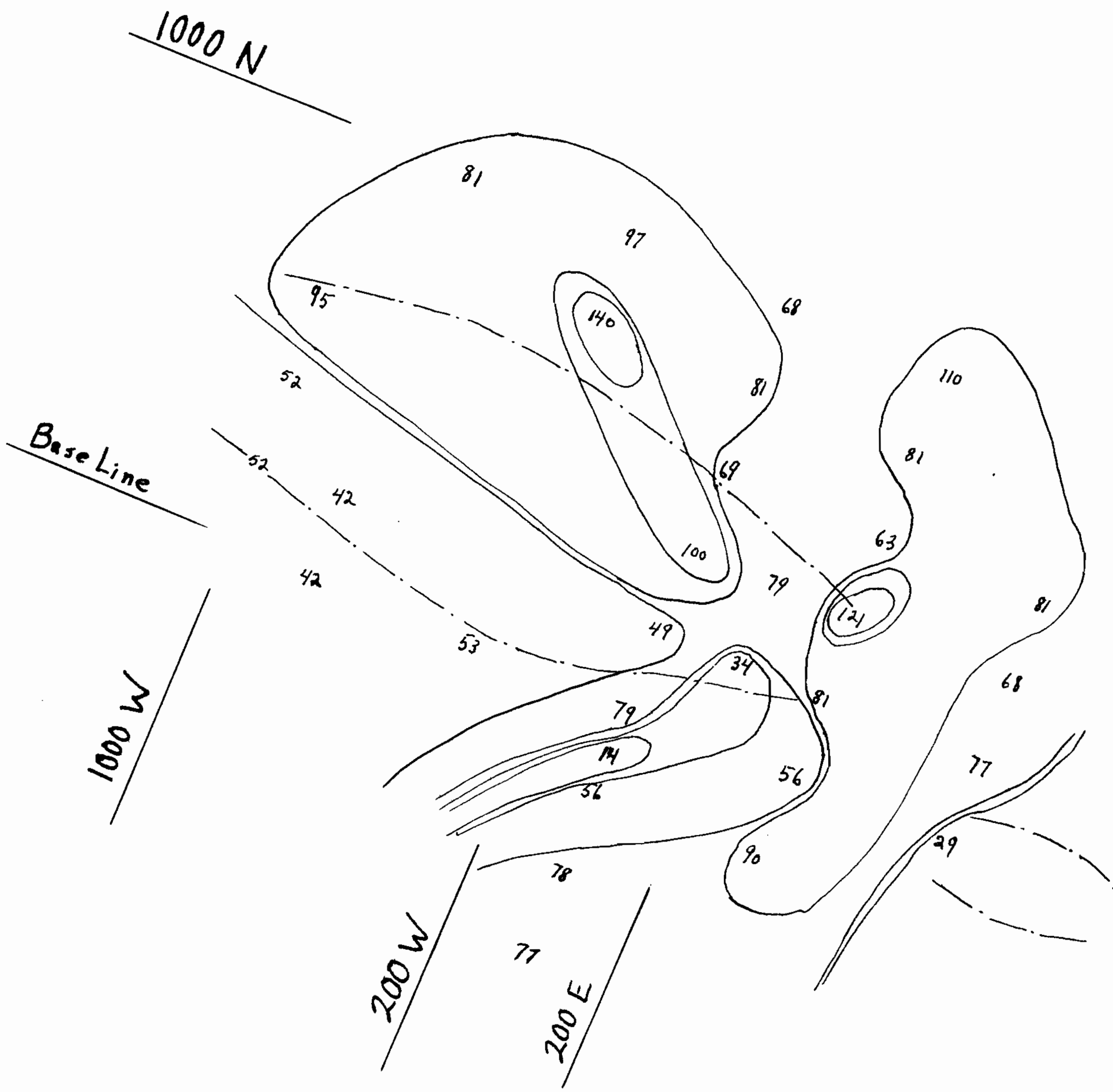


Figure 122. MATTAGAMI LAKE MINES - Contour map

Contour interval - 20 ppm (21 - 40)

Zinc contents of Speckled Alder

stems (2-5 yr. old) in ppm - dry wt.

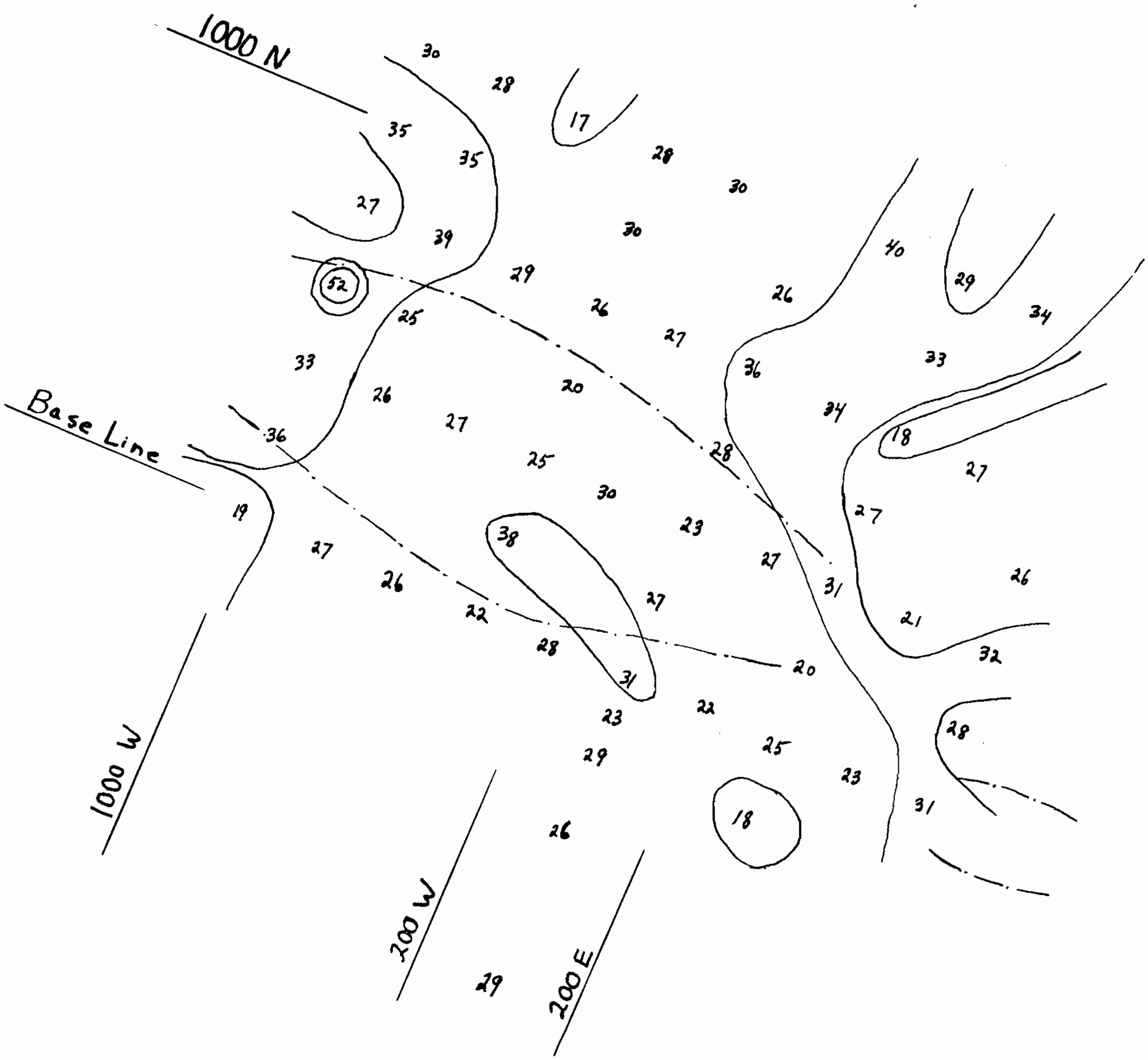


Figure 123 MATTAGAMI LAKE MINES - Contour map

Contour interval - 10 ppm (21-30)

Zinc contents of Labrador-tea

stems (2 yr. old) in ppm - dry wt.

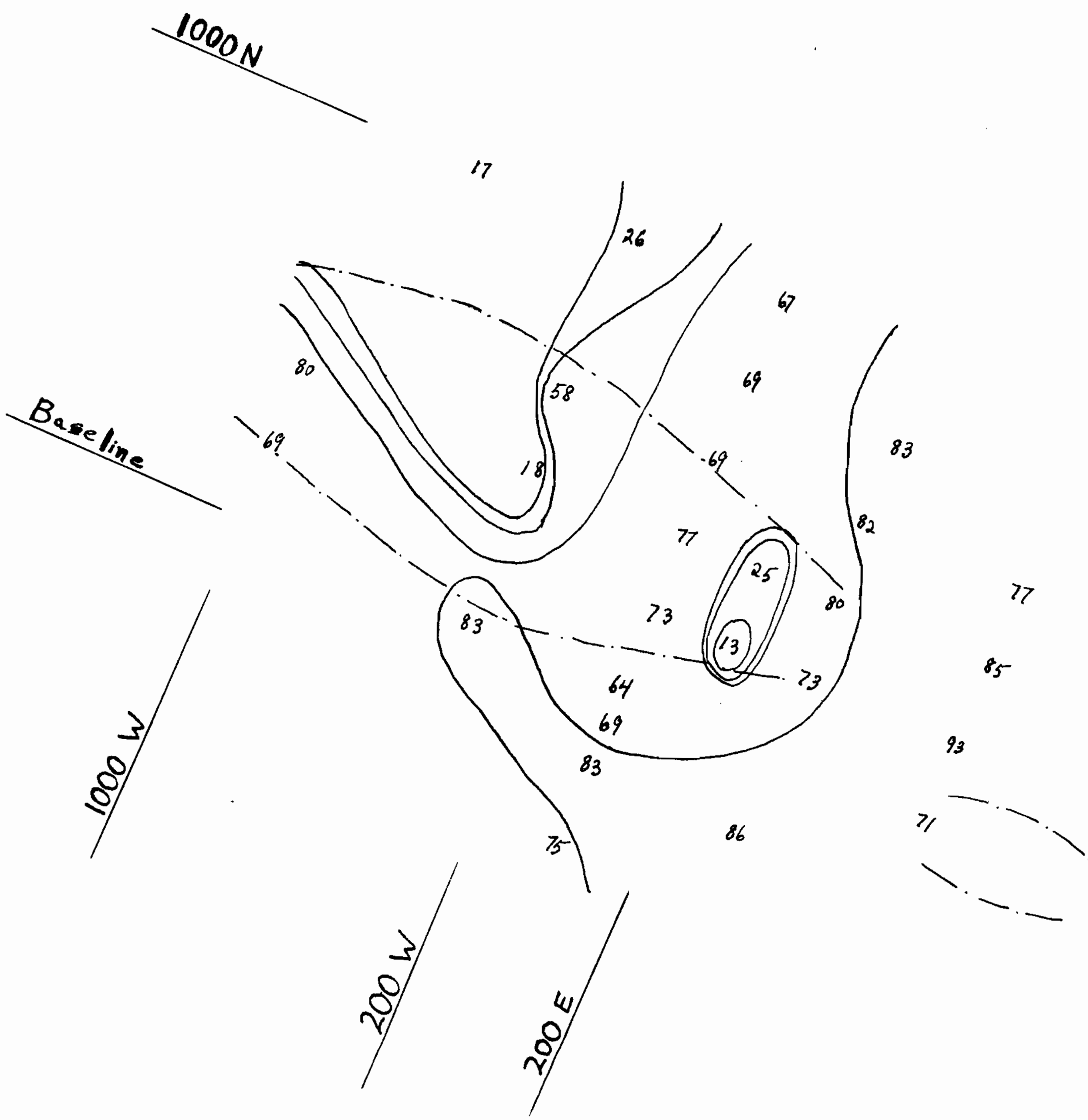


Figure 124. MATTAGAMI LAKE MINES - Contour map

Contour interval - 20 ppm (61 - 80)

Zinc contents of Wood-Horsetail plants

(shoots) in ppm - dry wt.

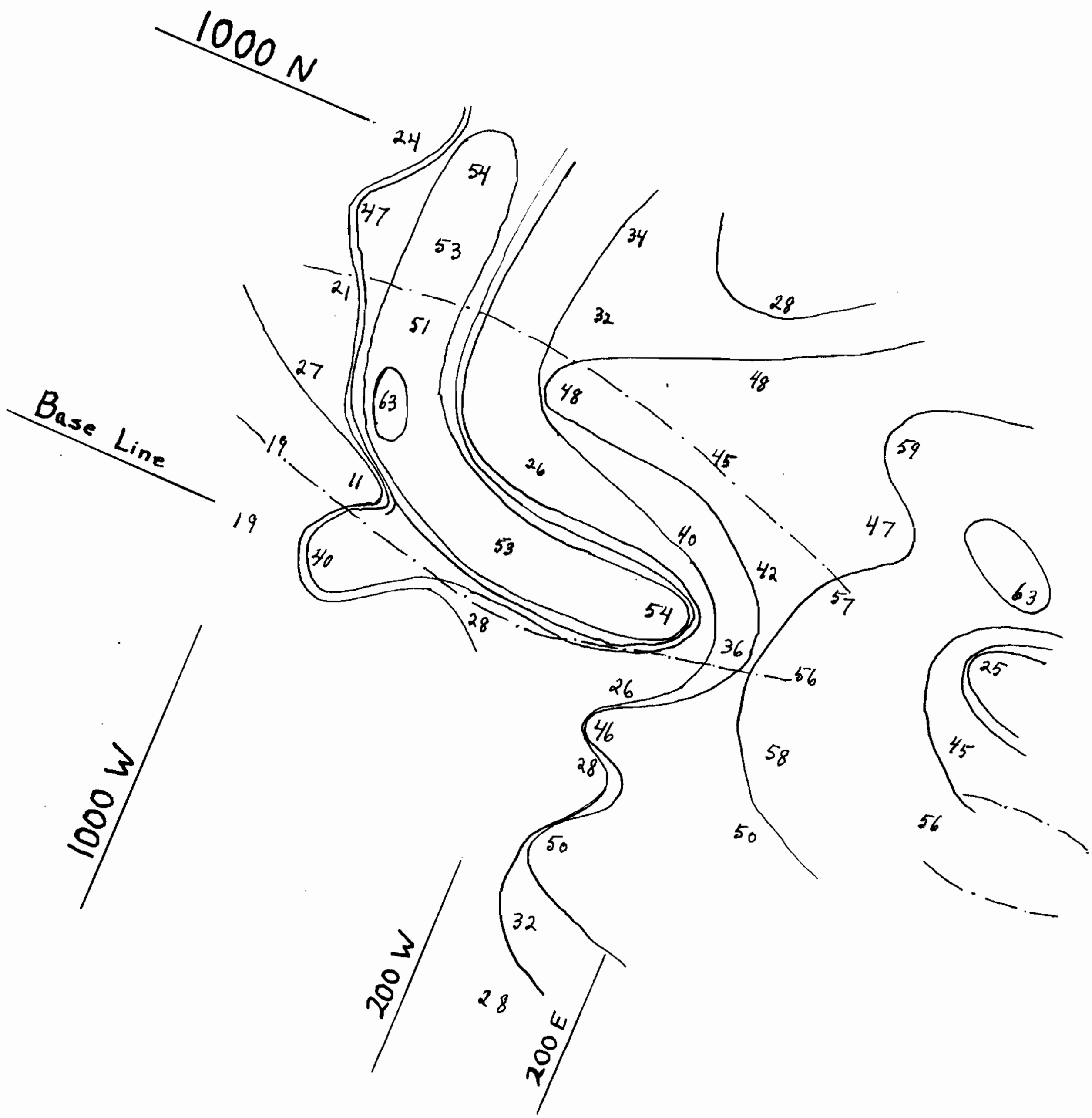


Figure 125. MATTAGAMI LAKE MINES - Contour map
Contour interval - 10 ppm (11 - 20)
Zinc contents of Sphagnum moss plants
(whole) in ppm - dry wt.

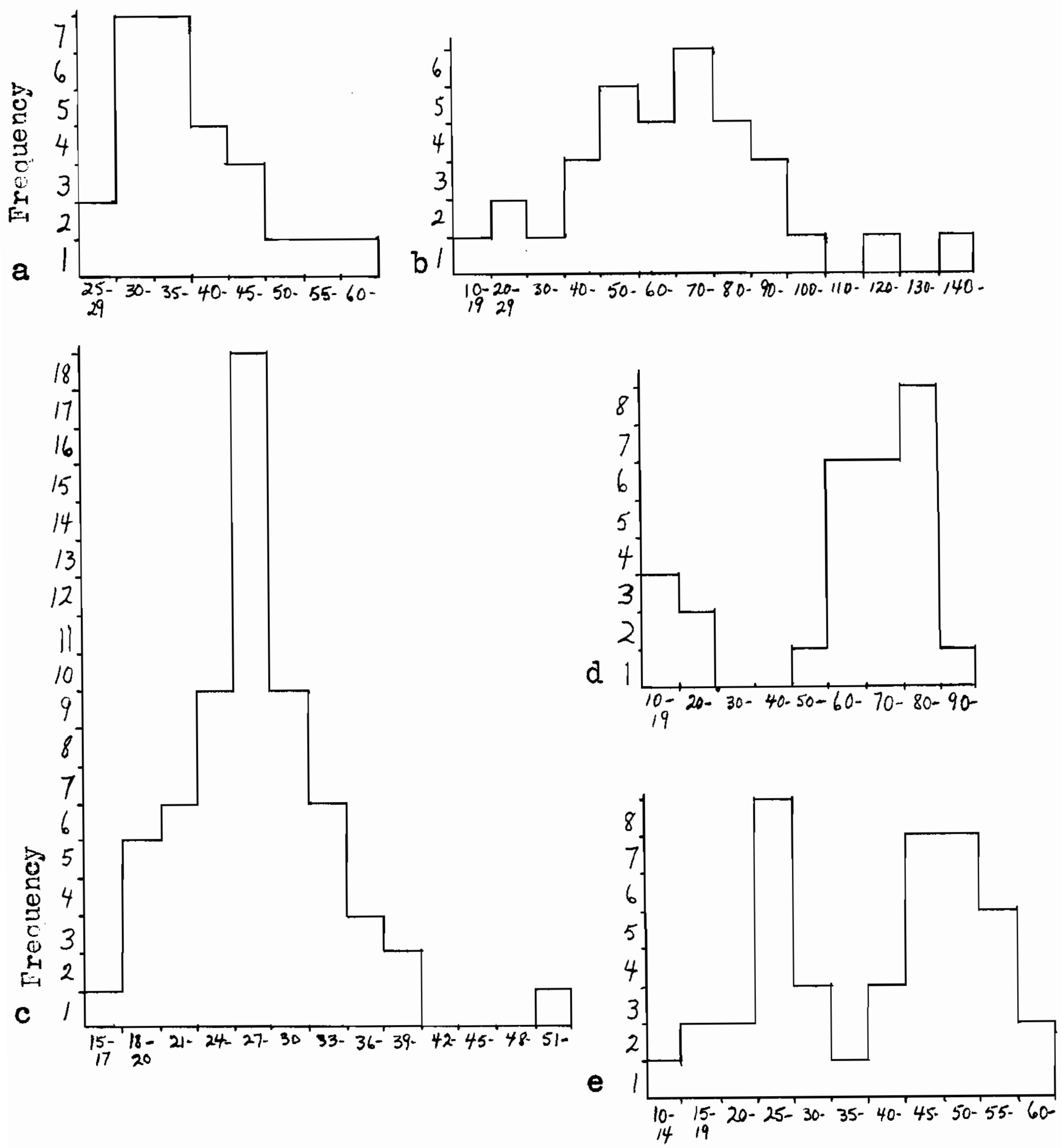


Figure 126. Histogramsof zinc contents (ppm - dry wt.) of plant samples from Mattagami Lake Mines.

	Interval
(a) Black Spruce stems (2 yr. old)	5 ppm
(b) Speckled Alder stems (2-5 yr.old)	10 ppm
(c) Labrador-tea stems (2 yr. old)	3 ppm
(d) Wood-Horsetail plants (shoots)	10 ppm
(e) Sphagnum moss plants (whole)	5 ppm

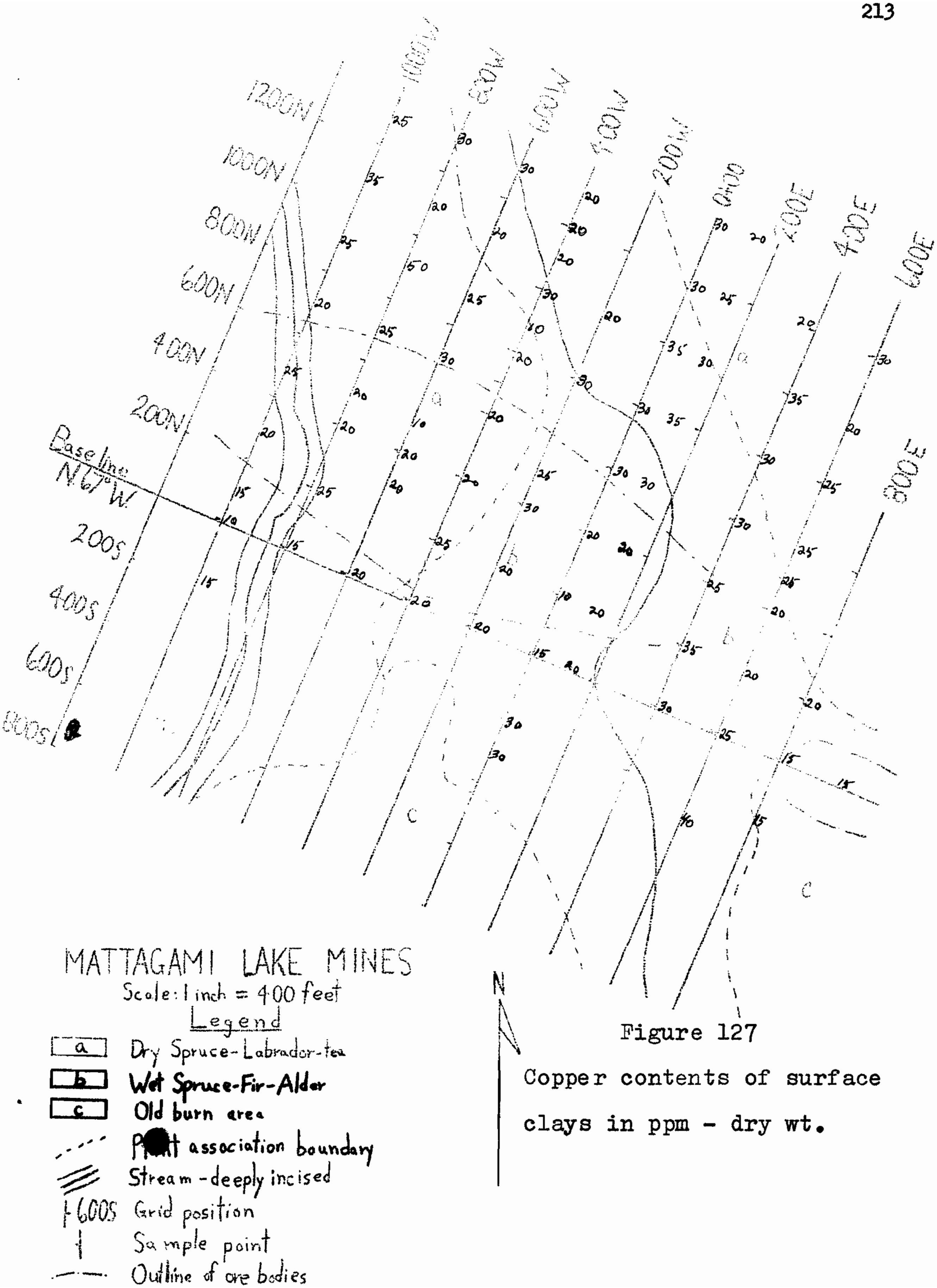


Figure 127

Copper contents of surface clays in ppm - dry wt.

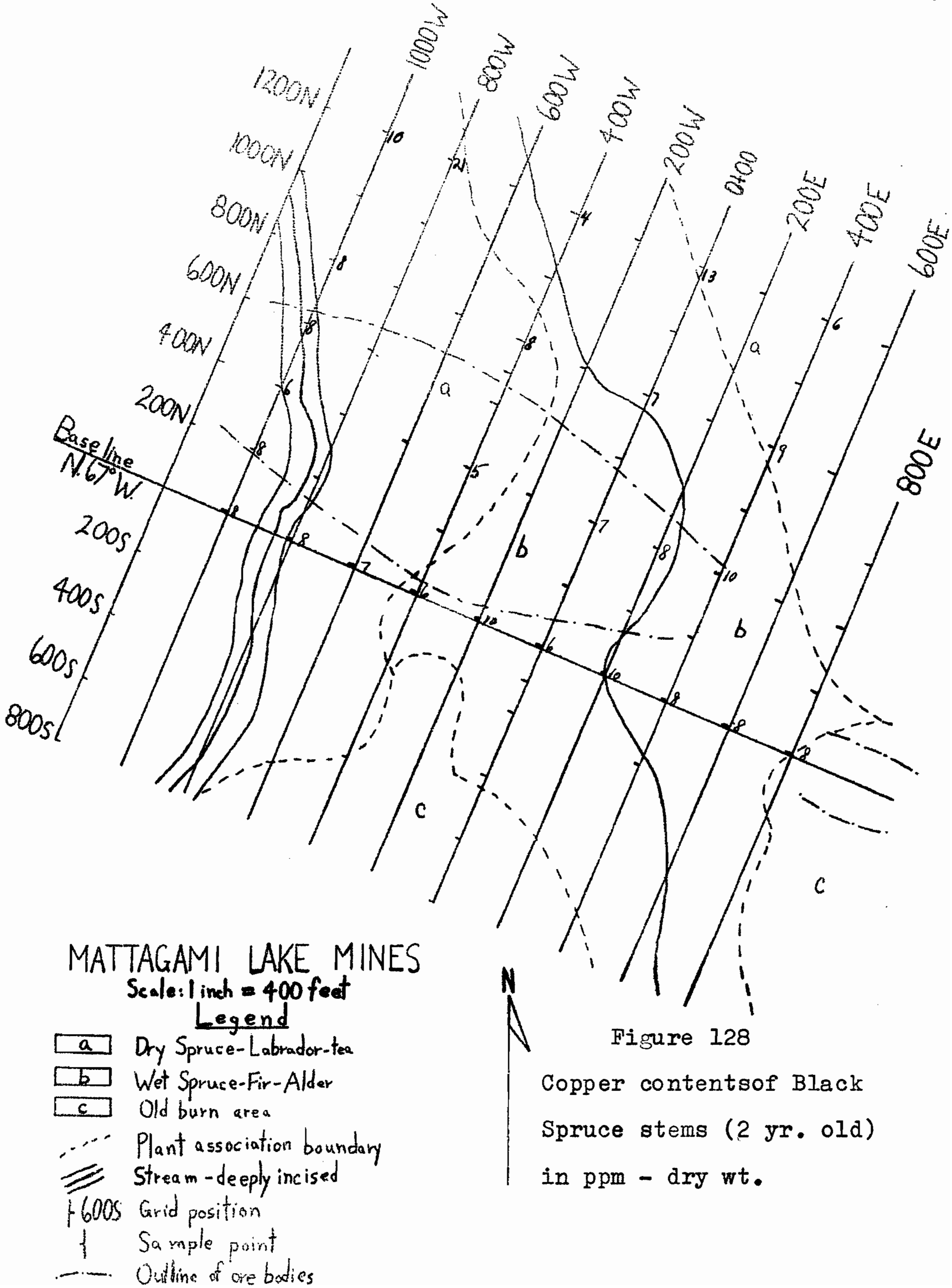


Figure 128

Copper contentsof Black Spruce stems (2 yr. old) in ppm - dry wt.

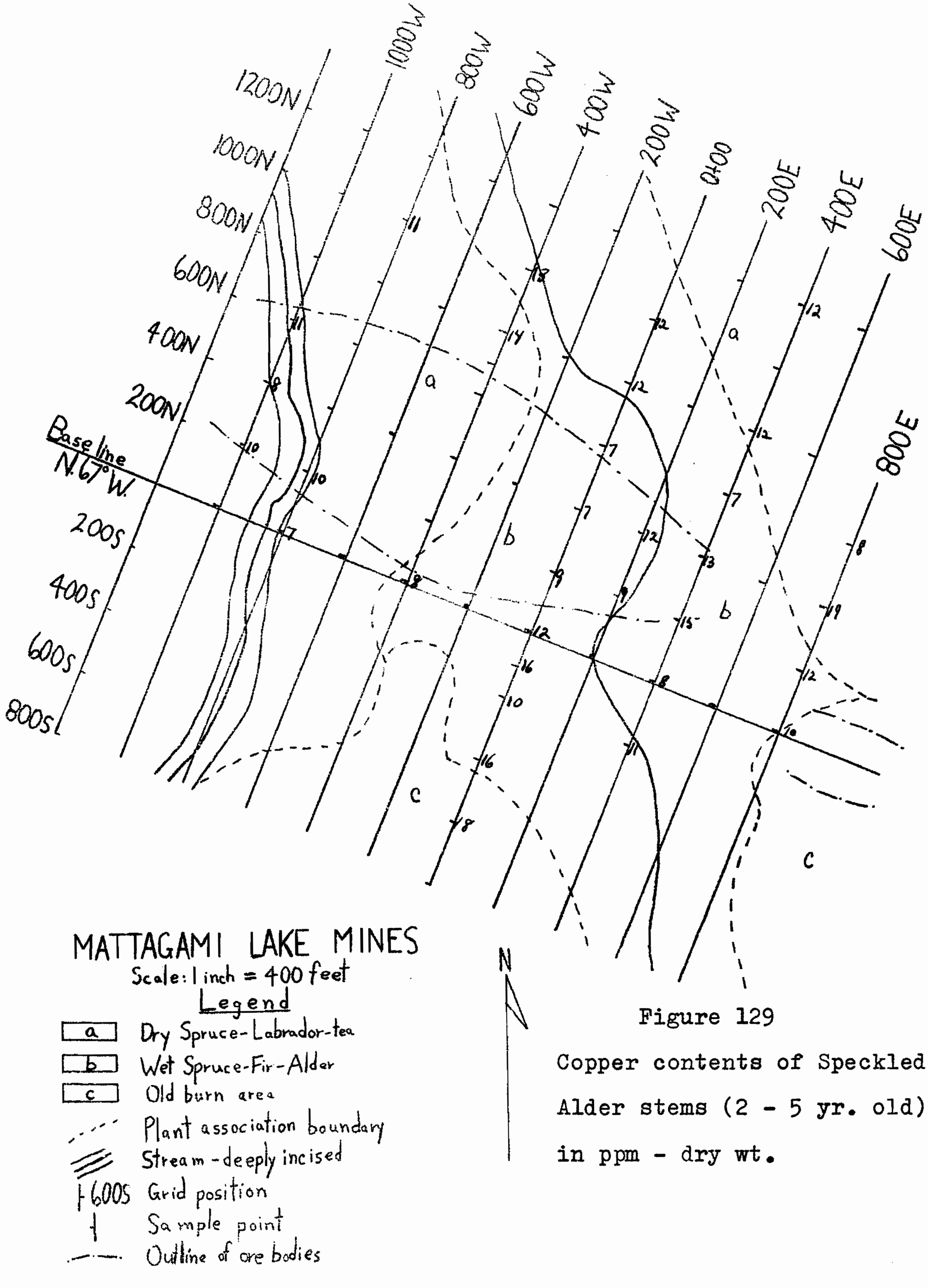


Figure 129

Copper contents of Speckled Alder stems (2 - 5 yr. old) in ppm - dry wt.

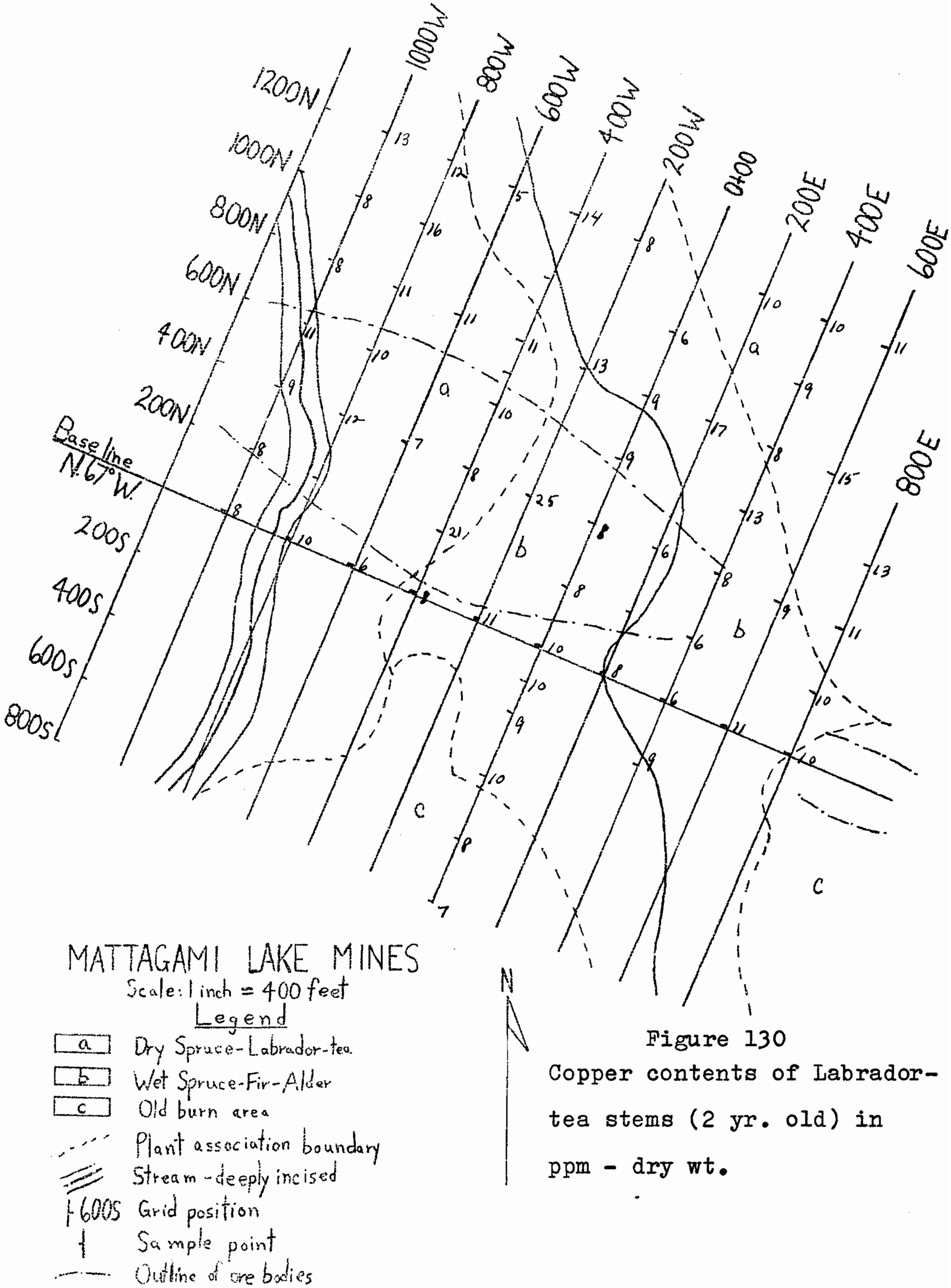


Figure 130
Copper contents of Labrador-tea stems (2 yr. old) in ppm - dry wt.

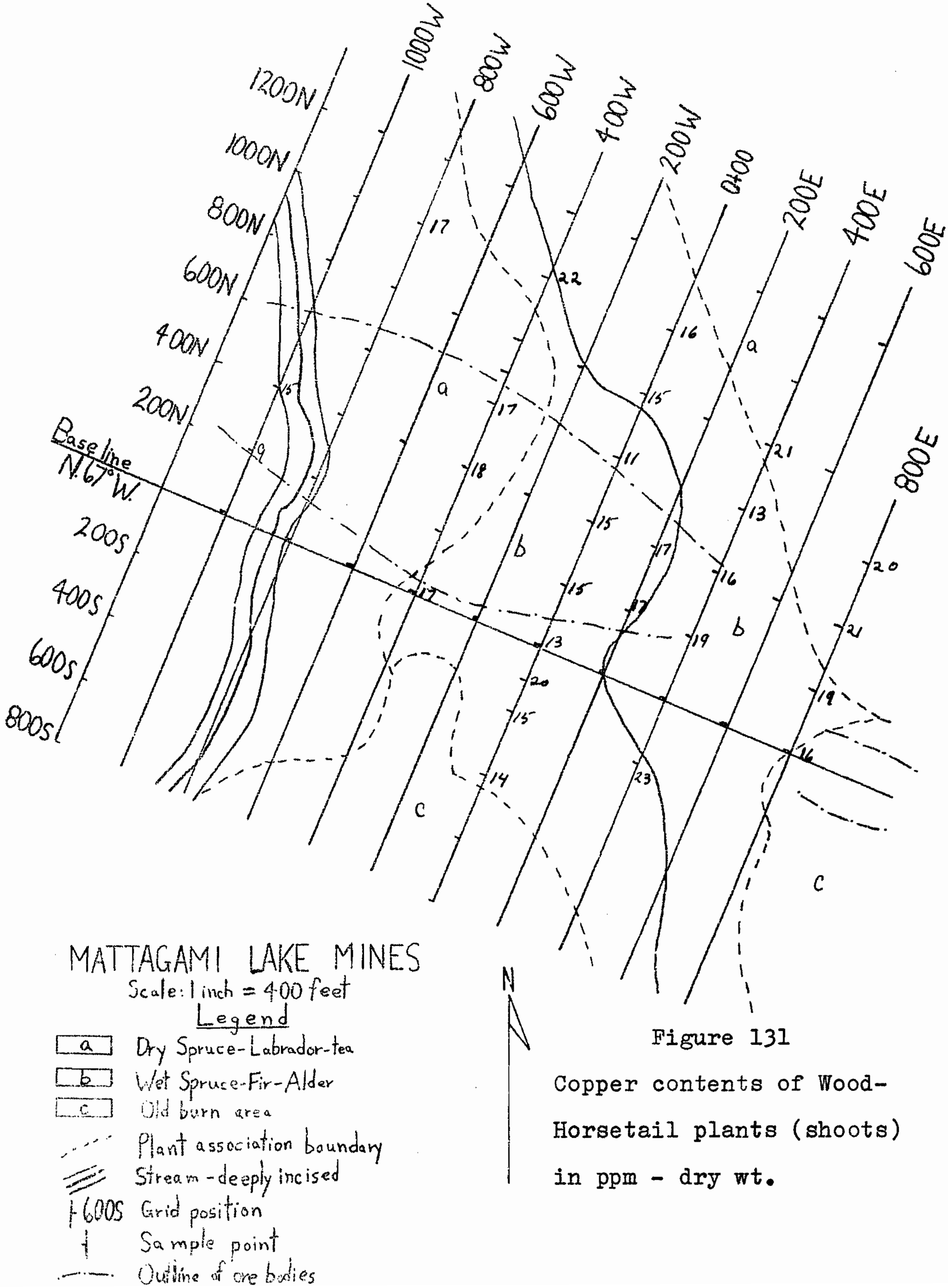


Figure 131

Copper contents of Wood-Horsetail plants (shoots) in ppm - dry wt.

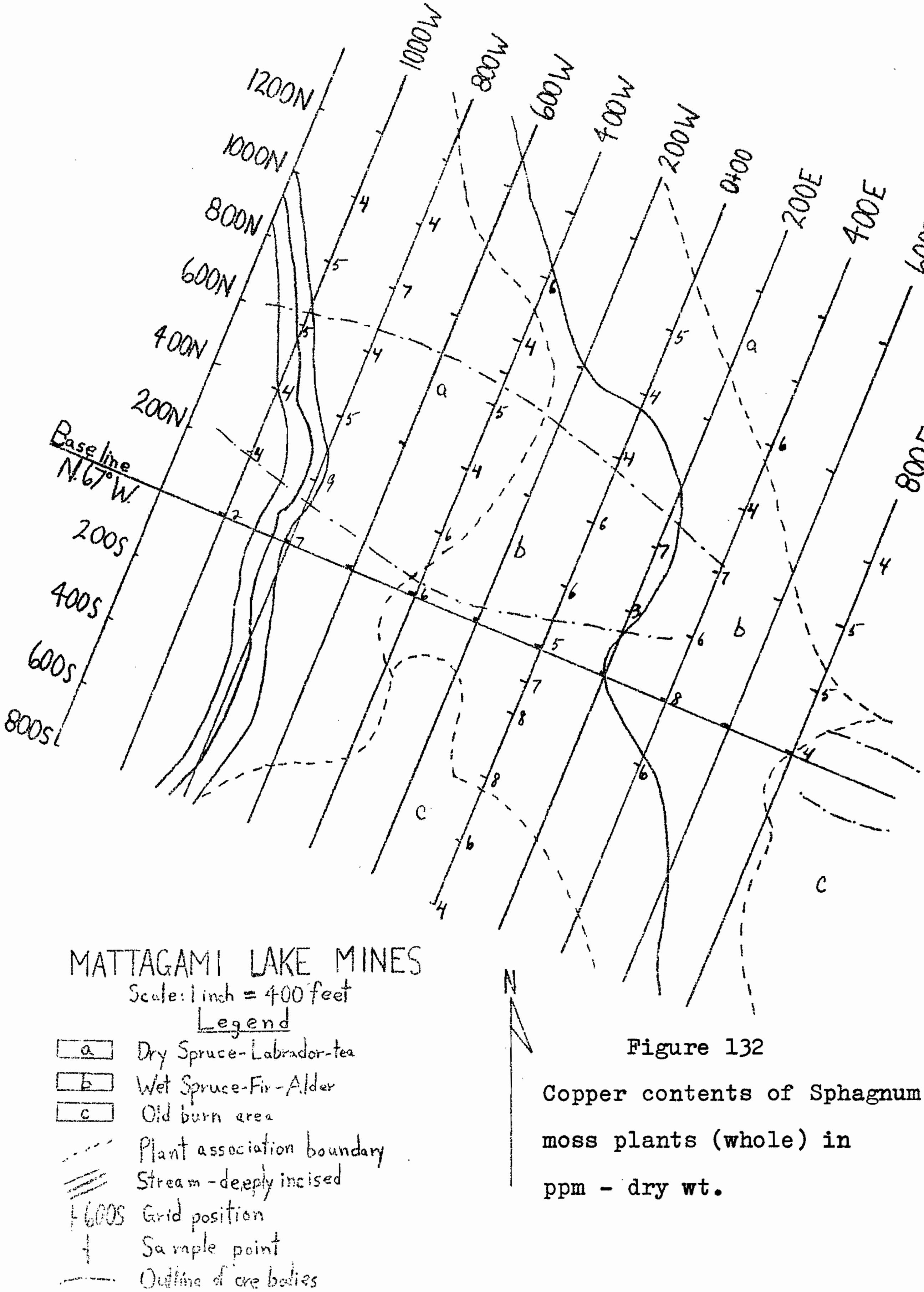


Figure 132

Copper contents of Sphagnum moss plants (whole) in ppm - dry wt.

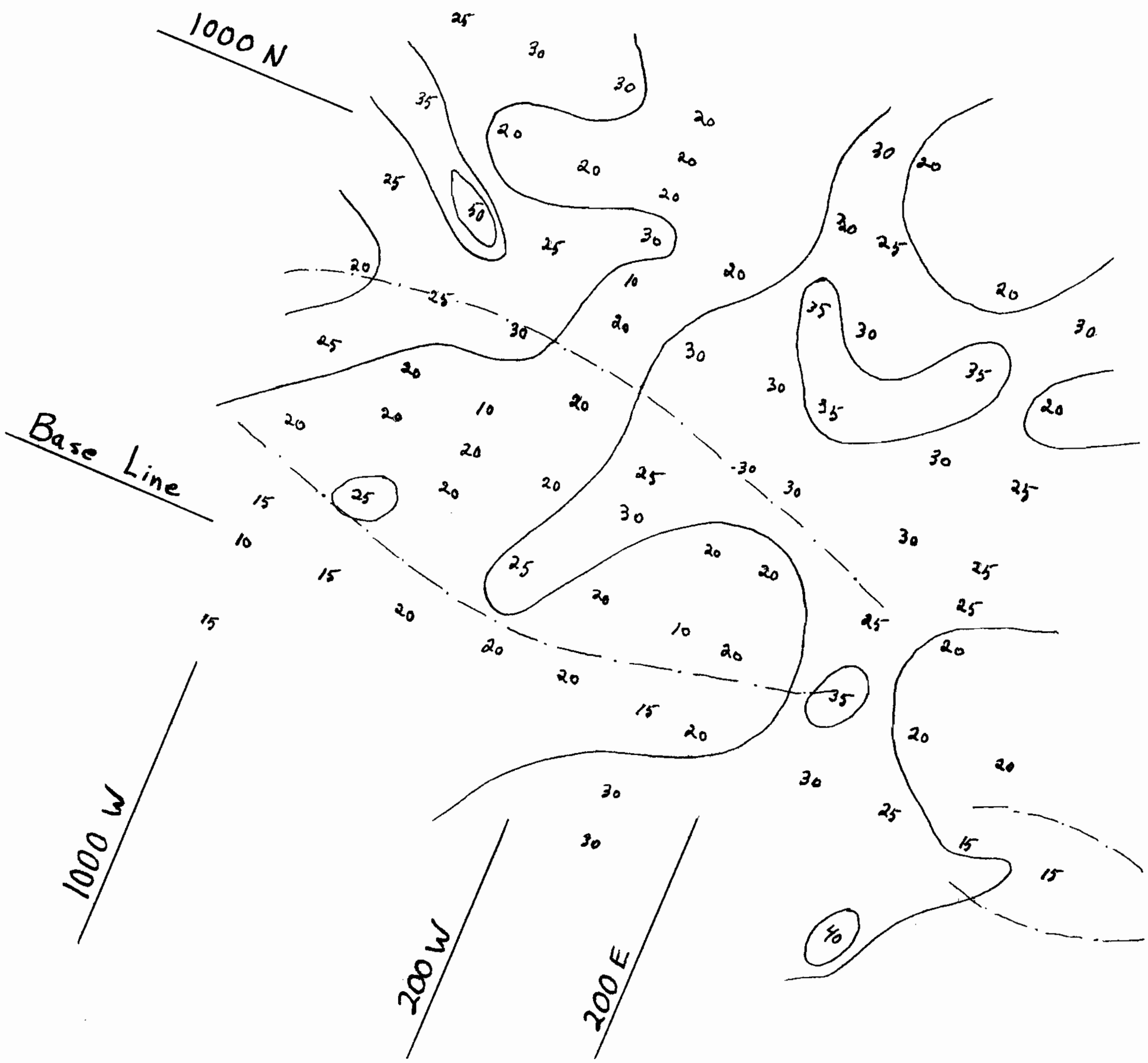


Figure 133. MATTAGAMI LAKE MINES - Contour map
Contour interval - 20 ppm (21-40)
Copper contents of the surface clays
in ppm - dry wt.

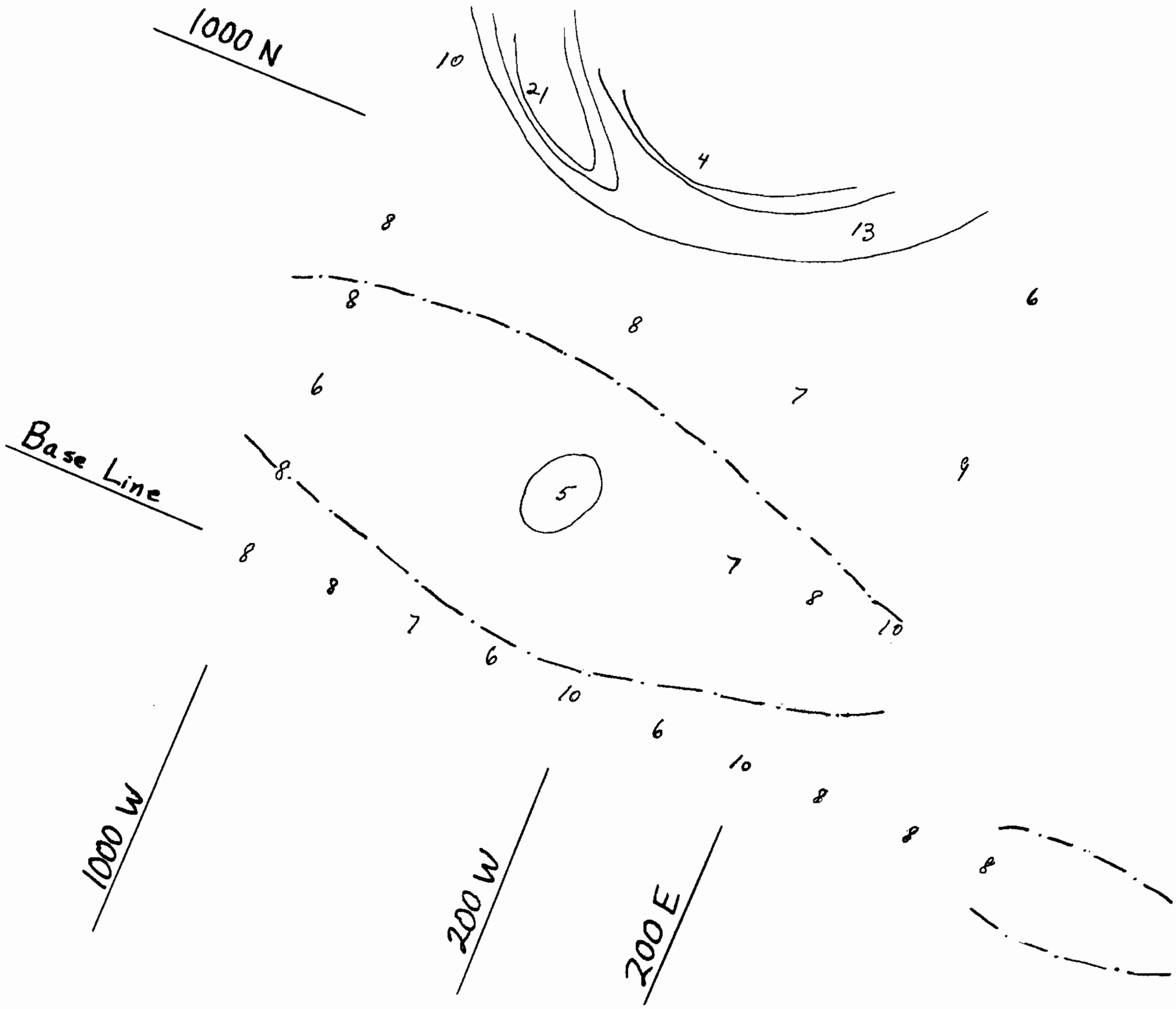


Figure 134. MATTAGAMI LAKE MINES - Contour map.

Contour interval - 5 ppm (6-10)

Copper contents of Black Spruce

stems (2 yr. old) in ppm - dry wt.

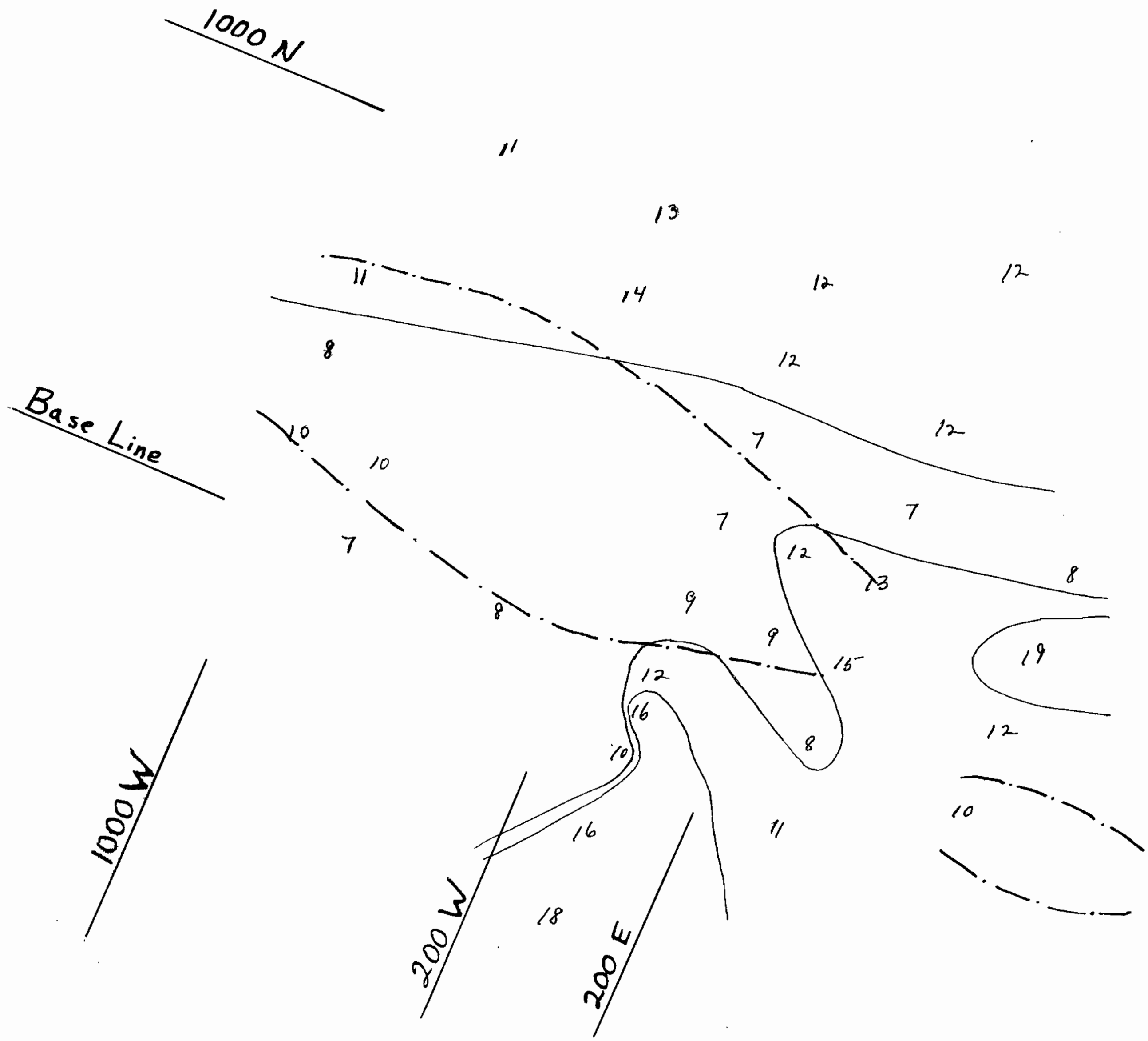


Figure 135. MATTAGAMI LAKE MINES - Contour map
Contour interval - 5 ppm (21-25)
Copper contents of Speckled Alder
stems (2 - 5 yr. old) in ppm - dry wt.

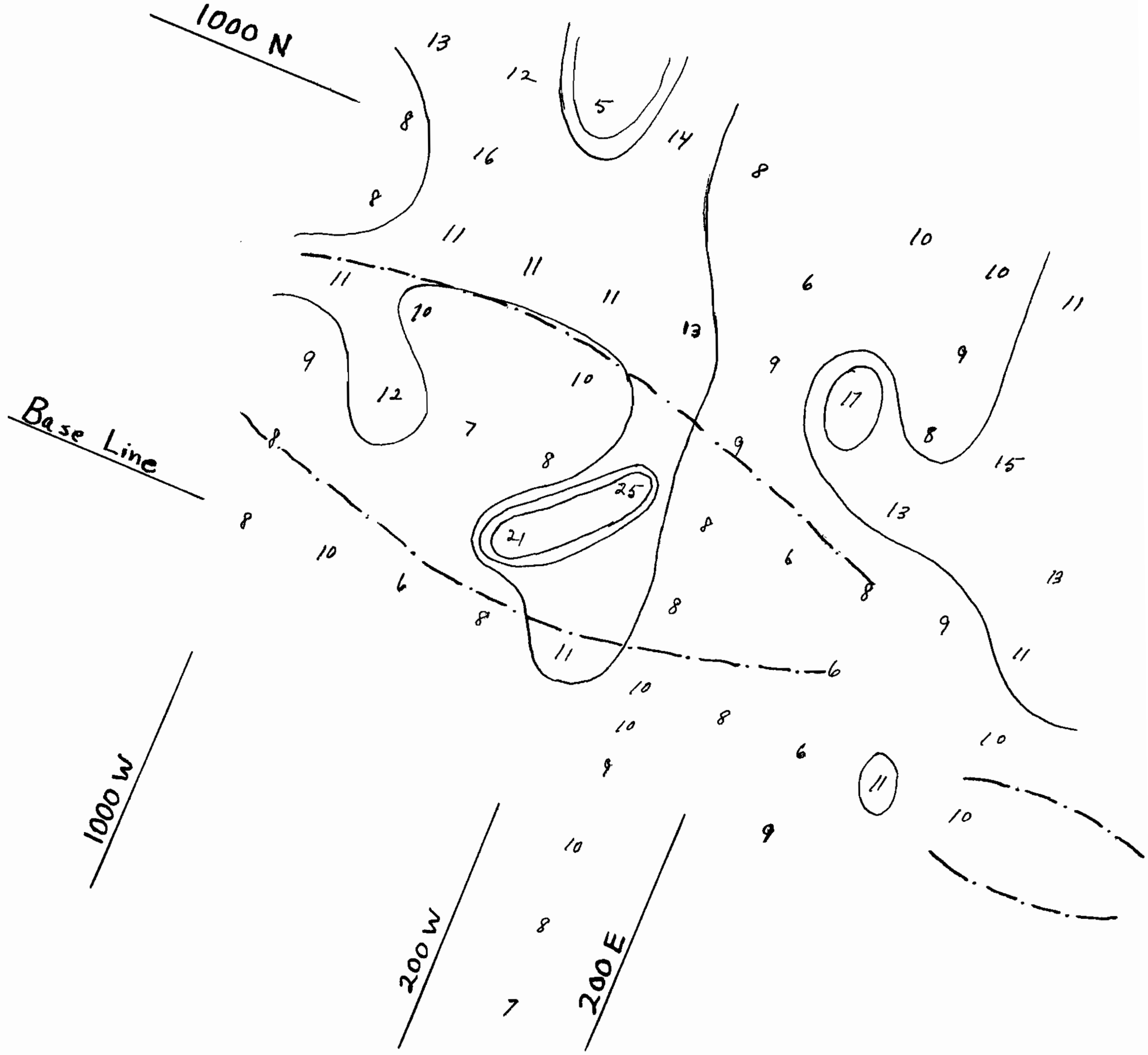


Figure 136. MATTAGAMI LAKE MINES - Contour map
Contour interval - 5 ppm (16-20)
Copper contents of Labrador-tea
stems (2 yr. old) in ppm - dry wt.

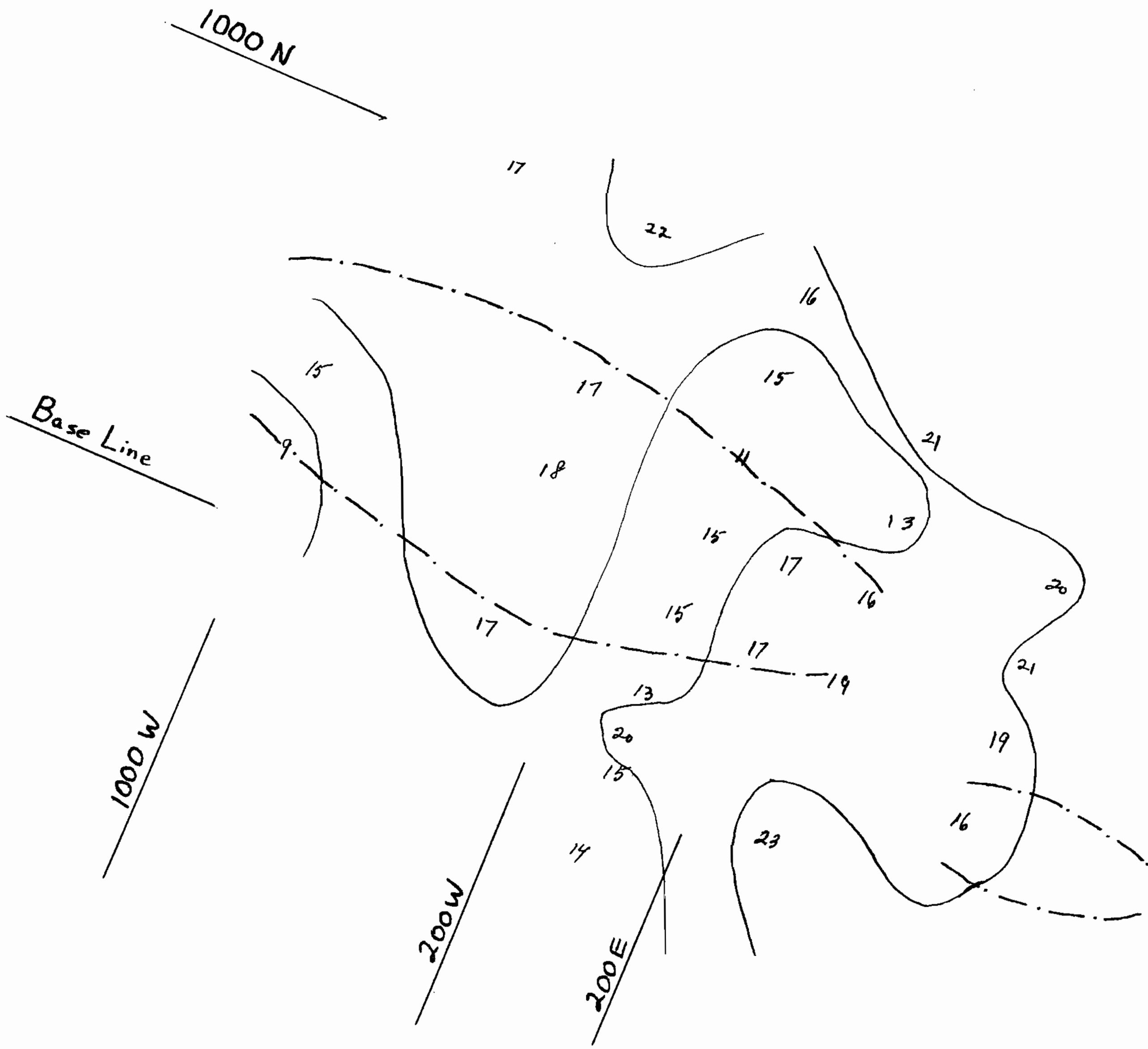


Figure 137. MATTAGAMI LAKE MINES - Contour map
Contour interval - 5 ppm (11-15)
Copper contents of Wood-Horsetail
plants (shoots) in ppm - dry wt.

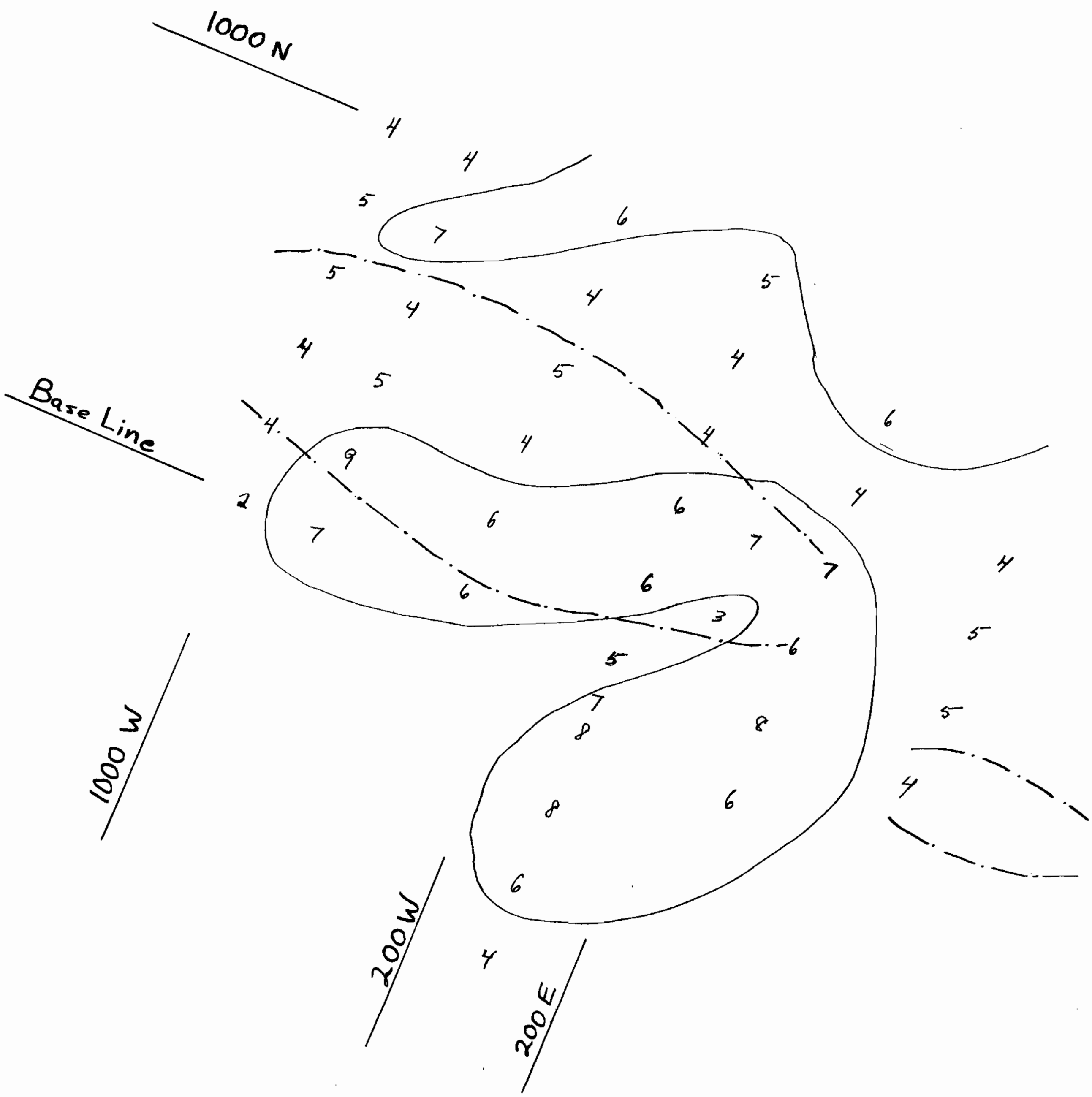


Figure 138. MATTAGAMI LAKE MINES - Contour map

Contour interval - 5 ppm (6-10)

Copper contents of Sphagnum moss

plants (whole) in ppm - dry wt.

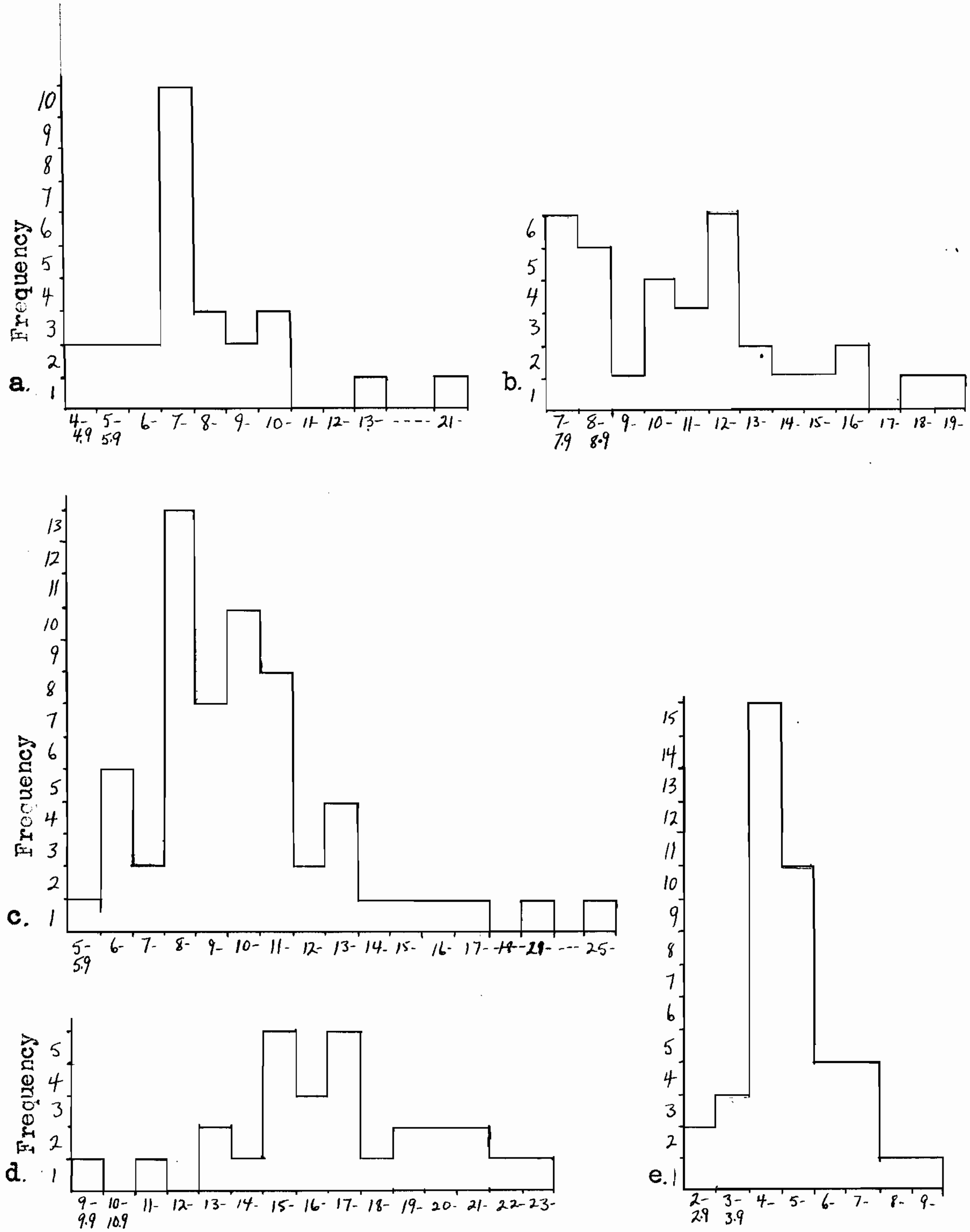


Figure 139. Histograms of the Copper contents (ppm - dry wt.) of plant samples from Mattagami Lake Mines.

	Interval
(a) Black Spruce stems (2 yr. old)	1 ppm
(b) Speckled Alder stems (2-5 yr. old)	1 ppm
(c) Labrador-tea stems (2 yr. old)	1 ppm
(d) Wood-Horsetail plants (shoots)	1 ppm
(e) Sphagnum moss plants (whole)	1 ppm

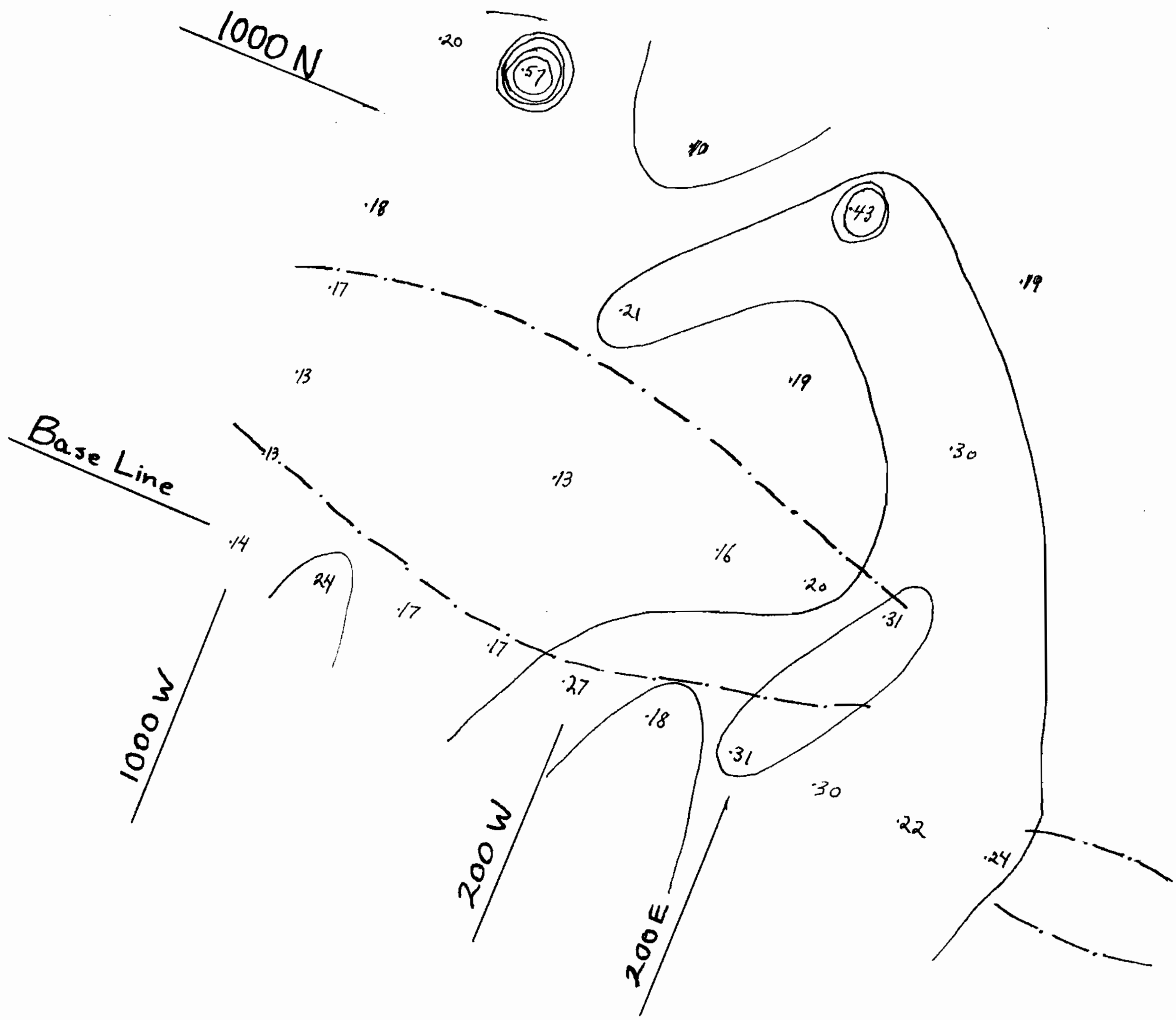


Figure 140. MATTAGAMI LAKE MINES - Contour map
Contour interval - 0.10 (0.11-0.20)
Copper:Zinc ratios in Black Spruce
stems (2 yr. old)

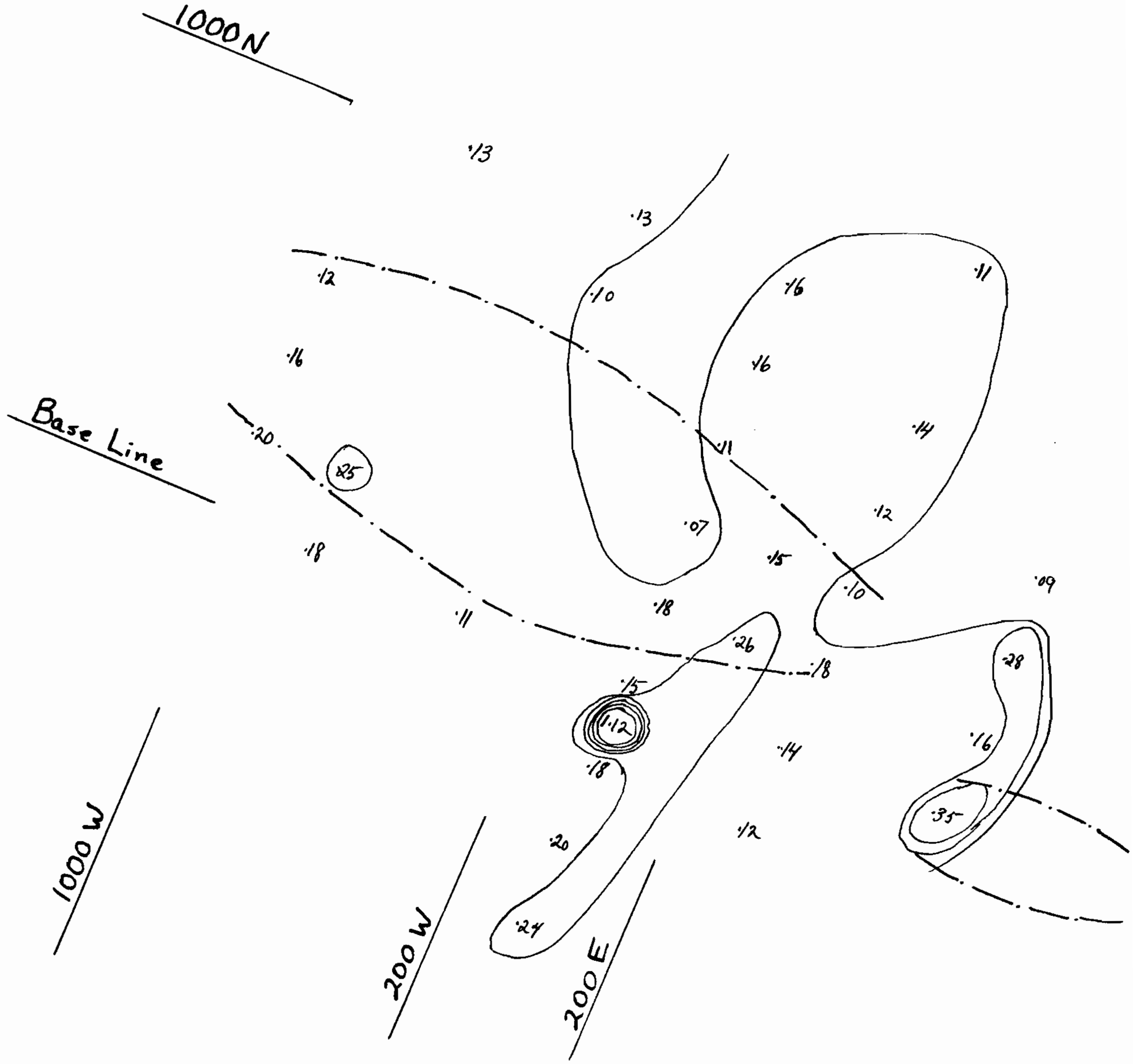


Figure 141. MATTAGAMI LAKE MINES - Contour map

Contour interval - 0.10 (o.11-0.20)

Copper:Zinc ratios in Speckled Alder stems (2 - 5 yr. old).

Figure 142. MATTAGAMI LAKE MINES - Contour map
Contour interval - 0.10 (0.11-0.20)
Copper:Zinc ratios in Labrador-tea
stems (2 yr. old).

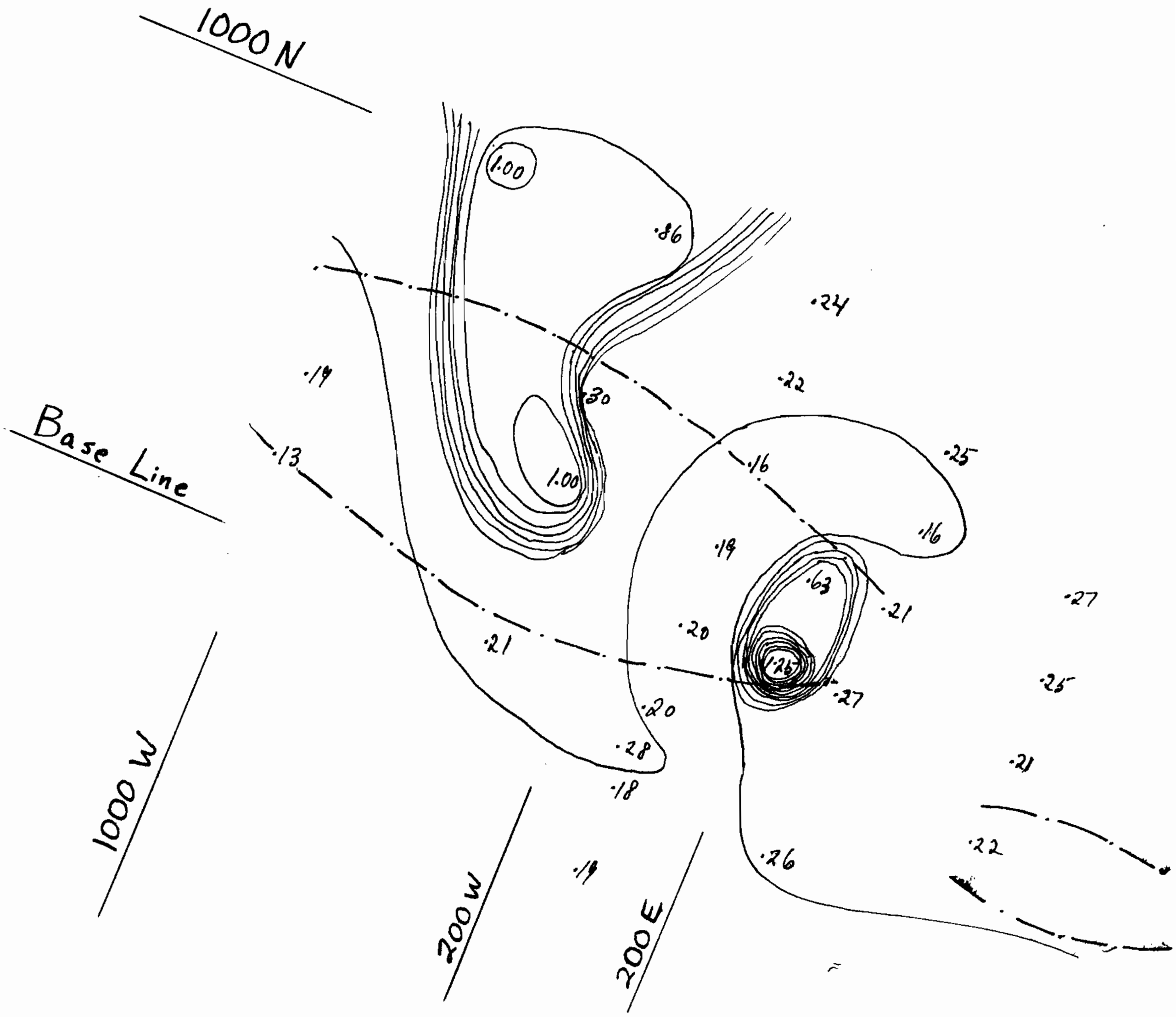


Figure 143. MATTAGAMI LAKE MINES - Contour map

Contour interval - 0.10 (0.11-0.20)

Copper:Zinc ratios in Wood-Horsetail plants (shoots).

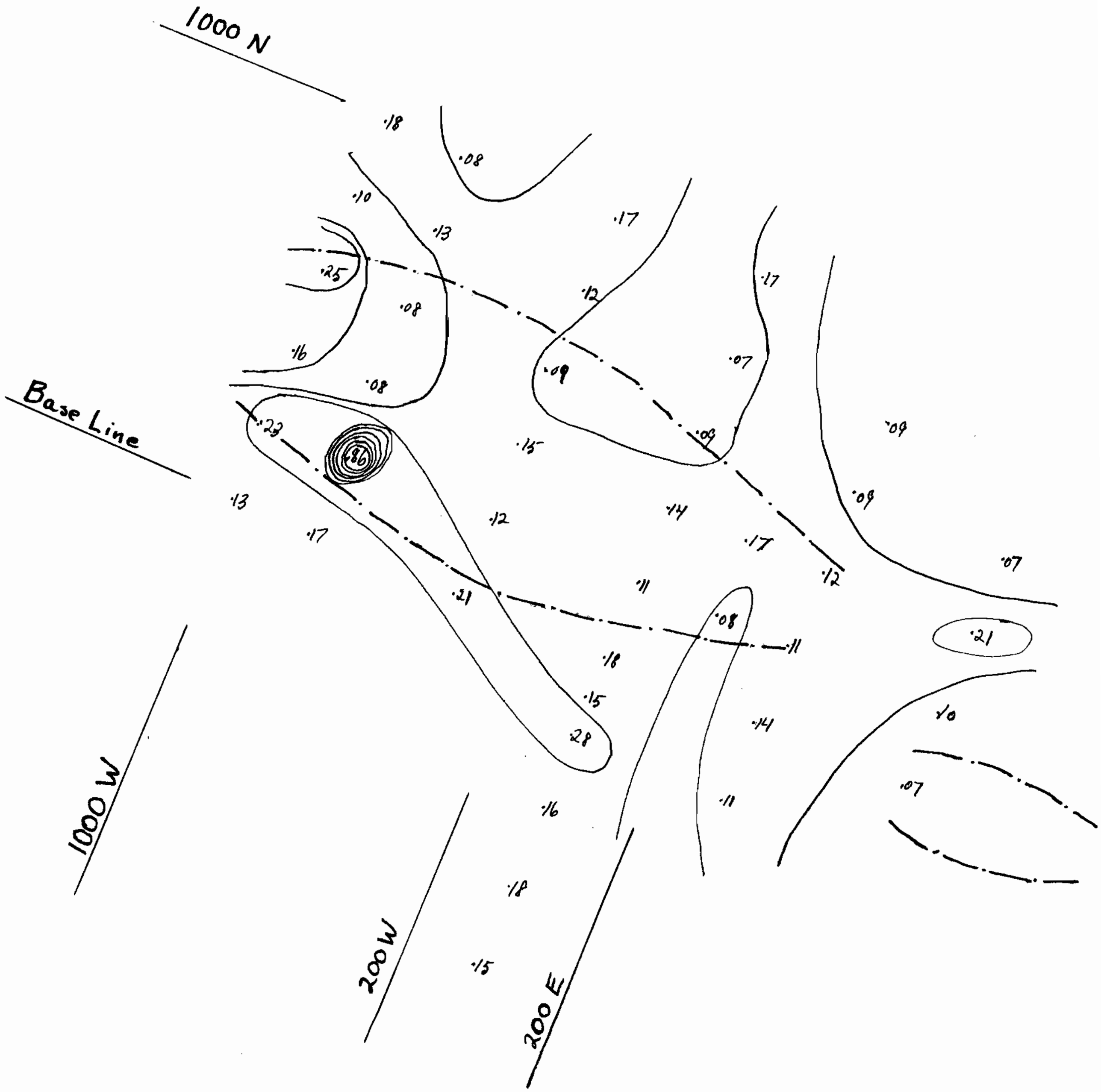


Figure 144. MATTAGAMI LAKE MINES - Contour map

Contour interval - 0.10 (0.11-0.20)

Copper:Zinc ratios in Sphagnum moss plants (whole).

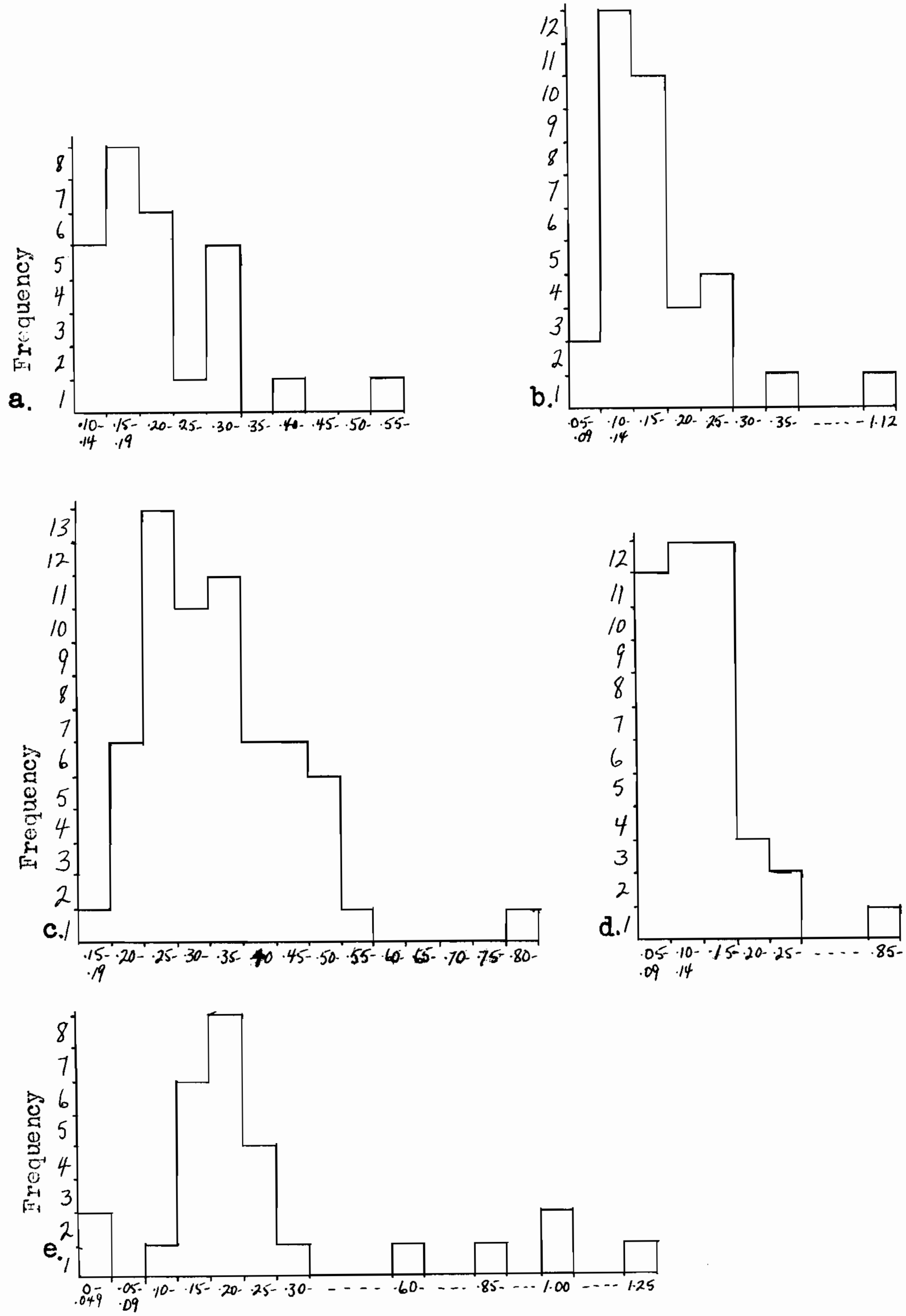


Figure 145. Histograms of the Copper:Zinc ratios in plant samples from Mattagami Lake Mines.

	Interval
(a) Black Spruce stems (2 yr. old)	0.05
(b) Speckled Alder stems (2-5 yr.old)	0.05
(c) Labrador-tea stems (2 yr. old)	0.05
(d) Wood-Horsetail plants (shoots)	0.05
(e) Sphagnum moss plants (whole)	0.05

Lead - The lead contents of each species are plotted on plant association maps in figures 146 to 150. The lead contents of each species are contoured in figures 151 to 155.

A histogram of the lead contents of each species is given in figure 156. All end rather abruptly on the high side except that of Labrador-tea.

Nickel - The nickel contents of three species are plotted on plant association maps in figures 158 to 160. The other species contained little or no nickel.

The nickel contents of each species are contoured in figures 162 to 164.

The nickel histograms for each species are given in figure 165. Each species shows some high values.

Average values

The tables of average values (Tables IX to XII) are presented for comparison to the published values of other workers. The tables give the number of samples used, the range in metal content, the modal (or most common) metal content, the mean (or average) metal content, the copper:zinc ratio, and the percentage ash when available. The maximum percentage variation above the mean value is also given in some cases.

Note: In Tables IX to XII 'd' means ppm dry weight, 'a' means ppm ash weight. All stems in these tables are 2 yr. old except Speckled Alder (2 - 5 yr. old) at Mattagami Lake Mines, and Larch (2 - 4 yr. old) at Scott Lake Bog.

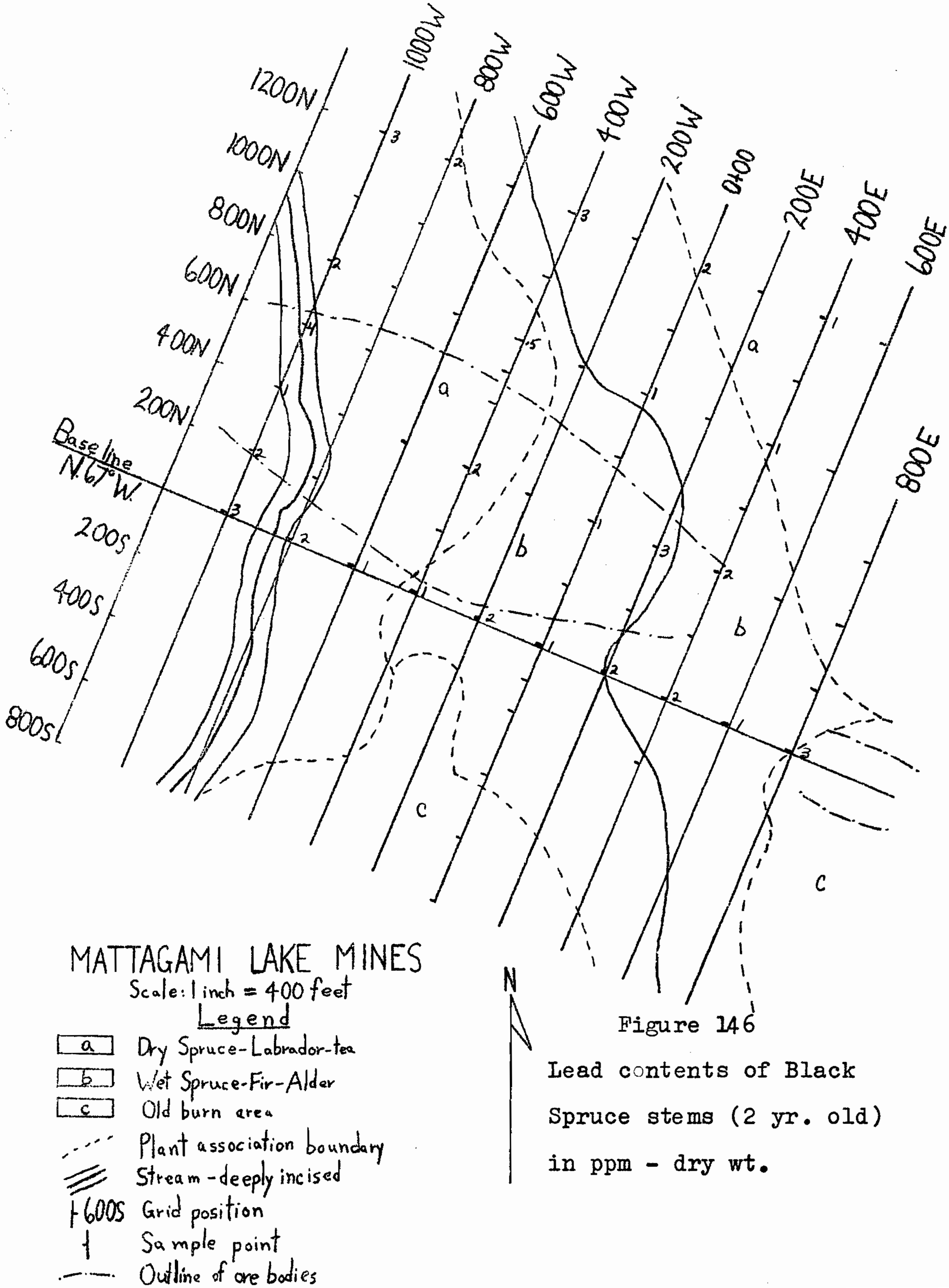


Figure 146

Lead contents of Black Spruce stems (2 yr. old) in ppm - dry wt.

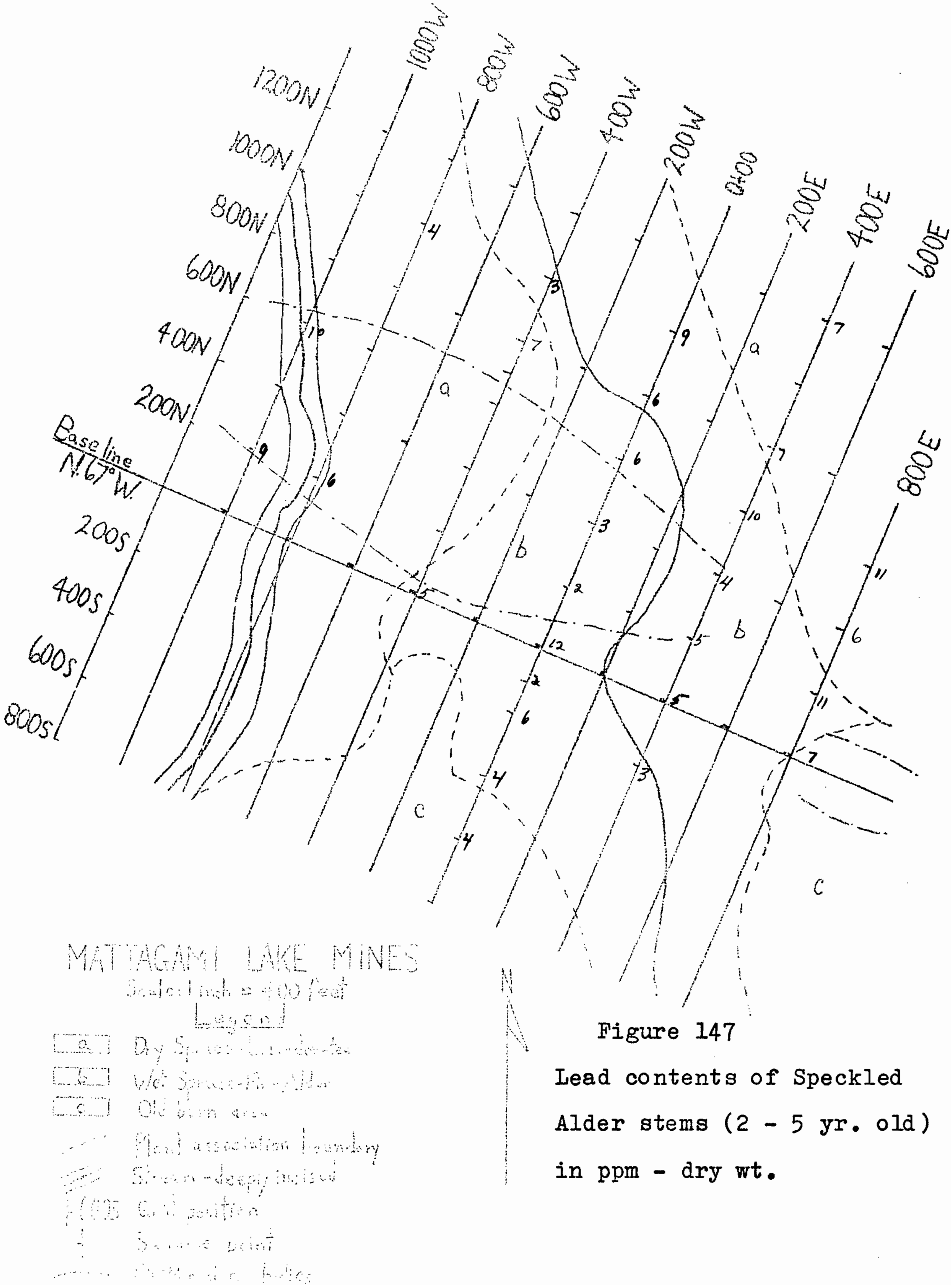


Figure 147

Lead contents of Speckled Alder stems (2 - 5 yr. old) in ppm - dry wt.

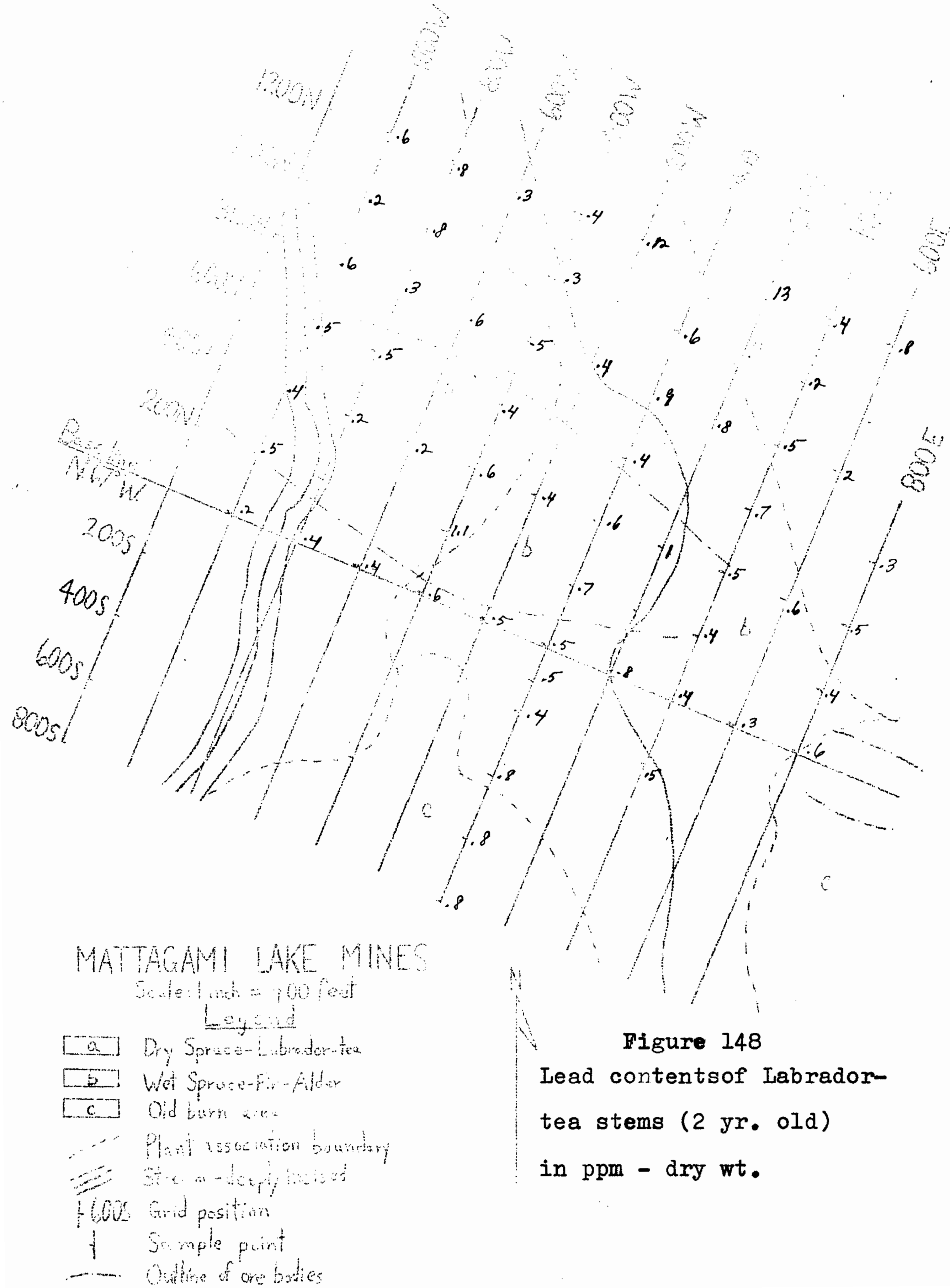


Figure 148

Lead contentsof Labrador-tea stems (2 yr. old) in ppm - dry wt.

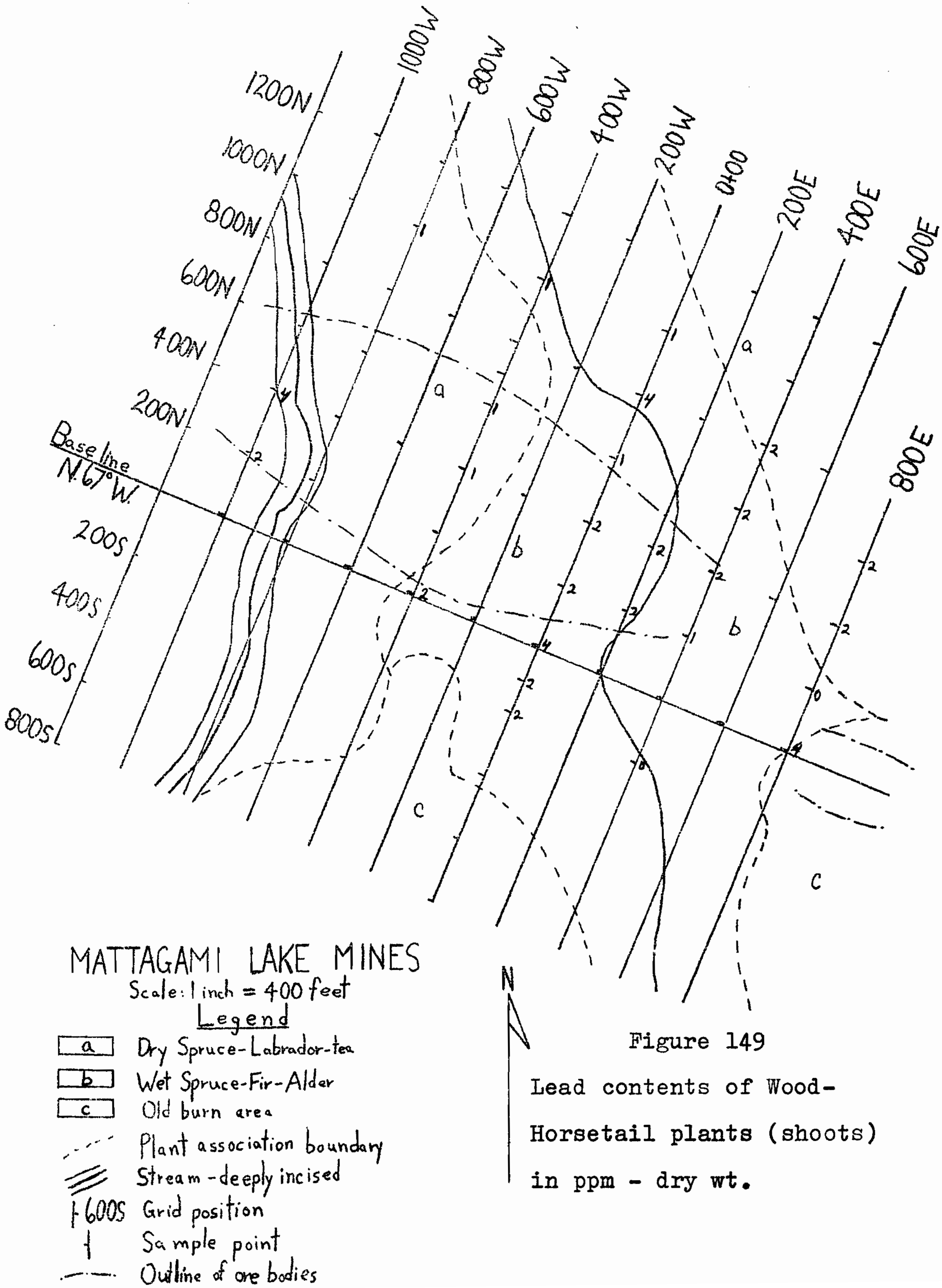


Figure 149

Lead contents of Wood-Horsetail plants (shoots) in ppm - dry wt.

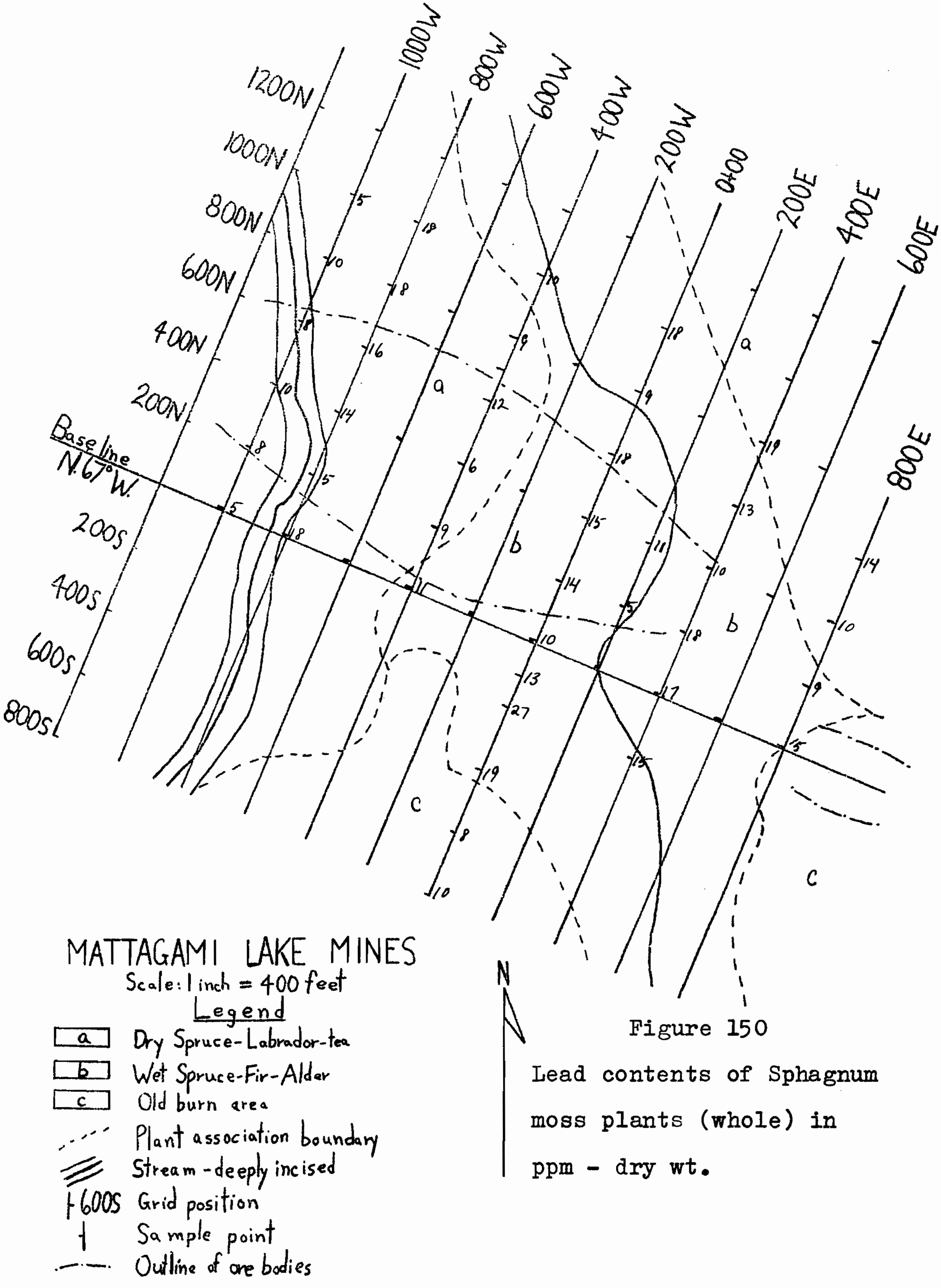


Figure 150

Lead contents of Sphagnum moss plants (whole) in ppm - dry wt.

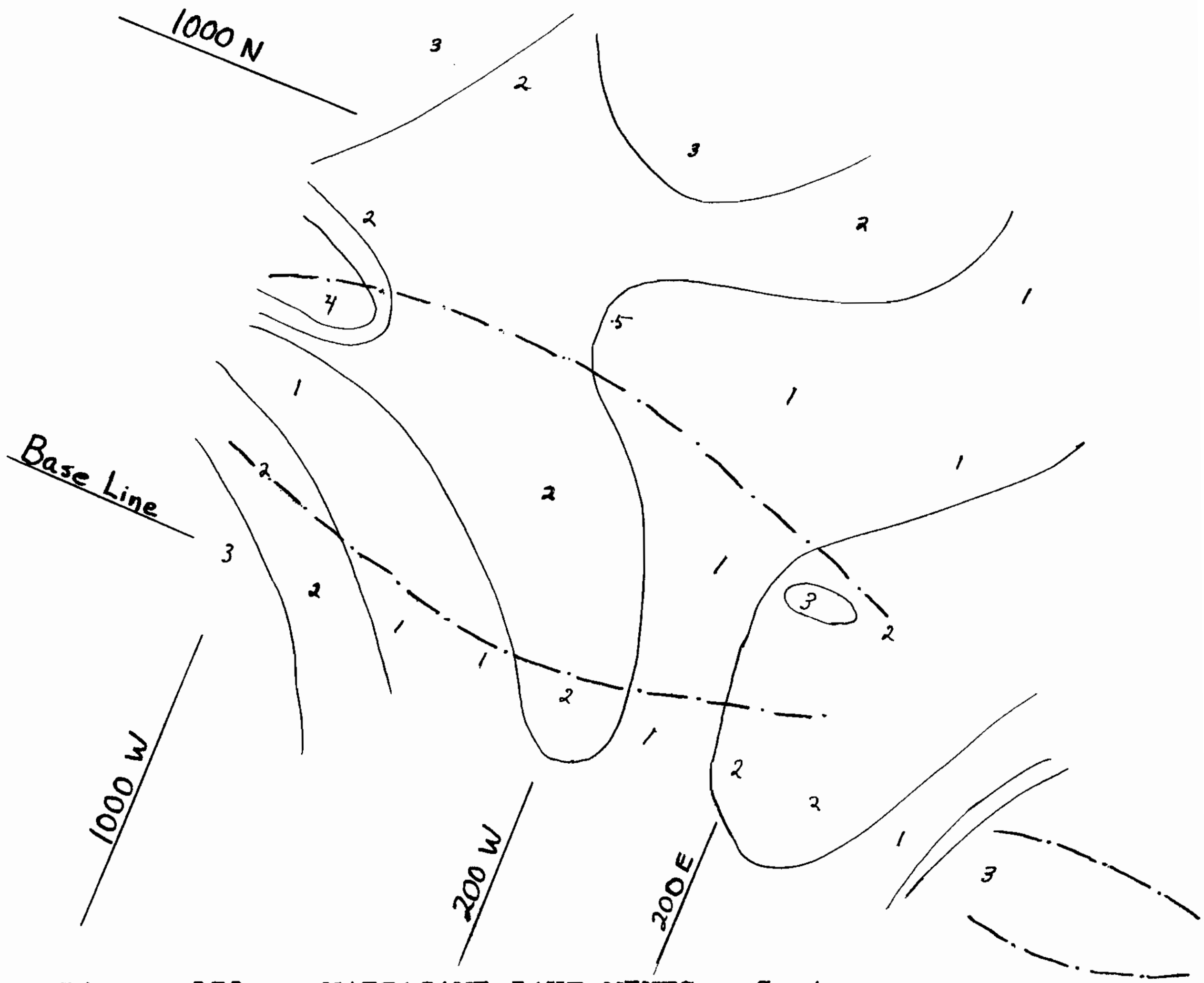


Figure 151. MATTAGAMI LAKE MINES - Contour map
Contour interval - 1 ppm (1-1.9)
Lead contents of Black Spruce stems
(2 yr. old) in ppm - dry wt.

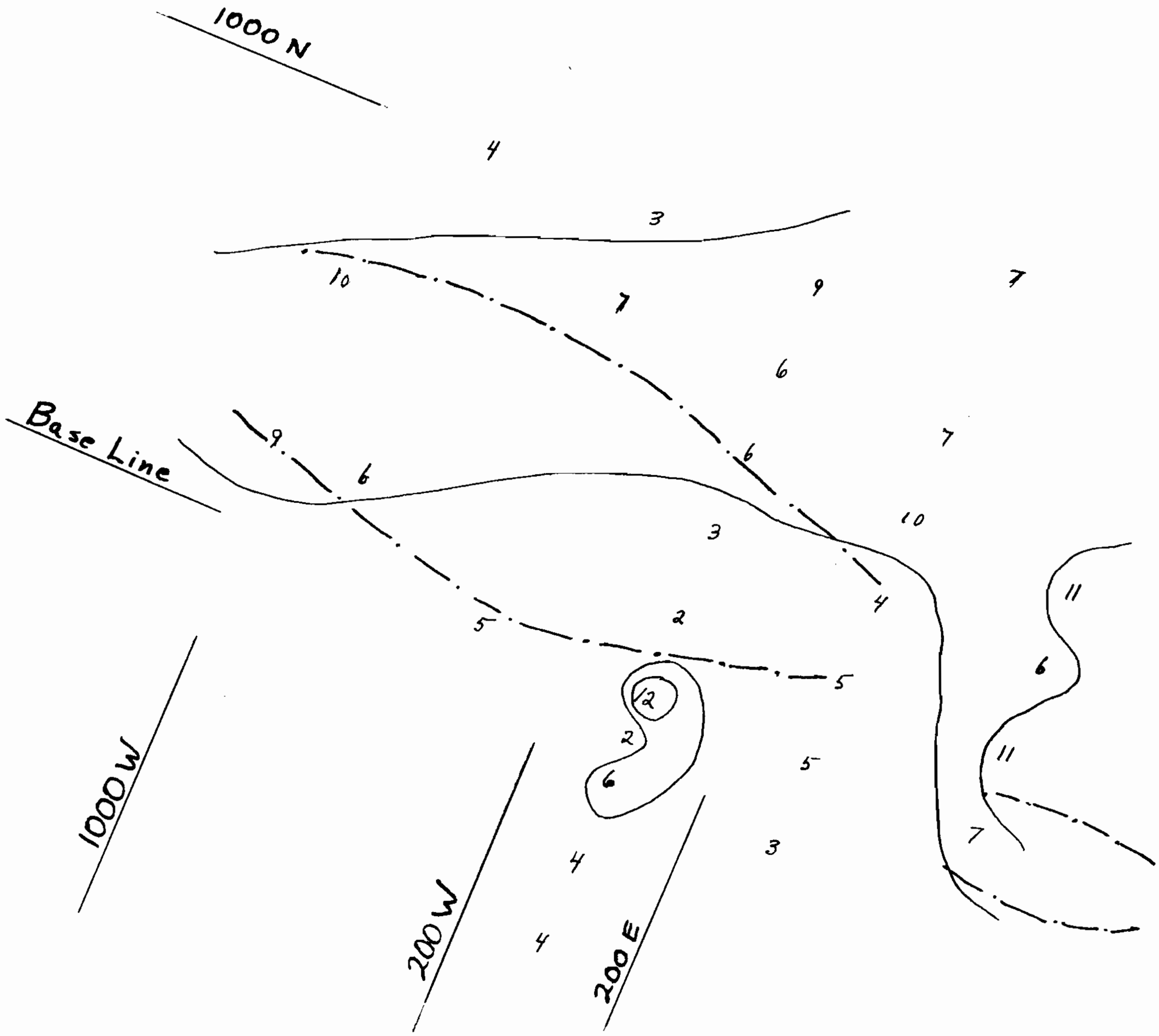


Figure 152. MATTAGAMI LAKE MINES - Contour map
Contour interval - 5 ppm (6-10)
Lead contents of Speckled Alder
stems (2 - 5 yr. old) in ppm - dry wt.

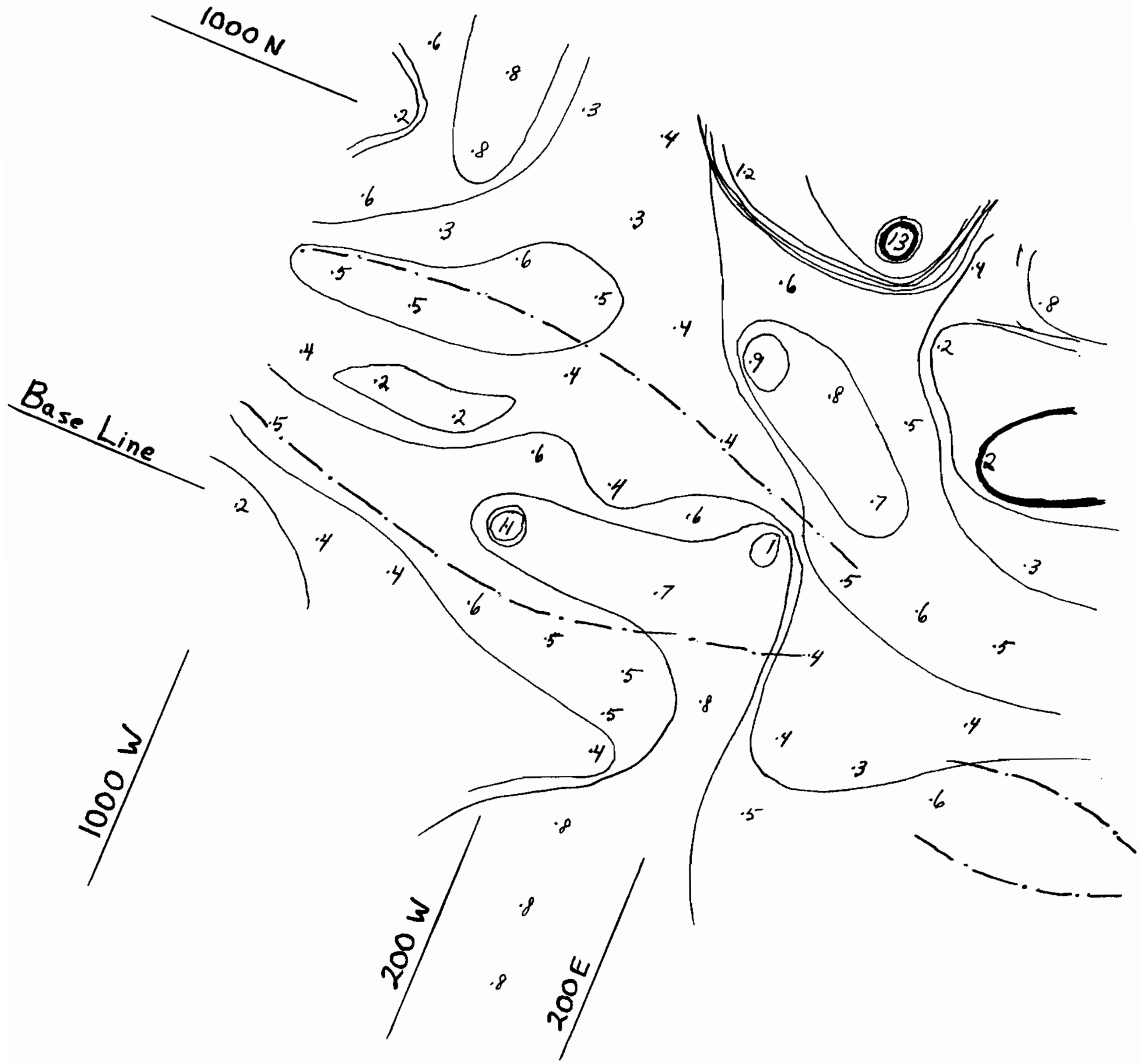


Figure 153. MATTAGAMI LAKE MINES - Contour map
Contour interval - 0.2 ppm (0.21-0.40)
Lead contents of Labrador-tea
stems (2 yr. old) in ppm - dry wt.

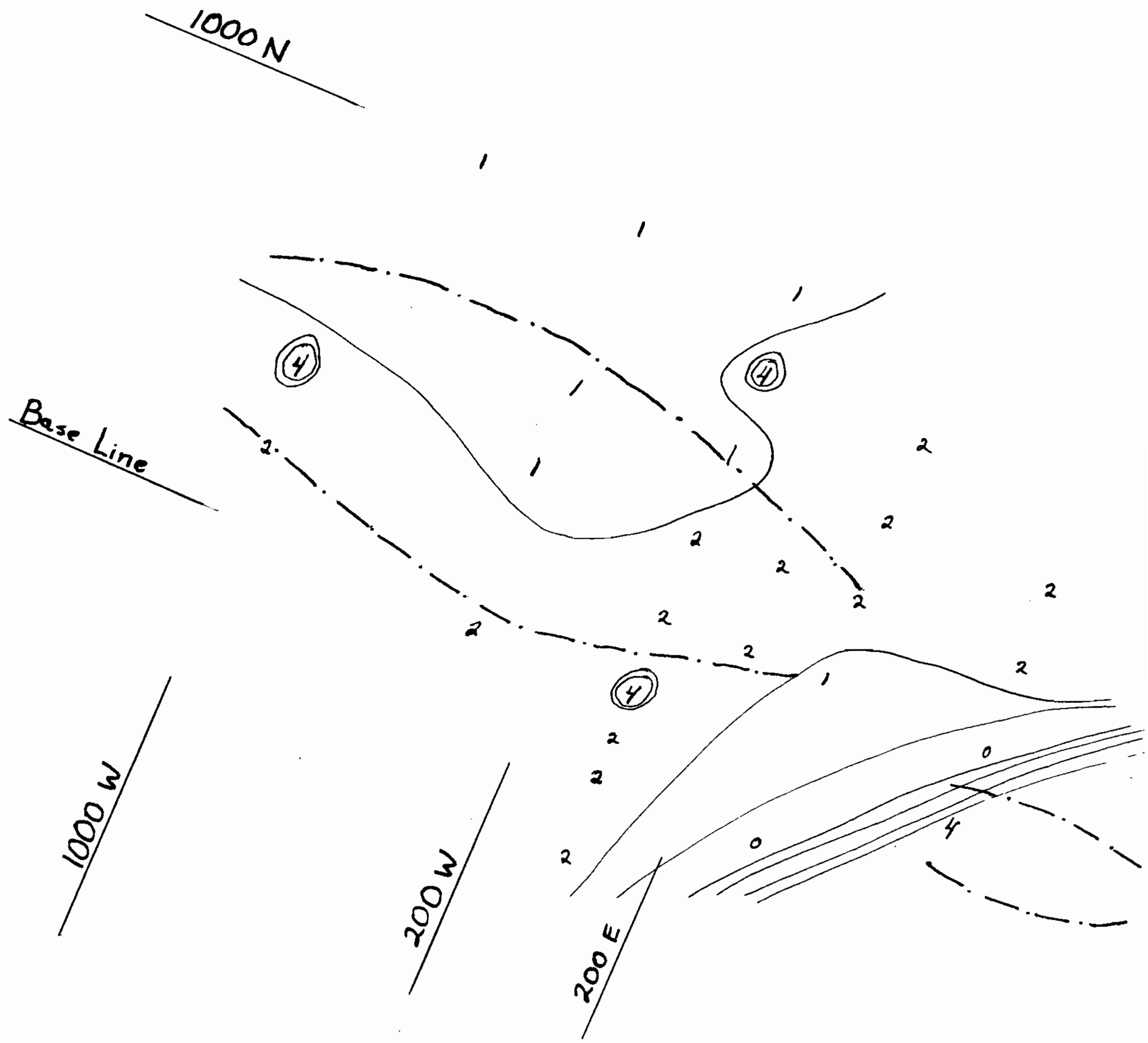


Figure 154. MATTAGAMI LAKE MINES - Contour map
Contour interval - 1 ppm (1-1.9)
Lead contents of Wood-Horsetail
plants (shoots) in ppm - dry wt.

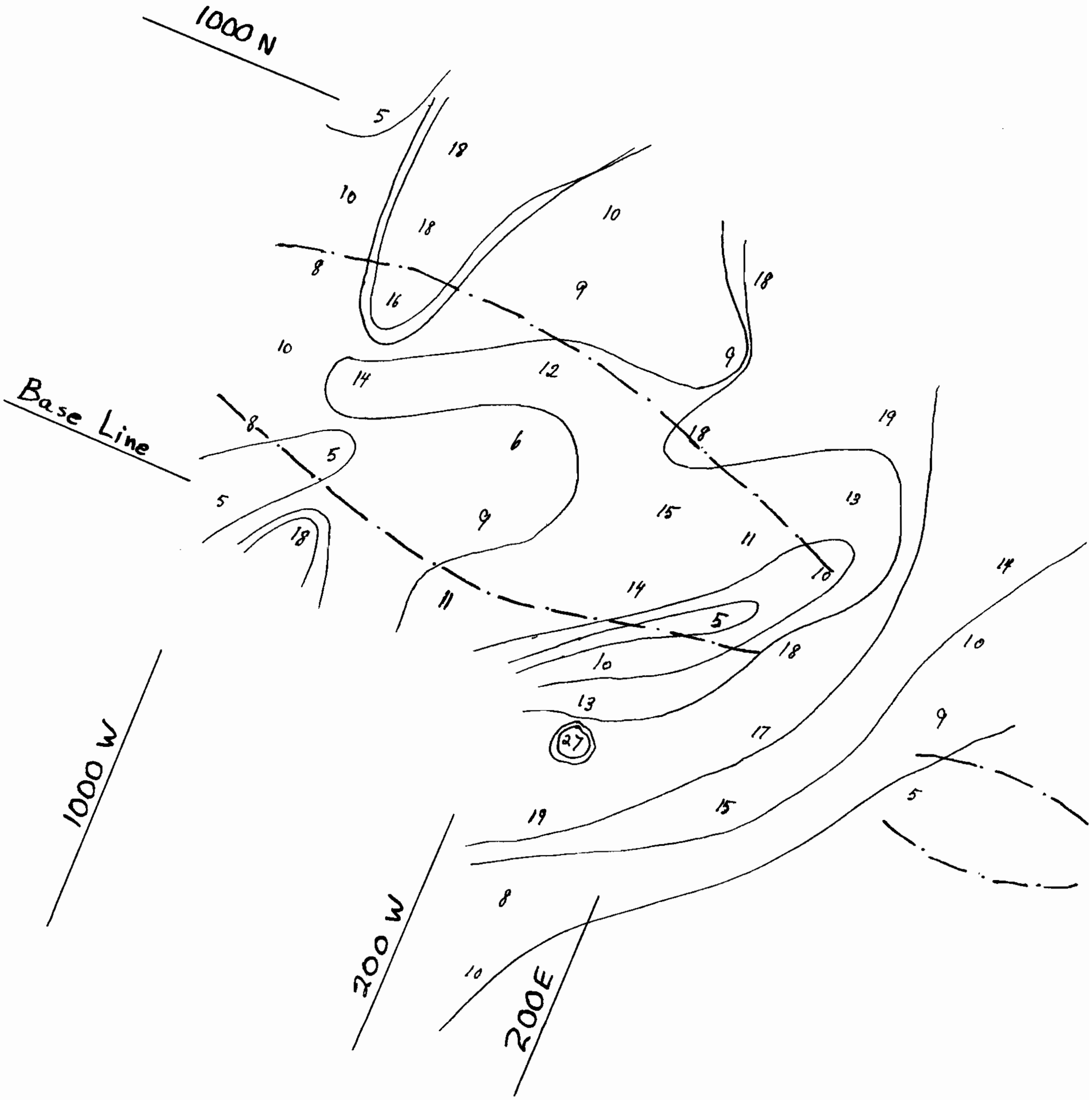


Figure 155. MATTAGAMI LAKE MINES - Contour map

Contour interval - 5 ppm (6-10)

Lead contents of Sphagnum moss plants (whole) in ppm - dry wt.

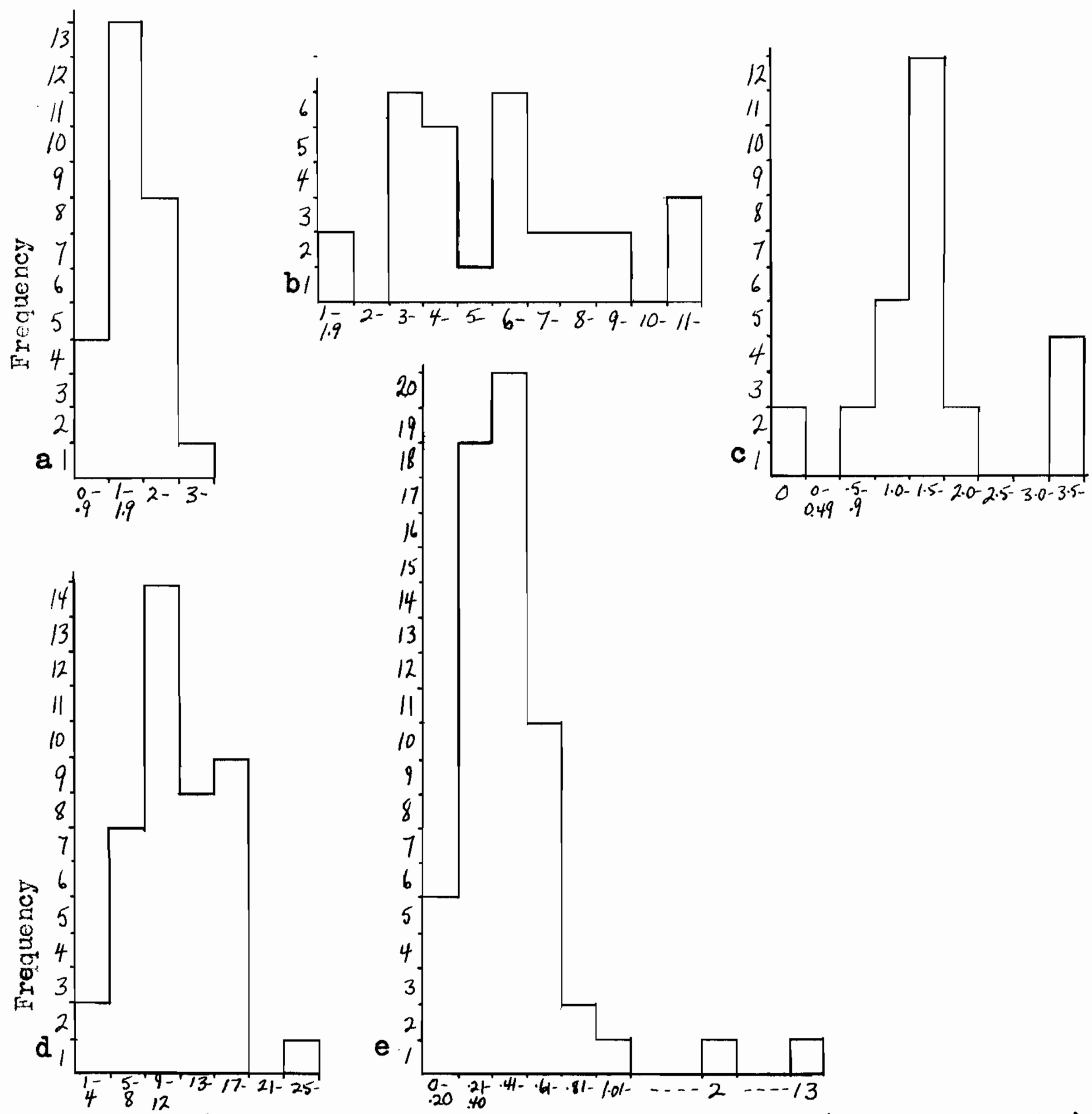
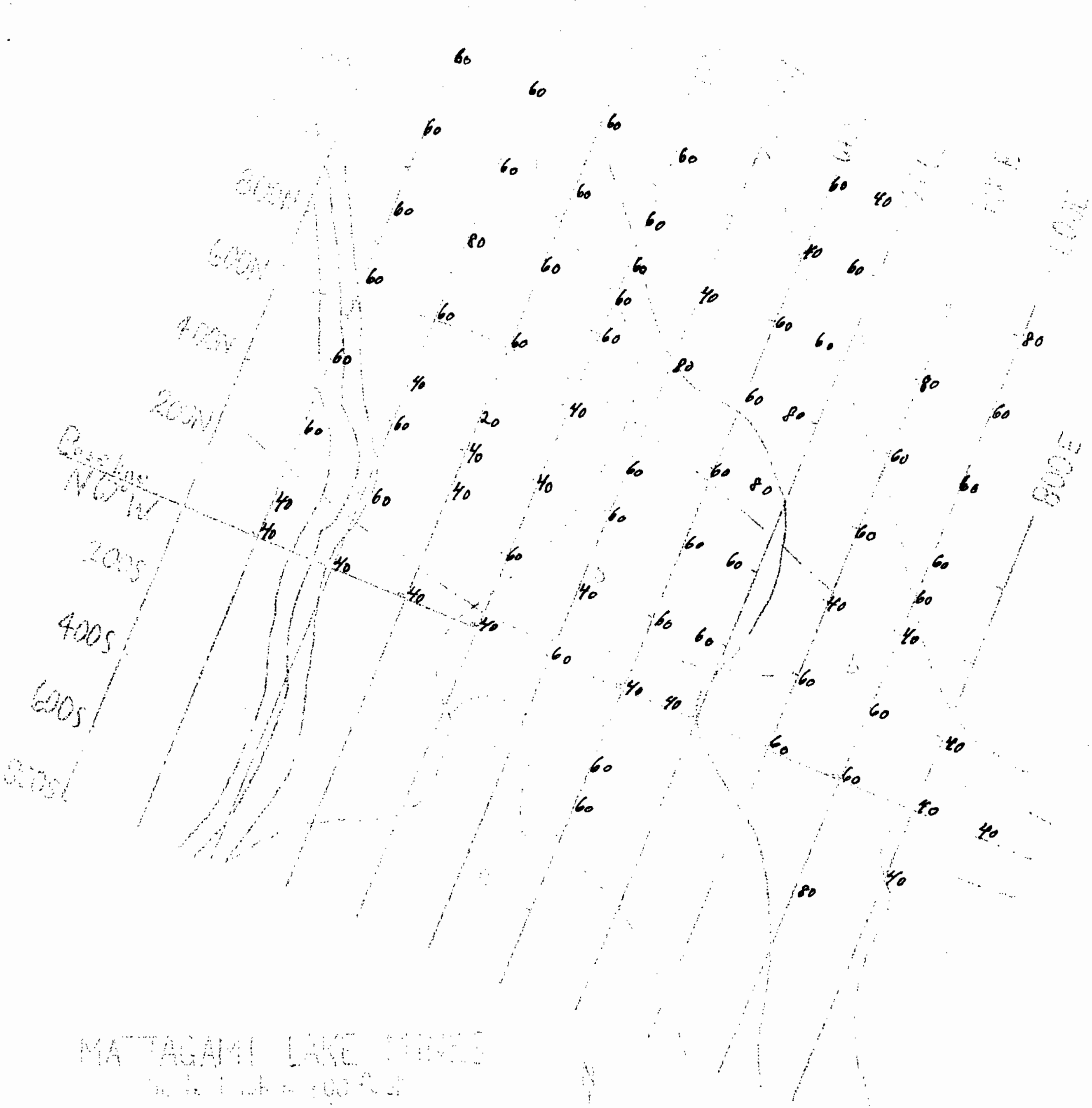


Figure 156. Histograms of the Lead contents (ppm - dry wt.) of plant samples from Mattagami Lake Mines.

	Interval
(a) Black Spruce stems (2 yr. old)	1 ppm
(b) Speckled Alder stems (2-5 yr. old)	1 ppm
(c) Wood-Horsetail plants (shoots)	0.5 ppm
(d) Sphagnum moss plants (whole)	4 ppm
(e) Labrador-tea stems (2 yr. old)	0.20 ppm



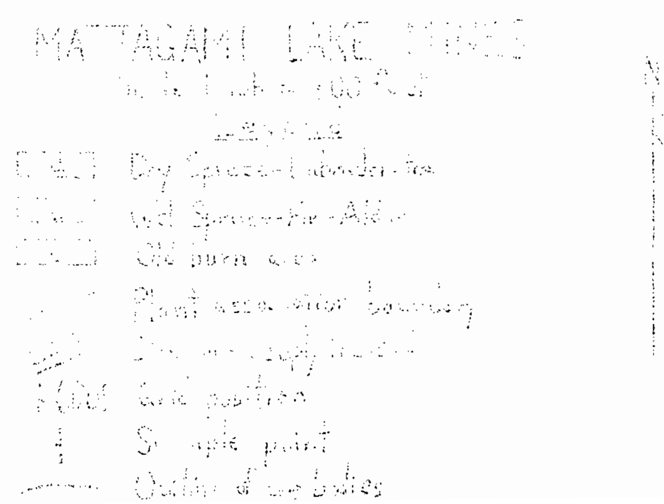


Figure 157
Nickel contents of surface clays in ppm - dry wt.

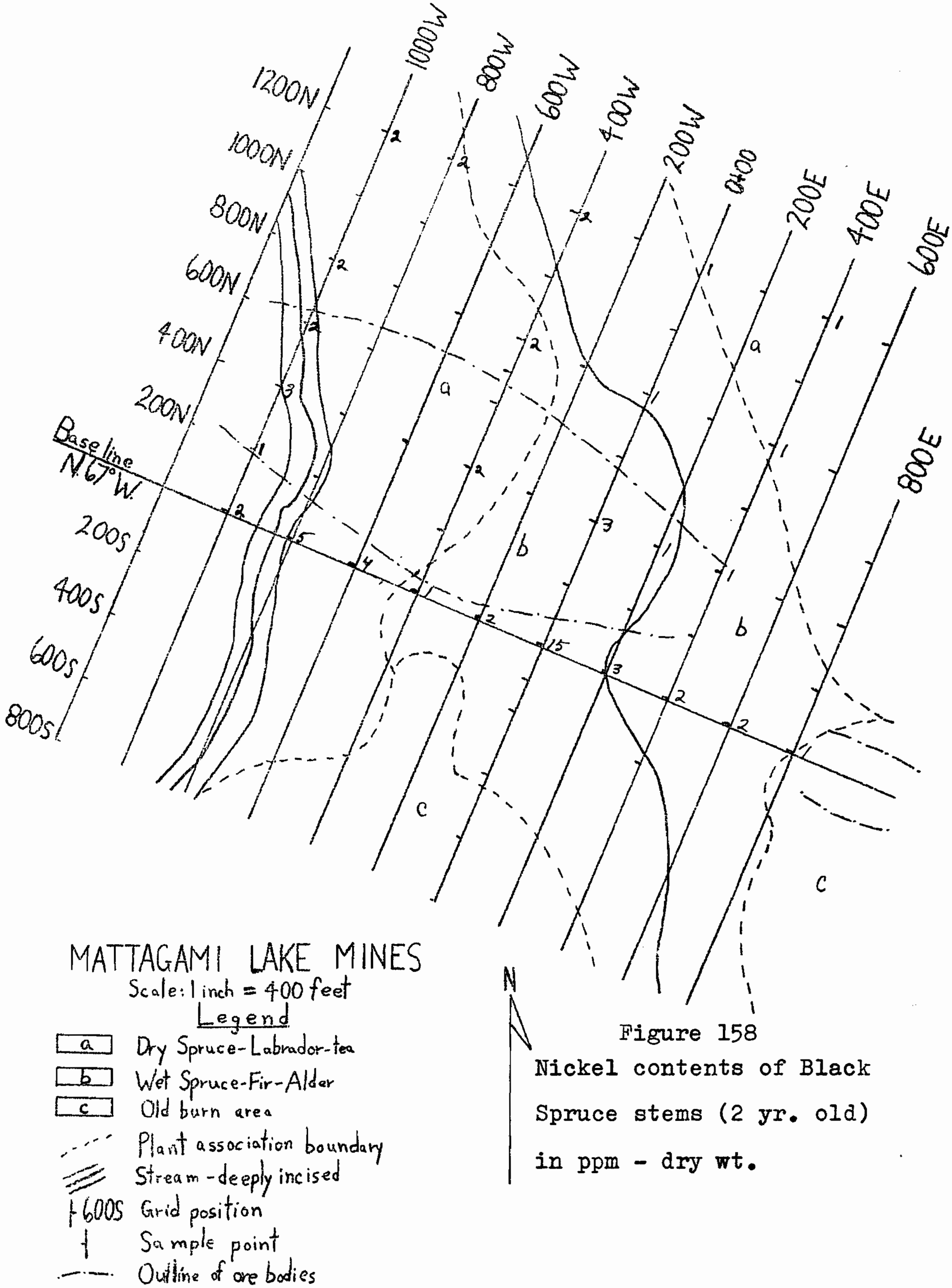


Figure 158

Nickel contents of Black Spruce stems (2 yr. old) in ppm - dry wt.

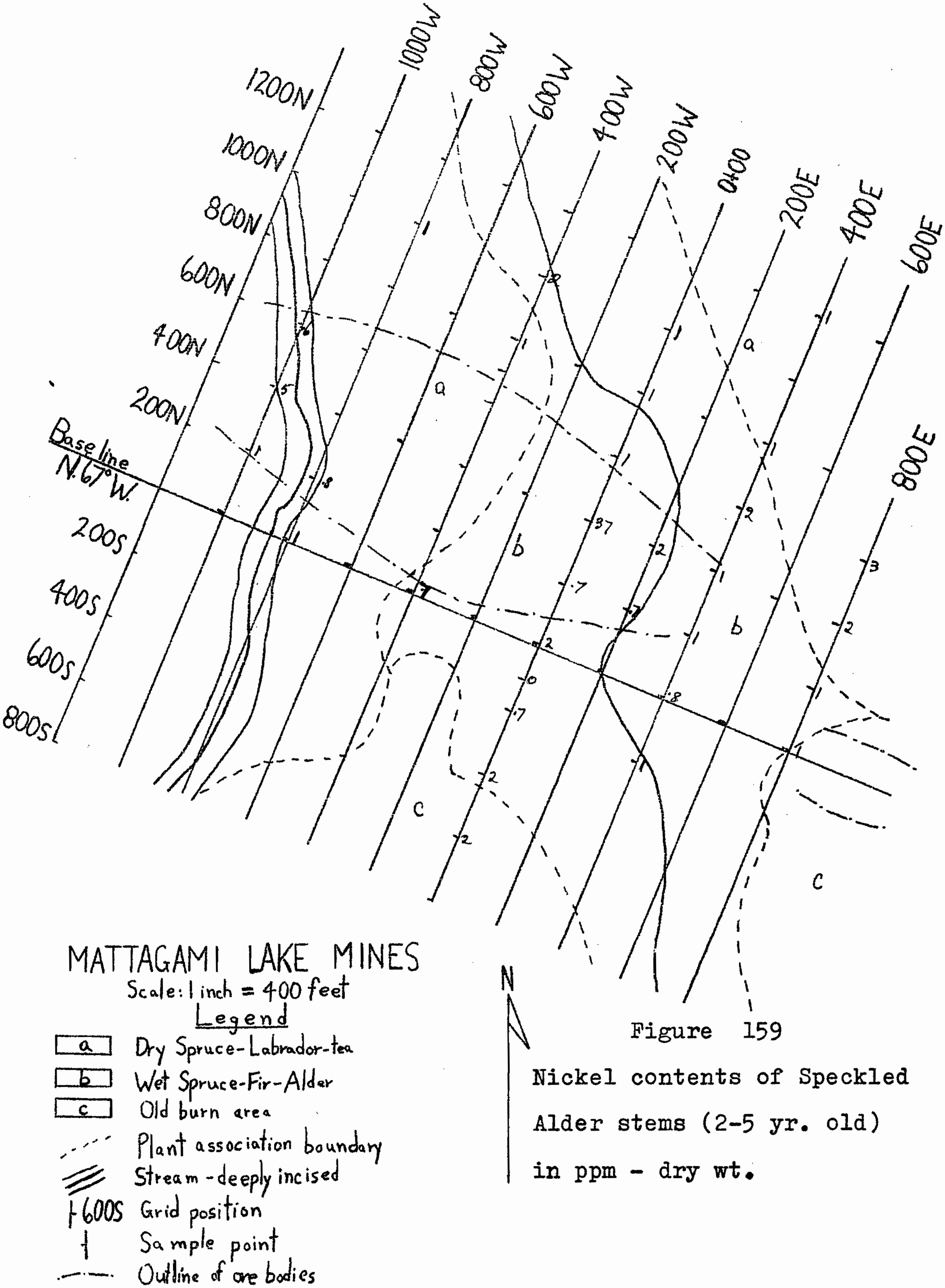
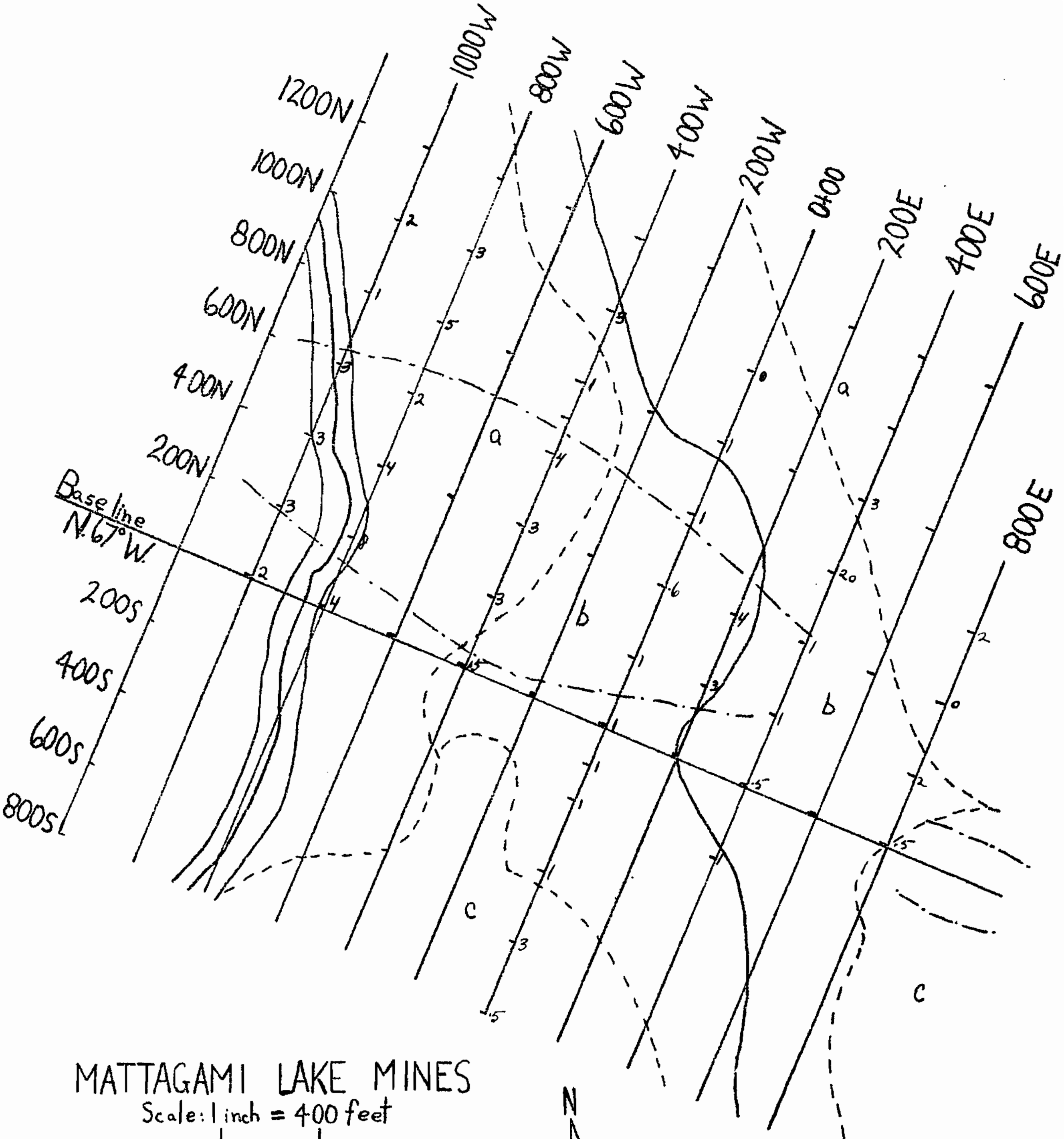


Figure 159

Nickel contents of Speckled Alder stems (2-5 yr. old) in ppm - dry wt.



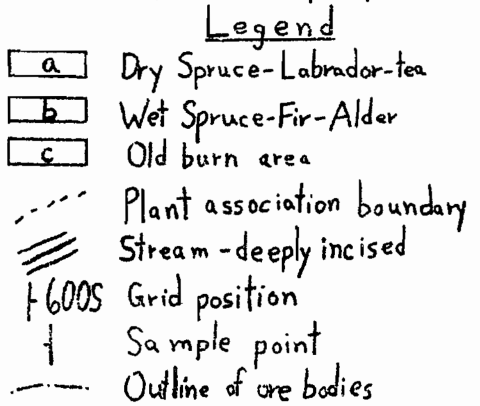


Figure 160

Nickel contents of Sphagnum moss plants (whole) in ppm - dry wt.

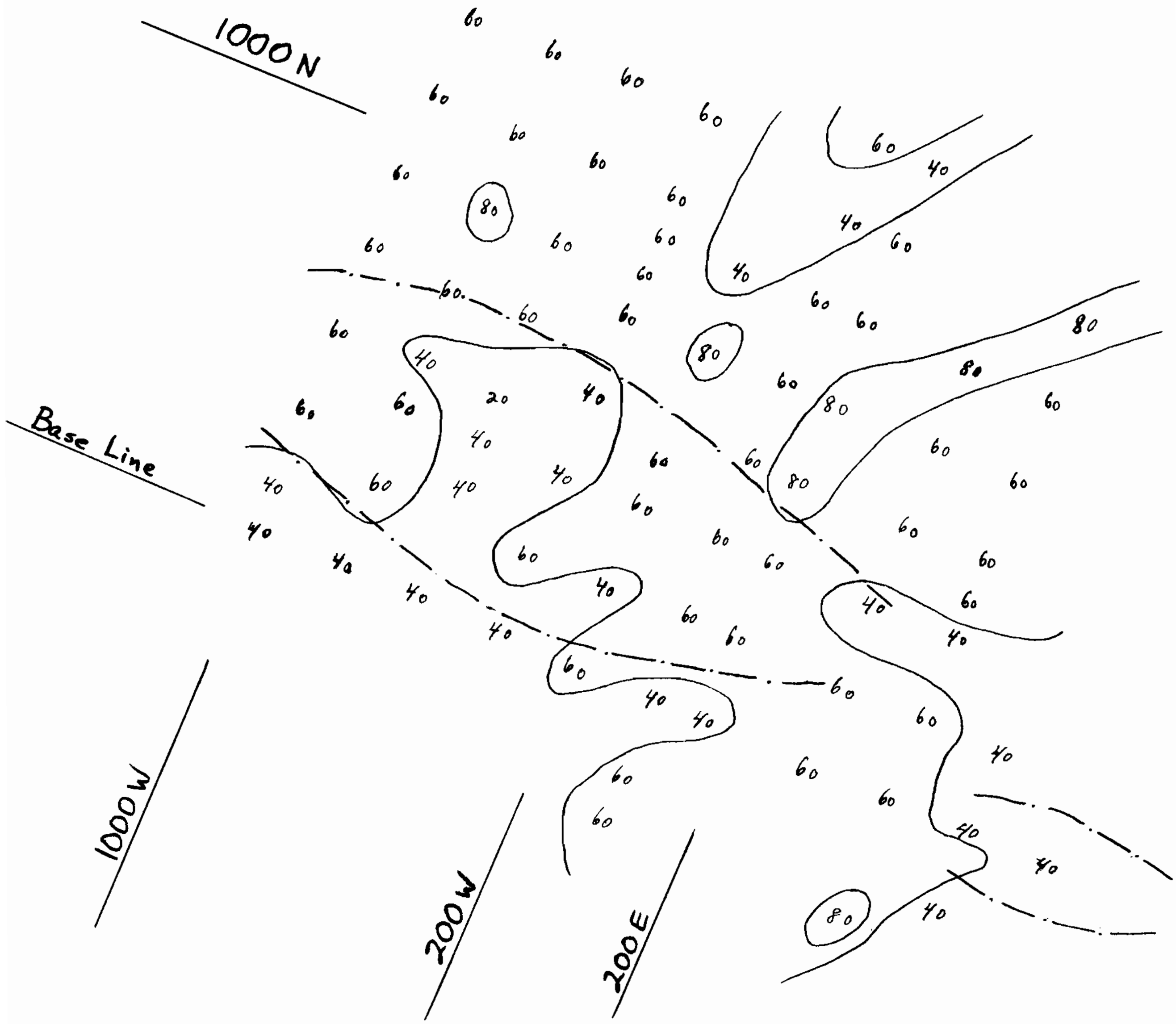


Figure 161. MATTAGAMI LAKE MINES - Contour map
Contour interval - 20 ppm (61-80)
Nickel contents of surface clays in
ppm - dry wt.

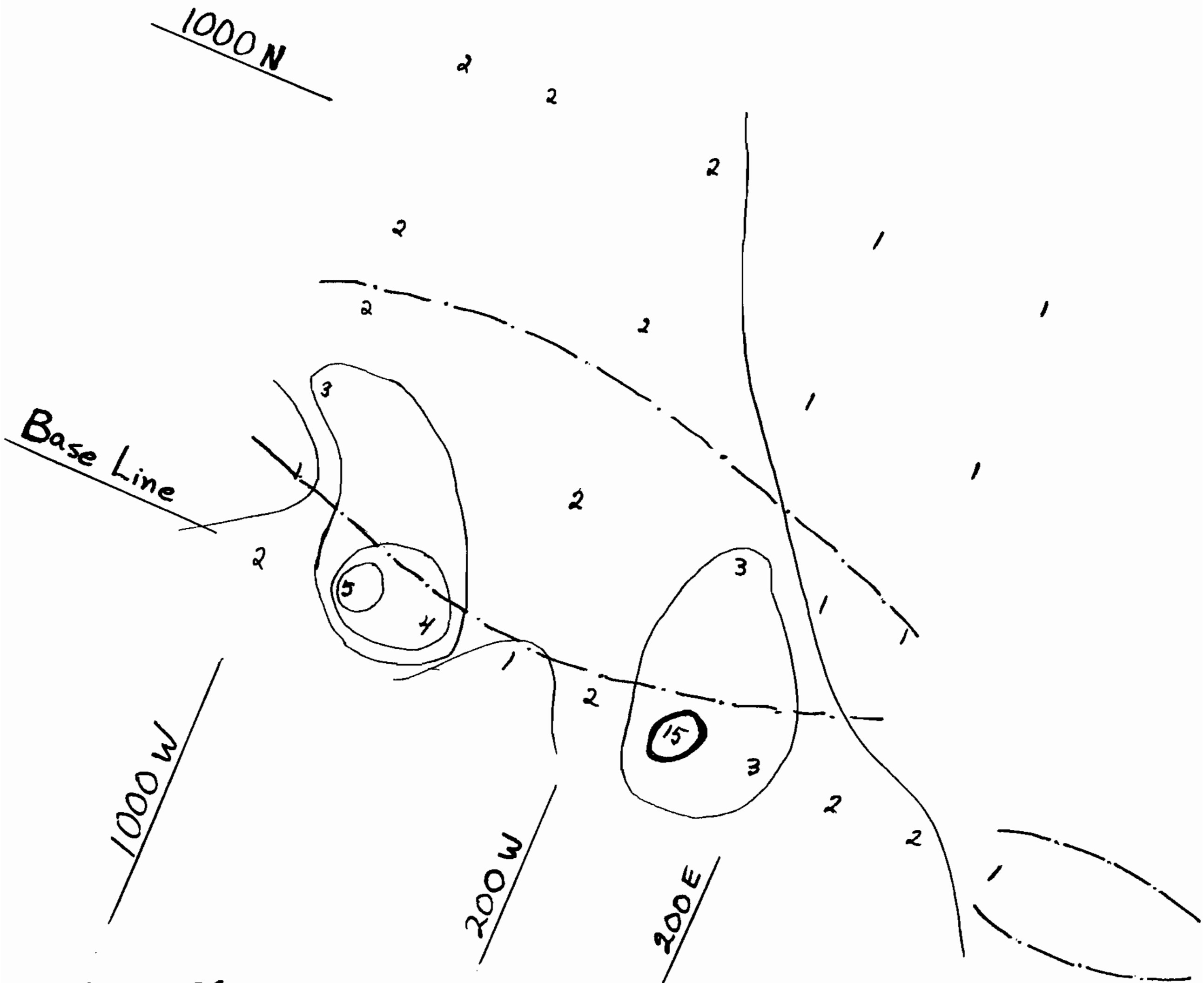


Figure 162. MATTAGAMI LAKE MINES - Contour map
Contour interval - 1 ppm (with exc.)
Nickel contents of Black Spruce stems
(2 yr. old) in ppm - dry wt.

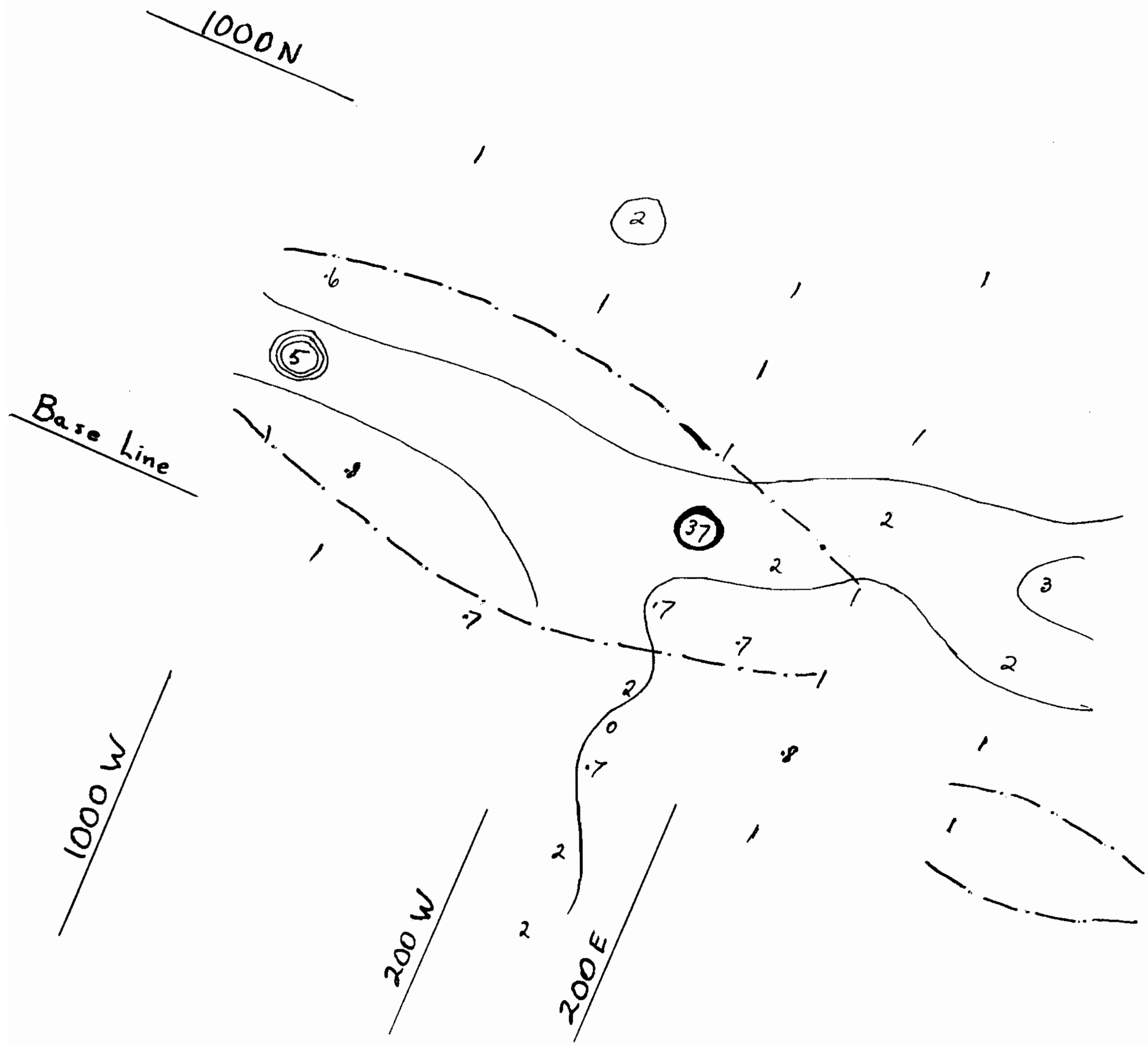


Figure 163. MATTAGAMI LAKE MINES - Contour map
Contour interval - 1 ppm with exc.
Nickel contents of Speckled Alder
stems (2 - 5 yr. old) in ppm - dry wt.

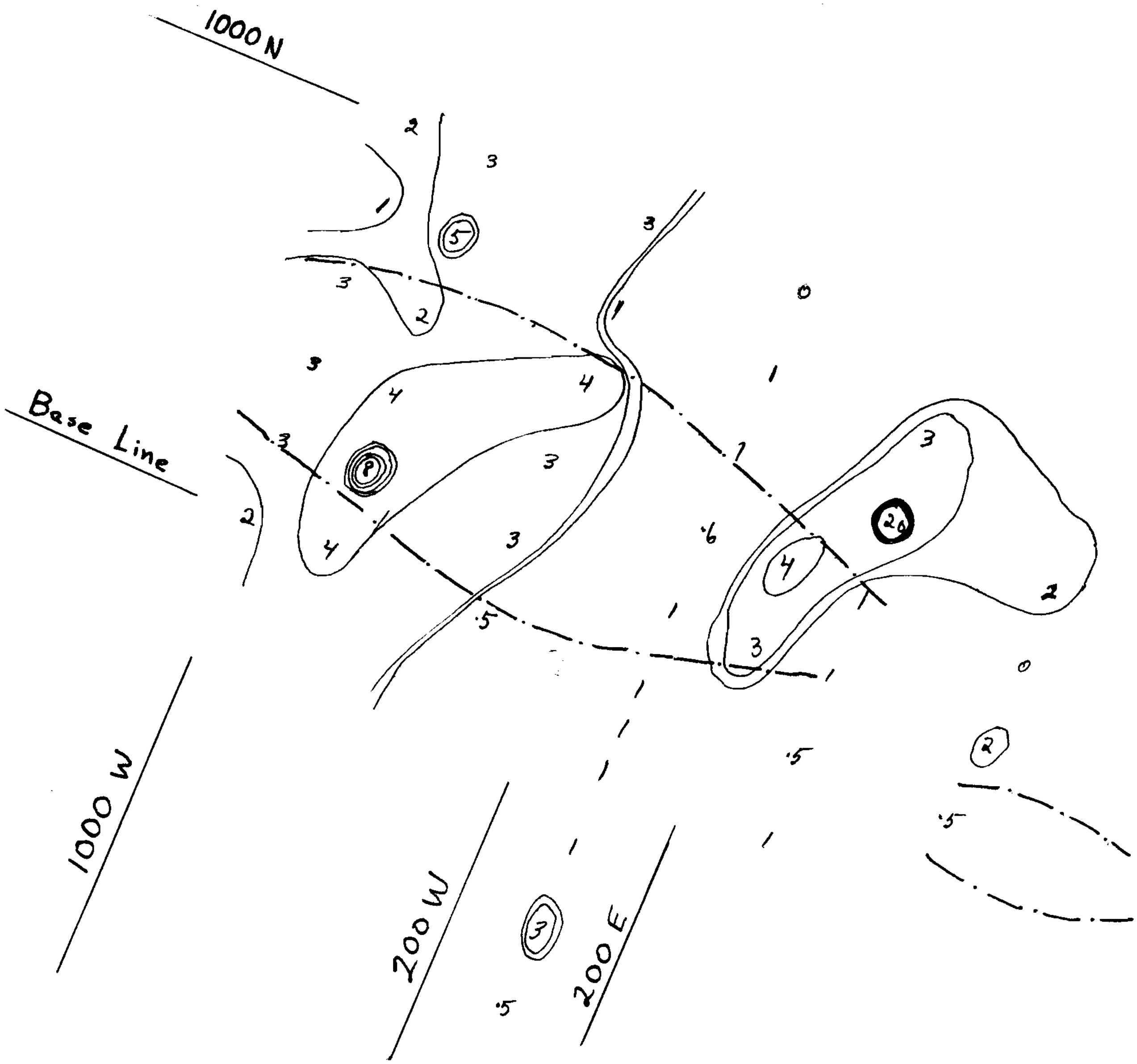


Figure 164. MATTAGAMI LAKE MINES - Contour map
Contour interval - 1 ppm (with exc.)
Nickel contents of Sphagnum moss
plants (whole) in ppm - dry wt.

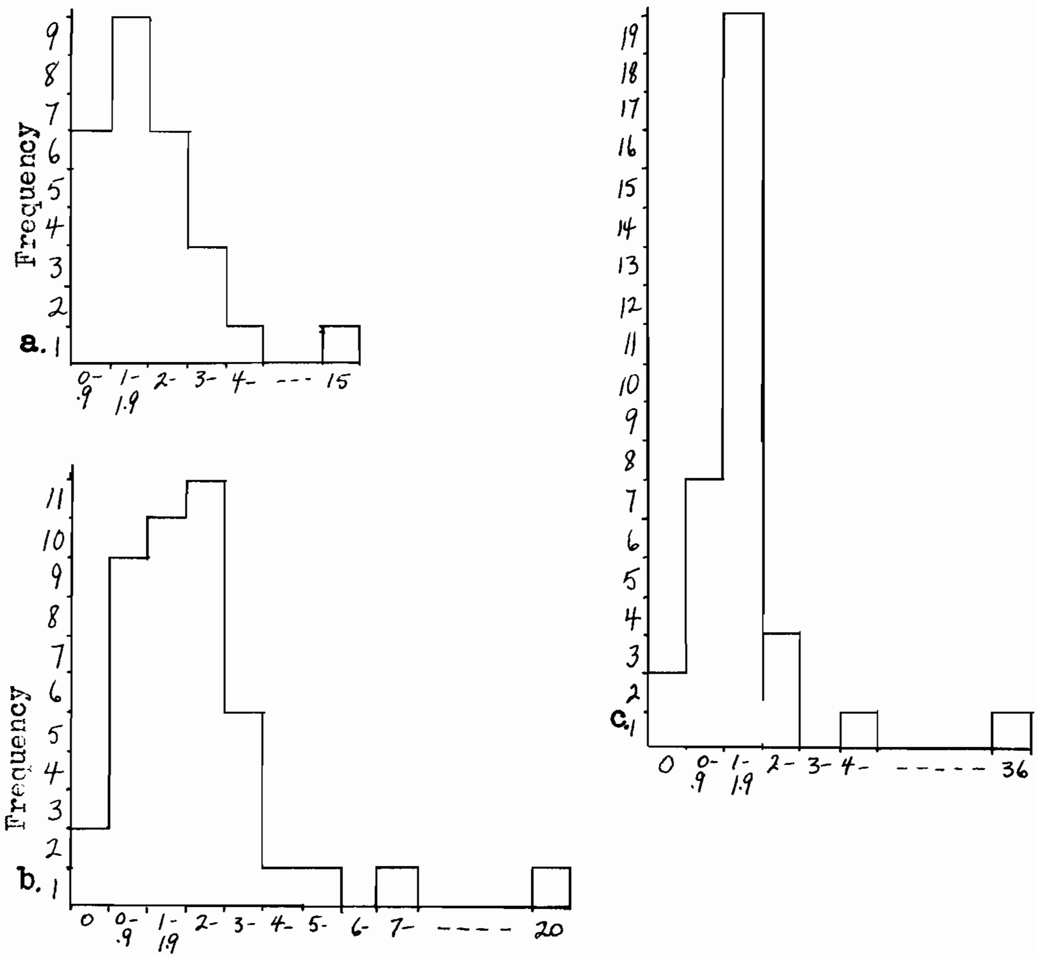


Figure 165. Histograms of the Nickel contents (ppm - dry wt.) of plant samples from Mattagami Lake Mines.

	Interval
(a) Black Spruce stems (2 yr. old)	1 ppm
(b) Speckled Alder stems (2 - 5 yr. old)	1 ppm
(c) Sphagnum moss plants (whole)	1 ppm

TABLE IX

AVERAGE AND SUMMARY TABLE - ZINC

Plant species	Plant organ	* ppm - basis	No. of samples	Range	Mode	Mean	Max.% variation above average
BLACKY BAY BOG							
Surface peats		d	28	20-150	30	35	330
Black Spruce	leaves	d	28	25-90	70	50	80
	stems	d	28	40-70	60	53	32
Labrador-tea	leaves	d	7	30-40	30&33	34	18
	stems	d	7	25-50	30&35	35	43
Swamp-Birch	leaves	d	3	100-120	110	110	9
	stems	d	3	90-120	90	100	20
Sweet Gale	leaves	d	15	10-50	40	31	61
	stems	d	15	25-40	30&40	32	25
Sedge	whole	d	28	5-50	30	32	56
False Solomon's-seal	whole	d	25	28-100	60	55	82
Sphagnum	whole	d	28	30-60	35&50	43	40
Pleurozium	whole	d	24	10-45	35	36	25
SCOTT LAKE BOG							
Surface peats		d	25	15-80	20	32	150
Black Spruce	stems	d	24	18-63	30&35	39	62
		a	24	1700-4800	3800 2600	3200	50
Larch	stems	d	20	20-44	25	29	52
		a	20	1200-2200	1200	1500	47
Leather-leaf	stems	d	22	15-34	21	22	55
		a	22	1000-2400	1300	1400	71
Leather-leaf	leaves	d	23	8-25	14	15	67
		a	23	270-930	350	560	66
MATTAGAMI LAKE MINES							
Surface clays		d	75	65-160	120	114	40
Black Spruce	stems	d	26	27-60	37	39	54
		a	26	1300-4300	19	2200	95
Speckled Alder	stems	d	32	14-140	81	72	94
		a	32	540-10000	4800	3900	156
Labrador-tea	stems	d	58	17-52	27	28	86
		a	58	710-1600	1000	1000	60
Wood-Horsetail	whole	d	27	13-93	69	65	43
		a	27	100-570	570	470	21
Sphagnum	whole	d	41	11-63	28	40	58
		a	41	55-2300	1200	1200	92

* see 'Note' page 232

TABLE X

AVERAGE AND SUMMARY TABLE – COPPER

plant species	Plant organ	* ppm – basis	No. of samples	Range	Mode	Mean	Max.% variation above average	Cu:Zn ratio	% Ash
BLACKY BAY BOG									
Surface peats		d	28	0-50	0	4	1150		
Black Spruce	leaves	d	28	3-16	3	5	220	.10	
	stems	d	27	5-12	8	8	50	.16	
Labroador-tea	leaves	d	7	4-5	5	5	0		
	stems	d	7	5-11	5	9	22	.24	
Swamp-Birch	leaves	d	3	4-8	4	5	60		
	stems	d	3	4-5	5	5	0		
Sweet Gale	leaves	d	15	0-12	5	6	100		
	stems	d	15	3-11	5	5	120	.16	
Sedge	whole	d	28	1-16	5	6	167	.21	
False Solomon's-seal	whole	d	25	3-11	5	5	120	.11	
Sphagnum	whole	d	27	3-15	6	8	88	.21	
Pleurozium	whole	d	26	1-13	5	5	160	.13	
SCOTT LAKE BOG									
Surface peats		d	25	5-30	20	18	67		
Black Spruce	stems	d	24	4-9	5	5	80	.14	1.2
		a	24	300-620	390	440	41		
Larch	stems	d	20	3-10	7	6	67	.22	1.9
		a	20	140-590	370	330	79		
Leather-leaf	stems	d	22	3-11	6	6	83	.37	2.7
		a	22	170-780	290 330	350	123		
	leaves	d	23	1-13	4&7	6	117	.24	1.6
		a	23	50-500	100	210	138		
MATTAGAMI LAKE MINES									
Surface clays			79	10-50	20	24	108		
Black Spruce	stems	d	26	4-21	8	8	163	.24	2.0
		a	26	210-1400	490	470	198		
Speckled Alder	stems	d	32	7-19	12	11	73	.19	1.9
		a	32	440-1000	550	580	72		
Labrador-tea	stems	d	58	5-25	8	10	150	.37	2.9
		a	58	190-790	400	350	126		
Wood-Horsetail	whole	d	27	9-22	15	17	29	.35	13.9
		a	27	67-150	120 130	120	25		
Sphagnum	whole	d	41	2#9	4	5	80	.15	3.1
		a	41	47-290	150 160	180	61		

* see 'Note' page 232

TABLE XI

AVERAGE AND SUMMARY TABLE - LEAD

Plant species	Plant organ	* ppm - basis	No. of samples	Range	Mode	Mean
BLACKY BAY BOG						
Surface peats		d	28	......most zero........		
Black Spruce	leaves	d	28	0-25	0	2
	stems	d	28	0-5	0	2
Labrador-tea	leaves	d	7	0-4	1	2
	stems	d	7	0-1	0	0
Swamp-Birch	leaves	d	3	0-1	1	1
	stems	d	3	0	0	0
Sedge	whole	d	28	0-8	0	1
False Solomon's-seal	whole	d	25	0-3	0	0.5
Sphagnum	whole	d	27	0-10	5	4
Pleurozium	whole	d	28	0-10	3	3
SCOTT LAKE BOG						
Black Spruce	stems	d	24	0-9	2& 3	3
		a	24	0-920	150-190 240	240
Larch	stems	d	20	2-19	7	7
		a	20	230-1000	400	410
Leather-leaf	stems	d	22	0-1	0	0.3
		a	22	0-83	0	24
	leaves	d	21	0-25	1	2
		a	21	0-910	30	96
MATTAGAMI LAKE MINES						
Black Spruce	stems	d	26	0.5-3	2	2
		a	26	44-300	120	110
Speckled Alder	stems	d	28	2-11	6	6
		a	28	70-690	330	340
Labrador-tea	stems	d	58	0.2-13	4	0.7
		a	58	7-76	16	21
Wood-Horsetail	whole	d	27	0-4	2	2
		a	27	0-28	11	13
Sphagnum	whole	d	41	5-27	10	12
		a	41	27-810	450	420

* see 'Note' page 232

TABLE XII

AVERAGE AND SUMMARY TABLE - NICKEL

Plant species	Plant organ	* ppm - basis	No. of samples	Range	Mode	Mean
BLACKY BAY BOG						
Surface peats		d	28	0-40	0	9
Sphagnum	whole	d	28	0-8	0	2
Pleurozium	whole	d	25	0-10	0&5	4
SCOTT LAKE BOG						
Surface peats		d	25	0-60	20	23
Black Spruce	stems	d	24	0-104	0.3	7
		a	24	0-8000	0	540
Larch	stems	d	20	0.5-30	2	4
		a	20	13-1600	75	240
Leather-leaf	stems	d	22	0-3	0	0.4
		a	22	0-170	0	29
	leaves	d	23	0-42	0	3
		a	23	0-1600	0	130
MATTAGAMI LAKE MINES						
Surface clays		d	76	26-80	60	57
Black Spruce	stems	d	26	1-15	2	3
		a	26	39-810	110	130
Speckled Alder	stems	d	32	6-37	1	2
		a	32	0-2200	50&56	140
Sphagnum	whole	d	41	0-20	1	3
		a	41	0-630	110	77

* see 'Note' page 232

GENERAL DISCUSSION

Sample areas - It is quite firmly established that Blacky Bay Bog is a normal area with no metallization under or near it. Gleeson (1960) considered the distribution of the metals in the peats of this bog and the one at Scott Lake to be of the normal type one would find in peat bogs over areas of non-sulphide mineralization. This normal distribution of metals would of course be altered by an outside source of metals.

Gleeson found the environment in the clays under the bogs to be moderately reducing and weakly basic, conditions under which sulphides are relatively stable. He also found the overburden under the bogs to be thick, non-porous, and relatively impermeable, and concluded that the peat-chemical method would be of little use under such conditions. Gleeson believed that Salmi's (1955, 1956, 1958) successes with the peat-chemical methods were due in part to the fact that under his bog areas the overburden was shallow and permeable. Salmi (1955) believed the movement of metal ions from bedrock to peat was due to capillary action.

Warren and Delavault (1950 a) state that biogeochemistry is useless where the mineralization is not reached by tree roots, or circulating ground waters, or not incorporated into the soil by some agency such as glaciation.

Warren and Delavault (1955 a) give some suggestions for biogeochemical prospecting in muskeg. They state that in muskeg anomalies are modest and not sharply defined. Factors which affect the detection of an anomally are (1) depth of overburden (they would expect to detect an anomally in muskeg only with less than 50 feet of overburden); (2) density of vegetation; (3) physiography; and (4) solubility of the element or elements.

The possibility does exist that mineralization is present beneath these bogs since Gleeson's sampling did occur at wide intervals. However, the same sampling points were used for peat samples and botanical samples. The third area studied, the Mattagami Lake Mines property, has no true peat deposit, but it has a proven zinc ore body.

Results of plant analyses - The metal contents of each species when plotted on plant association maps do not have any correlation with the plant associations. Harbaugh (1950) reached a similar conclusion. The distribution of the plant associations in each of the sample areas seems to reflect the drainage pattern of that area more strongly than any other pattern or factor. Differences in the average zinc contents of samples from the two forest associations at Mattagami Lake Mines have already been noted. The differences are small but they may reflect differences in the drainage of the plant associations. It can also be pointed out that the different species conflict in their response.

The contour maps of the metal contents show very little relationship between different species. Several contour maps of the Mattagami Lake Mines property do have high areas over and about the ore bodies and there is a weak correlation between species in this area.

The profiles showing the metal contents of the different plant species at the same point show no correlation between species.

The histograms of metal contents from Blacky Bay and Scott Lake Bogs nearly all have the shape of those from normal areas. The histograms from the Mattagami Lake Mines give some indications that the area is anomalous, but the indications are not strong. The histograms for zinc content from the bog areas (figures 23 and 75) are quite different from the histograms for zinc from Mattagami Lake Mines, (figure 126).

The average values for the metal contents obtained in this study as well as the percentage variation from the average are given in Tables IX to XII.

Warren and Delavault (1955 a) suggest normal metal contents for several Eastern Canadian plant species.

TABLE XIII

Normal values for several species (Warren & Delavault, 1955 a)
(ppm - dry wt, outside and ppm - ash, inside brackets)

	Cu	Zn	Cu:Zn	% ash
Black Spruce 2 yr. old stems	6(250)	75(3200)	0.08	2.3
American Larch 2 yr. old stems	6(200)	59(1800)	0.11	3.3
Alder 2 yr. old stems	12(350)	85(2500)	0.14	3.5
Labrador-tea 2 yr. old stems	7(300)	64(2800)	0.11	2.4

Warren and Delavault (1955 a) suggest that for Larch possibly anomalous values are 50 percent above normal for copper and 15 percent above normal for zinc. For Labrador-tea possibly anomalous values are 50 percent above normal for copper and 30 percent above normal for zinc. Probably anomalous values for Labrador-tea are 100 percent above normal for copper and 50 percent above normal for zinc.

Warren and Delavault (1954) suggest that normal values for nickel in 2 yr. old Black Spruce stems are less than 2 (100) ppm without exception.

The average values or normals found in the present study are different from those suggested by Warren and Delavault.

The following discussion of zinc refers to Tables IX and XIII. The average zinc content (ppm - dry wt.) of Black Spruce stems on Blacky Bay Bog was higher than on

Scott Lake Bog or the Mattagami Lake Mines Property. The average zinc content (ppm - ash) of Black Spruce stems was greater on Scott Lake Bog than on the Mattagami Lake Mines Property. Warren's normal value for the zinc content (ppm - dry wt.) of Black Spruce is higher than any obtained in this study, but his normal zinc content (ppm - ash) is the same as that found on Scott Lake Bog. Riddell (1952) found the zinc content (ppm - dry wt.) of Spruce in Quebec to range from 16.3 to 44.5 ppm in positive and negative areas. These values are in the same range as those of the author from Scott Lake Bog and Mattagami Lake Mines.

The average zinc content (ppm - dry wt.) of American Larch stems (2 - 4 yr. old) on Scott Lake Bog was much lower than Warren's normal value for 2 yr. old stems of this species, however, the zinc content (ppm - ash) was only slightly lower than Warren's.

The average zinc content (ppm - dry wt.) of the Speckled Alder stems (2 - 5 yr. old) on the Mattagami Lake Mines Property was lower than the normal value of Warren for 2 yr. old Alder stems. The average zinc content (ppm - ash) on Mattagami was much higher than Warren's normal value. The Alder at Mattagami did give some high values indicating an anomalous area.

The average zinc content (ppm - dry wt.) of

Labrador-tea stems on Blacky Bay Bog was higher than that of stems from Mattagami Lake Mines. Both of these values were much lower than the normal values of Warren. The average zinc content (ppm - ash) of Labrador-tea stems at Mattagami was also much lower than Warren's normal value.

Berrange (1958) found the zinc content (ppm - dry wt.) of whole Pleurozium moss plants to range from 25 to 90 ppm with an average content of 49 ppm. This average is higher than that found for Pleurozium moss from Blacky Bay.

Comparing Tables X and XIII - Average copper values found in this study (Table X) and the normal copper values suggested by Warren and Delavault (1955 a) in Table XIII.

The average copper content (ppm - dry wt.) of Black Spruce stems was the same at Blacky Bay and Scott Lake but higher at Mattagami. Warren's normal value was in between the two values. The copper content (ppm - ash) of Spruce was slightly higher at Mattagami than at Scott Lake but both values were much higher than Warren's normal value. Riddell(1952) found the copper content (ppm - dry wt.) of Spruce in Quebec to range from 3.9 to 6.9 ppm in positive and negative areas. These are in the same range as the author's values for this genus from western Quebec.

The average copper content (ppm - dry wt.) of American Larch stems (2 - 4 yr. old) at Scott Lake was the same as Warren's normal value for 2 yr. old stems. The copper content (ppm - ash) at Scott Lake was higher than Warren's normal value.

The average copper content (ppm - dry wt.) of Speckled Alder stems (2 - 5 yr. old) at Mattagami was the same as Warren's normal value for Alder stems (2 yr. old). The average copper content (ppm - ash) was higher at Mattagami than Warren's normal value.

The average copper content (ppm - dry wt.) of Labrador-tea stems at Blacky Bay and Mattagami are similar and slightly higher than Warren's normal value for the species. The average copper content (ppm - ash) at Mattagami is also slightly higher than Warren's value.

Berrange (1958) found the copper content (ppm - dry wt.) of whole Pleurozium moss plants to range from 5 to 8 ppm with an average content of 5 ppm. These values are very similar to the author's for Pleurozium moss from Blacky Bay Bog.

The average copper:zinc ratio for Black Spruce stems is much higher at Mattagami than at Blacky Bay or Scott Lake, and all values are higher than the normal value suggested by Warren. Riddell (1952) found the copper:zinc ratio in Spruce stems from Quebec to range from 0.104 to 0.294. The author's values from western Quebec are in the same range.

The average copper:zinc ratio for Larch stems

(2 - 4 yr. old) at Scott Lake is twice the value suggested by Warren for 2 yr. old stems.

The average copper:zinc ratio in Speckled Alder stems (2 - 5 yr. old) at Mattagami is higher than Warren's suggested normal value for Alder stems (2 yr. old).

The average copper:zinc ratio in Labrador-tea stems is higher at Mattagami than at Blacky Bay and both are much higher than the value of Warren.

The percentage ash for Black Spruce stems at Mattagami is near Warren's value, both of these are higher than that at Scott Lake.

Warren's value for the percentage ash in Larch stems (2 yr. old) is nearly double that found in Scott Lake Larch stems (2 - 4 yr. old), and a similar situation exists for the Speckled Alder at Mattagami.

The percentage ash in Labrador-tea stems at Mattagami was higher than Warren's value.

It can be noted that Wood-Horsetail (Table X) has a much higher percentage ash than most plants. Warren and Delavault (1950 b) found the percentage ash in plants of Equisetum sp. to range from 16.7 to 22.7 percent. These values are slightly higher than the author's average value of 13.9 percent. Warren and Delavault (1950 a) suggest that the percentage ash is lower in northern trees than in southern trees. This could be the reason for some of the low average ash percentages (below

Warren's values) obtained by the author for trees from Western Quebec. Berrange (1958) found that the lead content (ppm - dry wt.) of whole Pleurozium moss plants ranged from 15 to 50 ppm with an average of 27 ppm. These values are much higher than the author's (Table XI).

The average nickel contents (Table XII) of Black Spruce stems from Scott Lake and Mattagami are very close to Warren's maximum normal values (p.260 of thesis). Berrange (1958) found that the nickel contents (ppm - dry wt.) of whole Pleurozium moss plants had a narrow range and an average of 5 ppm. The author's average for this species was 4 ppm.

The differences between the average values of the author and other workers, Warren in particular, may be due to several factors. These factors may also explain differences between the different sample areas. Warren, Delavault and Irish (1952 b) state that there are in fact biogeochemical provinces in much the same way that there are metallogenetic provinces. Due to the differences between provinces normals vary from area to area. They also state that one or two high values mean little and that for thorough prospecting systematic sampling to obtain a picture of the whole area is necessary. Examples of differences between areas are given by Warren and Delavault (1955 b). This report records the average zinc content of Black Spruce in southeastern Canada to be 3200 ppm - ash, while in a northern area (supposedly normal) the average zinc content of Black Spruce was nearly double at 6000 ppm - ash. A similar difference is reported for Salix sp. from British Columbia and southeastern Canada, the normal zinc content in the west was 3100 ppm - ash or 80 ppm - dry wt. and in the east it was 8000 ppm - ash or 24 ppm - dry wt. Warren and Delavault (1955 b) suppose that these differences are due to the different biogeochemical provinces.

The differences between the author's and Warren's average values for Larch and Alder stems may be that the stems are not comparable in age. Stems of different ages cannot be directly compared (Warren, Delavault, and Fortescue, 1955).

The occasional very high values for nickel in the plants analyzed for this report cannot be explained (see Table XII). However several factors may be suggested as the cause. These include (1) the possibility of a response to mineralization, (2) the uptake of metal from circulating ground waters enriched by an outside source, (3) contamination of unknown origin, (4) in certain cases, accumulation in older wood of the sample.

The moss (Sphagnum spp.) can be compared between the two areas, Blacky Bay Bog and Mattagami Lake Mines. The zinc and nickel contents are similar in both areas. The lead content is higher and the copper content is lower in the

Mattagami area.

The metal contents of the surface peats at Scott Lake Bog and Blacky Bay Bog can be compared in the average tables. The average zinc contents are quite similar. The average copper contents are different with a low mean and a high percentage variation at Blacky Bay and the opposite situation at Scott Lake. The lead contents of the surface peats were very low in both cases. The nickel contents of the surface peats was much higher on Scott Lake Bog than on Blacky Bay Bog.

The maximum percentage variation above average is given for zinc and copper contents of plants in Tables IX and X.

It will be noted that the Mattagami Lake Mines Property has much higher percentage variation above average than the other two areas for zinc, (Table IX). Blacky Bay has two percentages that barely reach 80 percent, and Scott Lake has one percentage over 70 percent, while Mattagami has five percentages greater than 85 percent.

These percentages at Mattagami are in the ranges suggested by Warren and Delavault (p.260) as being from probably anomalous areas. It would seem that this character, as Warren and Delavault (1955 a) point out, is one of importance in biogeochemistry.

Warren and Delavault were quoted previously (p.260) as suggesting that there is more variation in copper contents than in zinc contents. Table X supports this suggestion. Variations above the average copper contents frequently surpass 100 percent in both the Blacky Bay Bog and Mattagami Lake Mines Property. These high percentages are above the ranges suggested by Warren and Delavault (p. 260) as being probably anomalous. The high values from Mattagami Lake Mines need no explanation as they are from an area rich in minerals. The higher values from Blacky Bay Bog may be due to (1) a response to mineralization, or (2) normal variation between samples. The lack of correlation from one species to another would indicate that the high values are within the normal range of variation.

Tables IX to XII give evidence on the accumulation of metals by plants. The average metal contents of the surface peats and clays are known. Gleeson (1960) noted that the metal content of the peat generally increased with depth, thus the average metal content of the surface peats is a minimum value. Table IX shows the following plants to accumulate zinc from the surface peats: Black Spruce, Swamp-Birch, False Solomon's-seal and Sphagnum. Swamp-Birch accumulates large amounts of zinc. Accumulation of zinc by birch trees is also noted by Warren, Delavault and Irish (1952 b). The zinc content of Leather-leaf is appreciably lower than that of the surface peats. The remainder of the species on peat bogs have zinc contents similar to those of the surface peats. The zinc contents of the surface clays at

Mattagami Lake Mines are much higher than those of the plants over the clays.

Table X shows all the plants of Blacky Bay Bog to accumulate some copper since the copper contents of the surface peats were very low. The surface peats of Scott Lake Bog were higher in copper content but no accumulation by the plants is indicated. A similar situation exists with plants over the clays of Mattagami Lake Mines.

Table XI shows the accumulation of lead from surface peats by the Sphagnum and Pleurozium mosses and by Larch trees. The lead values in the surface peats and clays were very low or not detectible. Alder trees and Sphagnum moss accumulated lead from the surface clays at Mattagami Lake Mines.

Table XIIdoes not show any of the plants to have accumulated nickel from the surface peats or clays (see earlier note on scattered high values).

CHAPTER V

SUMMARY

1. The vegetation of two peat bogs, one (Blacky Bay) near the southern edge of the Boreal Forest Region in Western Ontario, and one (Scott Lake) in the centre of the Boreal Forest Region in Western Quebec, has been quantitatively described. The vegetation of both bogs is similar to that described by Dansereau and Segadas-Vianna (1952) as the succession occurring on peat bogs in Northern Quebec and Ontario where the Canadian or Spruce-Fir forest is climax.
2. The vegetation of an upland third area (Mattagami Lake Mines) in Western Quebec was briefly described. This area falls within the Boreal Forest Region of Northern Canada and its vegetation is characteristic.
3. The vegetation on parts of the peat bogs and on part of the upland area is of the type termed "muskeg" by Hustich (1949).
4. The succession of Sphagnum spp. and their associated plants in relation to the moisture factor has been noted and is similar to that noted by Moss (1953).
5. The decreased growth rate of American Larch in the peat bog of Western Ontario is recorded. This was also noted by Isaak, Marshall and Buell (1959), who attributed it to an increased rate of precipitation since the early 1940's.

6. Biogeochemical data has been presented from Blacky Bay Bog in Western Ontario, Scott Lake Bog in Western Quebec, and Mattagami Lake Mines in Western Quebec. This data is in the form of copper, zinc, lead, and nickel contents expressed in ppm - dry wt. and ppm - ash for a total of twelve plant species. The total number of samples analyzed for the four metals was 431.
7. The two peat bogs sampled are regarded by Gleeson (1960) to be of normal type one would find over areas of non-sulphide mineralization. The possibility does exist that mineralization was not detected. Gleeson (1960) considers it unlikely that metals could reach the peats or plants due to the type (impermeable clays) and depth of overburden beneath the bogs. Warren and Delavault (1950 a, 1955 a) suggest similar reasons for a lack of chemical evidence of mineralization under such peat bogs.
8. The upland area sampled was over a zinc ore body overlain by impermeable clays.
9. The distribution of plant associations in each sample area was primarily controlled by the drainage pattern of that area.
10. Differences which occurred in the average zinc contents of samples from the two forest associations at Mattagami Lake Mines were confused because of the conflicting response of the different species.
11. Contour maps of the plant metal contents over the bog areas had a low relief with no correlation between species.

12. Contour maps of the plant metal contents over the Mattagami Lake Mines area had high areas over and about the ore bodies with a weak correlation between species.
13. The profile graphs showing the metal contents of the different plant species at the same point in the peat bogs have no correlation between species.
14. The frequency histograms of the plant metal contents from the bog areas nearly all have the shape of those from normal areas as described by Warren and Delavault (1955 a).
15. The frequency histograms of plant metal contents from the Mattagami Lake Mines give some indications that the area is anomalous, but the indications are weak.
16. The average metal contents for each plant species in each area are presented in Tables IX to XII.
17. The average metal contents of the plants are compared to other published data for this area. The average values of the author and of Riddell (1952) and Berrange (1958) are quite similar, especially for the plant samples from Quebec. The average values of the author and of Warren and Delavault (1955 a) are different in many cases. These differences may be due to the samples being from different biogeochemical provinces or to the use of different plant organs in sampling.
18. The occasional very high values for nickel in plants may be due to: (1) a response to mineralization, (2) enrichment from an outside source, (3) accumulation in older wood of the sample, (4) contamination of unknown origin.

19. It is suggested that the average metal contents in the plant samples from the peat bogs in Tables IX to XII are normal or near normal values for peat bogs in their respective areas.

20. The maximum percentages of variation above the average values are high for all areas but are highest for the Mattagami Lake Mines.

21. The following plants were found to accumulate zinc from the surface peats: Black Spruce, Swamp-Birch, False Solomon's-seal, and Sphagnum. Swamp-Birch accumulates large amounts of zinc. Leather-leaf has lower zinc contents than the surface peats.

22. All of the plant species sampled were found to accumulate small amounts of copper.

23. Lead was accumulated from peats by Sphagnum and Pleurozium mosses and by American Larch trees. Speckled Alder trees and Sphagnum moss accumulated lead from surface clays.

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