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FOREST RESEARCH LABORATORY
VICTORIA, BRITISH COLUMBIA
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FORESTRY BRANCH
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CANADA
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Summary

A survey of British Columbia forest nurseries showed that plant-parasitic nematodes are more abundant and potentially more important in coastal than in interior nurseries. High populations of Xiphinema bakeri Williams, 1961 were consistently associated with the corky root disease of Douglas-fir (Pseudotsuga menziesii) seedlings at Duncan, Green Timbers and Slesse 1 at Chilliwack. This nematode was also present, although in lower numbers in the nurseries at Campbell River, Langley, Chilliwack (Borden, and Slesse 2) and the Alouette nursery, but was not present at Koksilah, Snowden Creek or in the "new field" at Chilliwack. Tylenchus emarginatus was found in samples from about roots of Douglas-fir and spruces (Picea spp.) in all coastal nurseries except at Campbell River and the "new field" at Chilliwack. The Koksilah nursery was the only one where populations of Paratylenchus Micoletzky, 1922 and Pratylenchus Filipjev, 1934 were large enough to be of concern; Xiphinema americanum Cobb, 1913 was found in this nursery, however, the population levels were inconsistent.

The Rayleigh nursery was the only interior nursery where significant populations of plant-parasitic nematodes were found; Paratylenchus and Tetylenchus Filipjev, 1936 were the two genera present.

Introduction

Plant-parasitic nematodes are frequently found associated with forest nursery seedlings (4), but very little is known on their role as pathogens or as components in seedling disease complexes. A limited survey of British Columbia forest nurseries (Salisbury and Bosher (5)) in 1959, led to the conclusion that nematodes were of no importance to seedling

production. However, in 1968 Bloomberg (1) described a serious root rot (corky root) of Douglas-fir seedlings in which the nematode Xiphinema bakeri Williams, 1961 seemed to play a significant role. The disease is becoming more widespread in certain nurseries, and the possibility exists that it will spread to uninfected nurseries.

The purposes of the present study were to (1) determine if X. bakeri is consistently associated with corky root disease, (2) determine the kinds and numbers of other plant-parasitic nematodes in British Columbia forest nurseries and (3) to assess the significance of parasitic nematodes in seedling production.

Materials and Methods

A grid sampling pattern was used when collecting soil samples. Sample size varied with the number of years the nursery had been in production and the relative amount of seedling disorders which appeared to be attributable to nematodes; e.g., a 20 x 20 ft grid was used at the "older" nursery at Duncan while the pattern was 40 x 40 ft at the "newer" Campbell River nursery. Soil samples were composites of cores ($\frac{3}{4}$-inch diameter to an 8-inch depth) collected from the center of the seedbeds; i.e., when a 20 x 20 ft sampling pattern was used, soil cores were collected at 20-ft intervals along the row of seedbeds. The starting point for the next sample was 20 ft from the preceding sample. Schematic maps (results and conclusions section) show the starting points and the direction in which the sampling progressed. When seedbeds were present, every fourth seedbed was taken to be the 20-ft grid distance. Samples, 3 to 5 lb, collected in polyethylene bags, were sealed and brought to the laboratory

in an ice-cooled, insulated box. Samples were stored at 20 C until processed within one week after collection.

Each sample was put through a ¼-inch screen to remove large particles of debris, and twice through a halving device (soil riffler). A 400-g sample was then selected for nematode analysis. Nematodes were extracted by the Christie and Perry method (2), counted using a stereomicroscope, preserved in TAF (3), and later identified using a compound microscope. Dilutions and conversion factors were used when the populations were large.

Results and Conclusions

Each nursery is treated separately, and the order of presentation is: Vancouver Island, Mainland and Interior, B. C. Tables 2 - 19 give the results of the nematode surveys. Figures 1 - 9 are schematic maps; i.e., they are not drawn to scale and the boundaries of a nursery or field may have changed since the time the samples were taken. No maps are given for nurseries consisting of only one field. Sampling area numbers do not always correspond with the British Columbia Forest Service numbers for each field.

Variables in nursery practices, noted when soil samples were taken, seemed to have only a minor influence on the overall populations of nematodes. Thus no attempt was made to sort out differences in nematode populations and relate these to cultural practices such as seed source and times of showing.

Table 1 has been included to familiarize the reader with the food habits of the various nematodes listed in the tables. Taxonomic authorities for the nematode genera and species, other than Xiphinema bakeri Williams, 1961, are given by Thorne (6).

Table 1. Food habits of the nematodes found in British Columbia forest nurseries.

Nematodes	Food habits and possible significance
Non-stylet-bearing	These nematodes do not possess a stylet (the spear-like apparatus used to puncture plant cells) so they can not feed on seedling roots. They are usually bacteriophagous (bacterium-feeders) and their populations are usually largest in soils where organic matter is undergoing bacterial decomposition.
Stylet-bearing	The majority of the nematodes listed below belong to the order Tylenchida, Thorne, 1949 and have a stylet, i.e., a spear-like apparatus used to puncture plant cells during feeding. However, the presence of a stylet does not mean the nematode feeds on roots, e.g., some stylet-bearing nematodes are mycophagous (fungus-feeders) while others parasitize aerial plant parts. No nematodes are known to feed on the aerial parts of coniferous seedlings. Members of the order Dorylaimida, Pearse, 1942 do not possess a "true stylet" (in the sense of the order Tylenchida), but have an onchiostyle. Nematodes of the genus Mononchus, Bastian, 1865 possess a tooth-like structure which they use when preying on other nematodes.
Aphelenchoides sp.	Probably fungus-feeding, thus could interfere with mycorrhizal formation.
Aphelenchus sp.	As above.
Criconemoides sp.	Ectoparasites on roots. Large populations could be harmful to seedling growth.
Diphtherophora sp.	Biology unknown, possibly root parasites.
Ditylenchus sp.	Probably feed on aerial parts of herbaceous plants or on fungi. Not of any likely significance in forest nurseries.
Dorylaimida (unidentified)	Biology largely unknown, possibly predaceous on other nematodes or root parasites. Significance in forest nurseries unknown.

Table 1. Food habits of the nematodes found in British Columbia forest nurseries (continued).

Nematodes	Food habits and possible significance
Heterodera sp. (larvae)	Probably the oat-cyst nematode, *H. avenae*, thus of no significance in forest nurseries.
Meloidogyne sp. (larvae)	Root parasites on many kinds of plants, but conifers are not hosts.
Mononchus spp.	Predaceous on other nematodes. Could influence the development of populations of plant-parasitic nematodes.
Neotylenchidae (unidentified)	Possibly root parasites or mycophagous nematodes. Food habits largely unknown thus at present no importance can be given to their occurrence.
Paratylenchus spp.	Ectoparasites on roots. Large populations of these nematodes probably can significantly hinder plant growth.
Pratylenchus spp.	These root endoparasites can retard growth and probably are also important components in root rot diseases.
Rotylenchus sp.	Ectoparasites on roots. Potentially important on seedlings.
Tetylenchus sp.	Feed as ectoparasites on roots. High populations probably could influence seedling growth.
Trichodorus spp.	Large populations of these ectoparasites could influence seedling growth.
Tylenchus davainii	The biology of this nematode is unknown; however it might be an ectoparasite on roots.
Tylenchus emarginatus	These nematodes are ectoparasites on roots. Whether or not they can retard plant growth is unknown.
Tylenchus spp.	Possibly root parasites or mycophagous forms. Since their biology is largely unknown no prediction can be made on their importance in forest nurseries.

Table 1. Food habits of the nematodes found in British Columbia forest nurseries (continued).

Nematodes	Food habits and possible significance
Xiphinema americanum	A root ectoparasite found only at Koksilah. Importance to growth of local seedlings is unknown.
Xiphinema bakeri	Ectoparasite on roots. Seems to prefer Douglas-fir. High populations of *X. bakeri* are consistently associated with the corky root disease of this seedling species.
Xiphinema sp.	Root ectoparasite found at Rayleigh. Not present in numbers large enough to be of concern.

Campbell River Nursery

The Campbell River nursery was sampled on February 28, 1968. The area was only recently cleared and the first seedbeds were sown in the spring of 1968. Samples were collected on a 40 x 40 ft grid pattern.

Xiphinema bakeri was the only potentially important plant-parasitic nematode obtained from the samples and the population was too low to be damaging (Table 2). The nursery should be sampled at 2- or 3-year intervals to determine if the X. bakeri population is building up.

Snowdon Creek Nursery

The Snowdon Creek transplant nursery was sampled on February 27, 1968, on a 40 x 40 ft grid pattern. Samples were collected only from those areas where seedlings were present (Figure 1).

No obvious nematode damage was observed at the nursery. Douglas-fir seedlings whose root systems had been partly ruined by the corky root disease when they were brought to the nursery seemed to be recovering. The only plant-parasitic nematodes present, Pratylenchus sp. and Tylenchus emarginatus (Table 2), do not appear in high enough numbers to present an immediate problem.

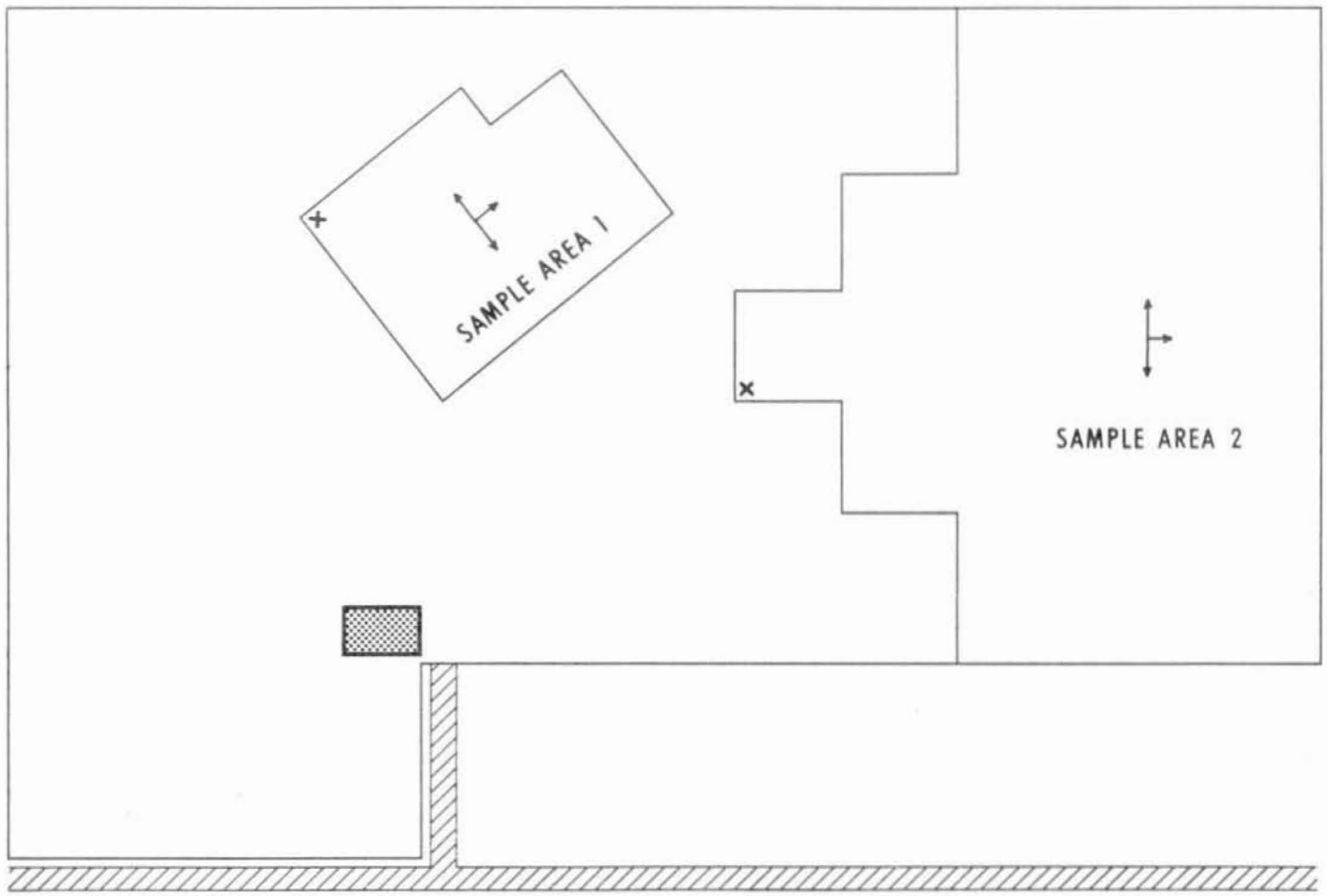

FIGURE 1. SNOWDON CREEK NURSERY

Table 2. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil at the Campbell River and Snowdon Creek nurseries.

	Campbell River	Snowdon Creek *Pseudotsuga menziesii*
Seedling age:	Fallow	2-1
Number of samples:	18	5
Nematodes		
Non-stylet-bearing	215	229
Stylet-bearing		
Aphelenchoides sp.	77	56
Ditylenchus sp.	0	7
Dorylaimida (unidentified)	16	36
Heterodera sp. (larva)	1	0
Mononchus sp.	3	6
Neotylenchus sp.	0	7
Pratylenchus sp.	0	3
Tylenchus emarginatus	0	32
Tylenchus spp.	12	30
Xiphinema bakeri	1	0

Duncan Nursery

Samples were taken at the Duncan nursery from August 17 to 24, 1967, using a 20 x 20 ft grid pattern.

The only plant-parasitic nematodes present in sufficient number to warrant concern were Xiphinema bakeri and Tylenchus emarginatus (Tables 3, 4 and 5). The largest populations were found in Douglas-fir beds in sampling areas 1 and 2 (Table 3), where corky root disease occurred. No other seedling problems seemed to be attributable to nematodes.

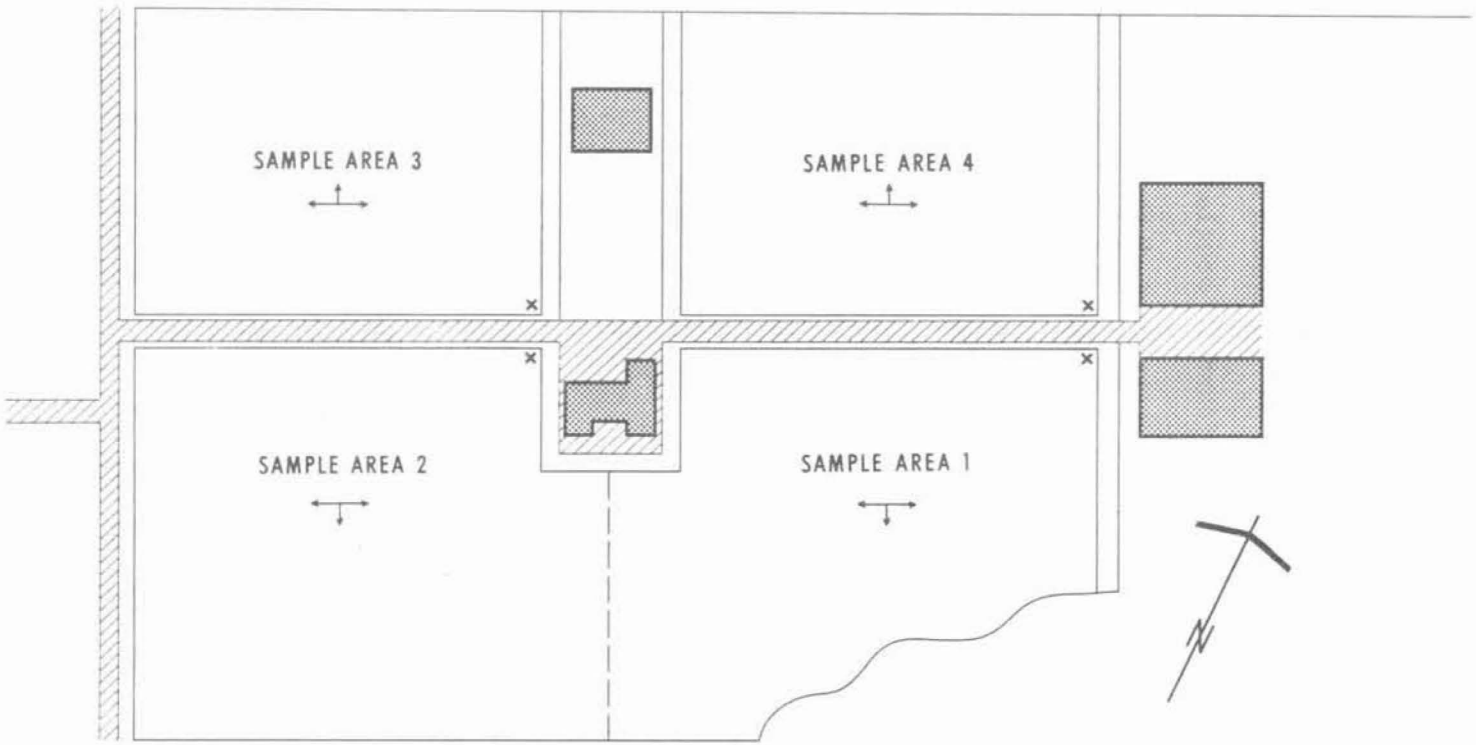

FIGURE 2. DUNCAN NURSERY

Table 3. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil in sampling areas one and two at the Duncan nursery.

	Area one	Area two				
	Pseudotsuga menziesii	*Pseudotsuga menziesii*	*Tsuga heterophylla*	*Pinus contorta*	*Pinus monticola*	*Thuja plicata*
Seedling age:	2-0	2-0	2-0	2-0	2-0	2-0
Number of samples:	9	14	5	1	1	1
Nematodes						
Non-stylet-bearing	268	145	165	374	342	1735
Stylet-bearing						
Aphelenchoides sp.	209	150	42	100	45	1143
Aphelenchus sp.	10	9	7	0	0	0
Dorylaimida (unidentified)	48	68	9	75	69	45
Mononchus sp.	11	24	39	0	0	0
Neotylenchidae (unidentified)	2	0	0	0	0	0
Neotylenchus sp.	3	312	37	574	592	641
Paratylenchus sp.	17	0	0	0	0	0
Pratylenchus sp.	2	0	0	0	0	0
Tylenchus emarginatus	1964	2639	471	1570	820	90
Tylenchus spp.	22	12	7	0	0	90
Xiphinema bakeri	22	102	9	0	0	0

Table 4. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil in sampling areas three and four at the Duncan nursery.

	Area three		Area four
	Picea sitchensis	*Tsuga heterophylla*	*Picea sitchensis*
Seedling age:	1-0	1-0	1-0
Number of samples:	2	6	8
Nematodes			
Non-stylet-bearing	586	487	642
Stylet-bearing			
Aphelenchoides sp.	55	151	76
Aphelenchus sp.	0	24	13
Dorylaimida (unidentified)	0	17	22
Mononchus sp.	13	0	31
Neotylenchus sp.	17	58	25
Paratylenchus sp.	13	0	13
Pratylenchus sp.	0	0	7
Tylenchus emarginatus	37	68	205
Tylenchus spp.	228	30	57
Xiphinema bakeri	0	5	0

Table 5. Summary table of areas 1 to 4 at the Duncan nursery.

	Pseudotsuga menziesii	*Picea sitchensis*	*Tsuga heterophylla*		*Pinus contorta*	*Pinus monticola*	*Thuja plicata*
Seedling age:	2-0	1-0	1-0	2-0	2-0	2-0	2-0
Number of samples:	23	10	6	5	1	1	1
Nematodes							
Non-stylet-bearing	207	614	487	165	374	342	1735
Stylet-bearing							
Aphelenchoides sp.	180	66	151	42	100	45	1143
Aphelenchus sp.	10	7	24	7	0	0	0
Dorylaimida (unidentified)	58	11	17	9	75	69	45
Mononchus sp.	18	25	0	39	0	0	0
Neotylenchidae (unidentified)	1	0	0	0	0	0	0
Neotylenchus sp.	158	48	58	37	574	592	641
Paratylenchus sp.	9	13	0	0	0	0	0
Pratylenchus sp.	1	4	0	0	0	0	0
Trichodorus sp.	0	0	48	0	0	0	0
Tylenchus emarginatus	2301	121	20	471	1570	820	90
Tylenchus sp.	17	143	30	7	0	0	90
Xiphinema bakeri	62	0	5	9	0	0	0

Koksilah Nursery

The Koksilah nursery is located on former agricultural land. Sampling areas 1 and 2 (Figure 3) have been in production for 3 years, while 3 and 4 have just recently been brought into production. A large portion of areas 3 and 4 had been treated with soil fumigants a year before sampling; however, some strips (see map) were left untreated. Samples for nematode analyses were collected from these untreated strips (September 25 to October 23, 1967) on a 20 x 20 ft grid pattern.

Although several kinds of plant-parasitic nematodes were found throughout the nursery (Tables 6, 7 and 8), only Pratylenchus sp. and a species of Paratylenchus were consistently present in high numbers. These two nematodes were associated mainly with Douglas-fir and spruce (Table 8). Xiphinema americanum populations were highest in areas most recently converted to nursery. This nematode could be potentially important, especially on Douglas-fir, and periodic surveys will be required to assess its development. The Heterodera larvae (Table 8) were H. avenae, the oat cyst nematode.

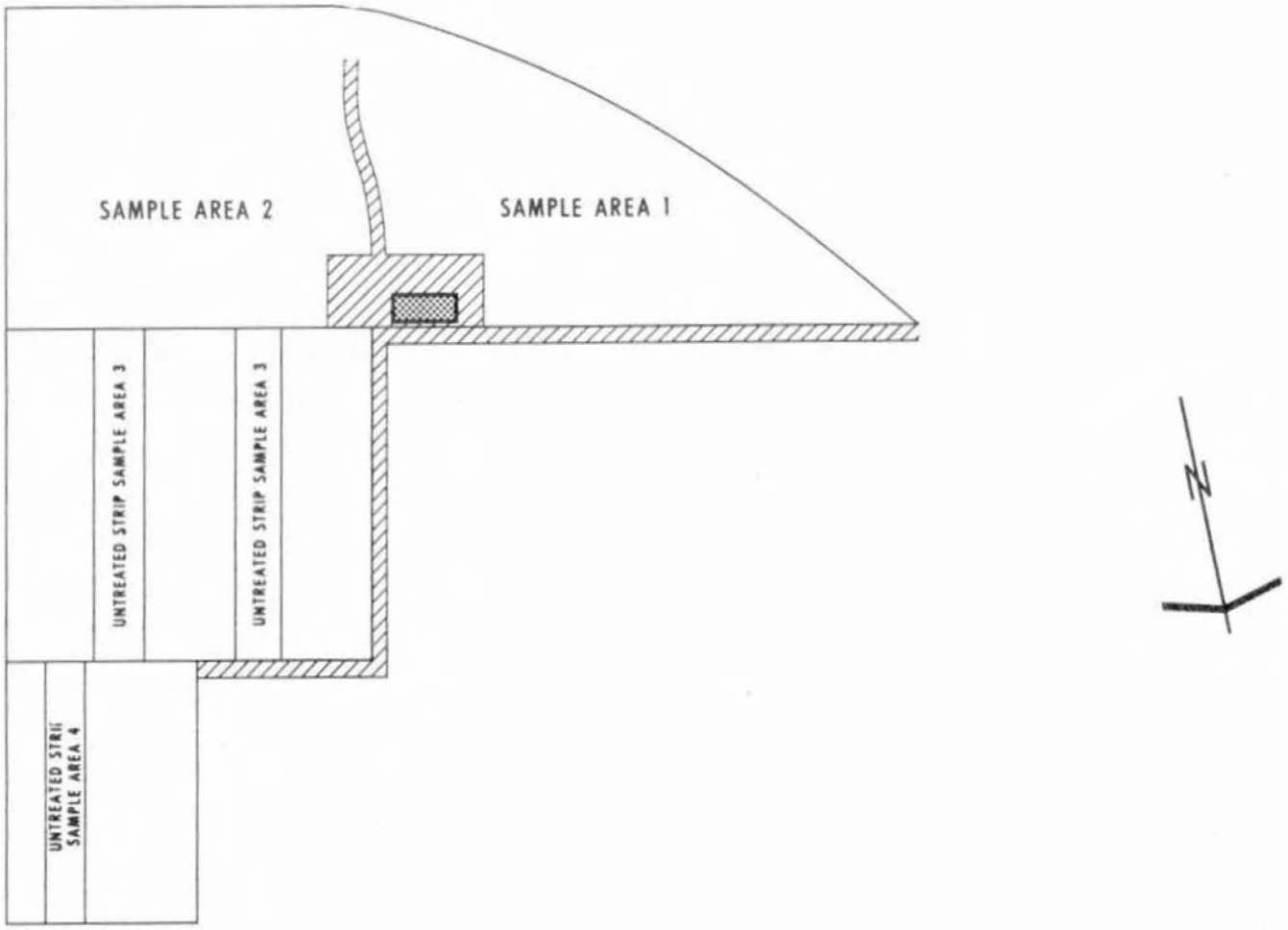

FIGURE 3. KOKSILAH NURSERY

Table 6. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil in sampling areas one and two at the Koksilah nursery.

	Area one			Area two		
	Pseudotsuga menziesii	*Picea sitchensis*	*Picea glauca* (interior)	*Pseudotsuga menziesii*	*Picea sitchensis*	*Tsuga heterophylla*
Seedling age:	2-0	2-0	2-0	1-0	1-0	1-0
Number of samples:	8	10	5	2	11	7
Nematodes						
Non-stylet-bearing	312	352	348	43	442	121
Stylet-bearing						
Aphelenchoides sp.	45	9	0	5	9	17
Aphelenchus sp.	59	58	156	23	56	33
Diphtherophora sp.	0	0	0	0	2	0
Dorylaimida (unidentified)	15	35	14	27	58	20
Heterodera avenae (larvae)	11	0	20	6	2	3
Mononchus sp.	8	9	0	5	8	4
Neotylenchus sp.	16	12	7	0	25	43
Paratylenchus sp.	250	338	291	94	63	38
Pratylenchus sp.	64	148	88	38	53	67
Trichodorus sp.	0	0	8	0	0	0
Tylenchus emarginatus	3	20	13	0	1	3
Tylenchus davainii	4	7	0	0	29	8
Tylenchus spp.	7	5	22	22	38	65
Xiphinema americanum	7	0	23	50	12	7

Table 7. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil in sampling areas three and four at the Koksilah nursery.

	Area three		Area four
	Pseudotsuga menziesii	Picea sitchensis	Pseudotsuga menziesii
Seedling age:	1-0	1-0	1-0
Number of samples:	18	2	27
Nematodes			
Non-stylet-bearing	161	165	391
Stylet-bearing			
Aphelenchoides sp.	39	15	19
Aphelenchus sp.	32	11	63
Dorylaimida (unidentified)	39	100	42
Heterodera avenea (larvae)	0	0	1
Mononchus sp.	1	0	3
Neotylenchus sp.	114	46	31
Paratylenchus sp.	355	55	184
Pratylenchus sp.	43	16	528
Tylenchus davainii	3	0	27
Tylenchus emarginatus	17	5	3
Tylenchus spp.	0	12	38
Xiphinema americanum	2	5	39

Table 8. Summary table of areas 1 to 4 at the Koksilah nursery.

	Pseudotsuga menziesii		*Picea sitchensis*		*Picea glauca* (interior)	*Tsuga heterophylla*
Seedling age:	1-0	2-0	1-0	2-0	2-0	1-0
Number of samples:	20	25	13	10	5	7
Nematodes						
Non-stylet-bearing	102	352	304	352	348	121
Stylet-bearing						
Aphelenchoides sp.	22	32	12	9	0	17
Aphelenchus sp.	28	61	34	58	156	33
Diphtherophora sp.	0	0	1	0	0	0
Dorylaimida (unidentified)	33	29	79	35	14	20
Heterodera avenae (larvae)	3	6	1	0	20	3
Mononchus sp.	3	6	4	9	0	4
Neotylenchus sp.	57	24	36	12	7	43
Paratylenchus sp.	225	217	59	338	291	38
Pratylenchus spp.	41	296	35	148	88	67
Trichodorus sp.	0	0	0	0	8	0
Tylenchus davainii	2	16	15	7	0	8
Tylenchus emarginatus	9	3	3	20	13	3
Tylenchus spp.	14	23	25	5	22	65
Xiphinema americanum	26	23	9	0	23	7

Green Timbers Nursery

One hundred and five soil samples were taken at the Green Timbers nursery on November 7 and 21, and December 14, 1967, using a 20 x 20 ft sampling grid. Corky root infection centers were present in Douglas-fir seedlings in sampling areas 4, 7, 8 and 9 but was most severe and widespread in the latter three areas (Figure 4).

Xiphinema bakeri was found throughout the nursery (Tables 9 and 10) mainly associated with Douglas-fir and Sitka spruce seedlings (Table 11). No visual damage was evident on the spruce. There was a close relationship between corky root and X. bakeri populations; i.e., the largest numbers of the nematode were found in those seedbeds where corky root was most prevalent. Large populations of Tylenchus emarginatus were also found in the nursery's soils, but there was no apparent injury to seedlings. Two other parasitic nematodes, species of Paratylenchus and Pratylenchus, were confined to small areas; e.g. sampling area 6, and do not seem to be a problem at this time.

Langley Nursery

The nursery area (Figure 5) under development at Langley was fallow when sampled on March 25, 1968; the area was previously used for agricultural crops. Soil samples were collected on a 40 x 40 ft grid.

Paratylenchus sp. and Pratylenchus sp. were found in high numbers (Table 11). It is impossible at this time to predict if these parasitic nematodes will influence seedling growth or disease development. A survey to assess population development will be required when the nursery has been in production for a few years.

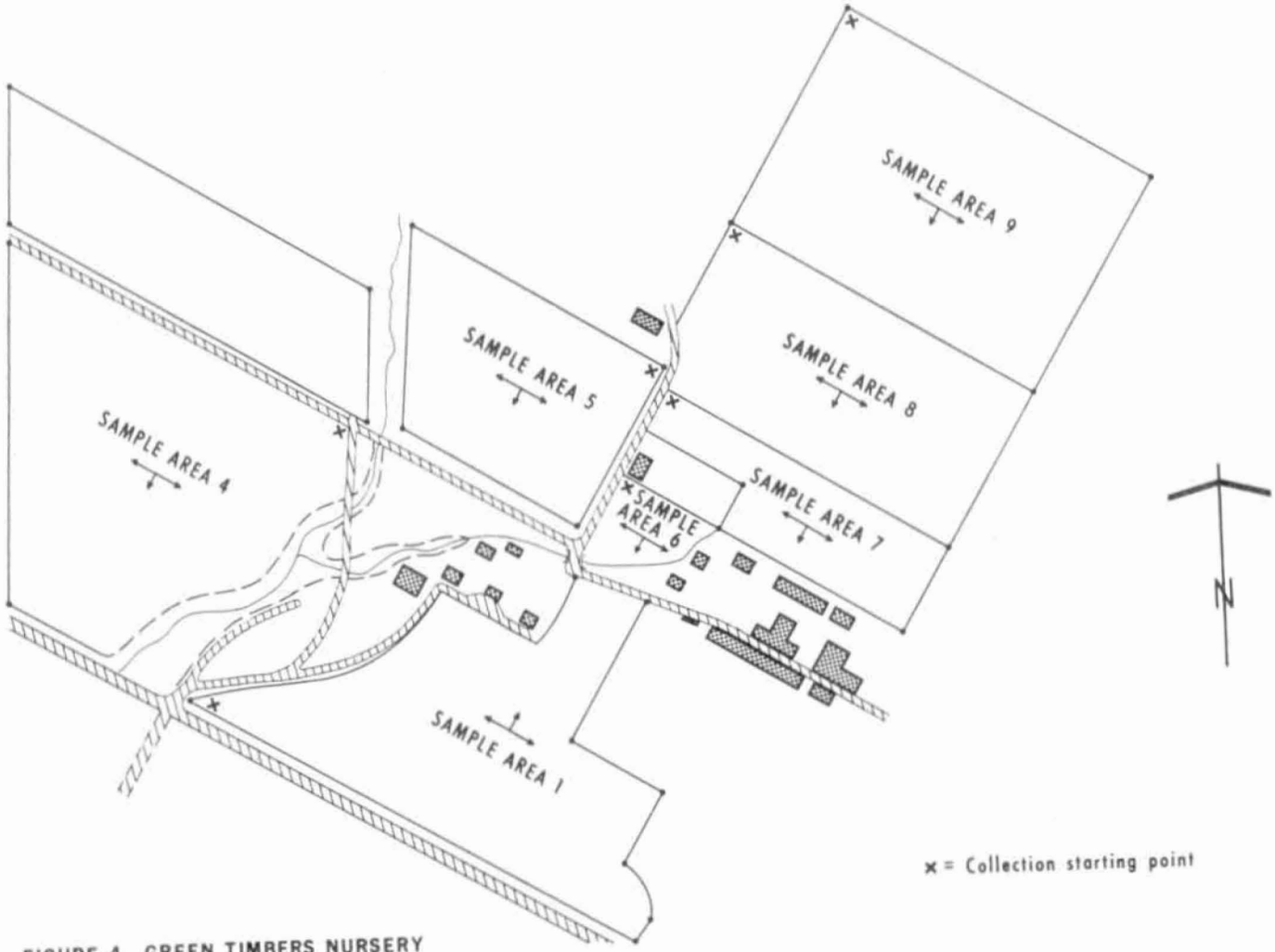

FIGURE 4. GREEN TIMBERS NURSERY

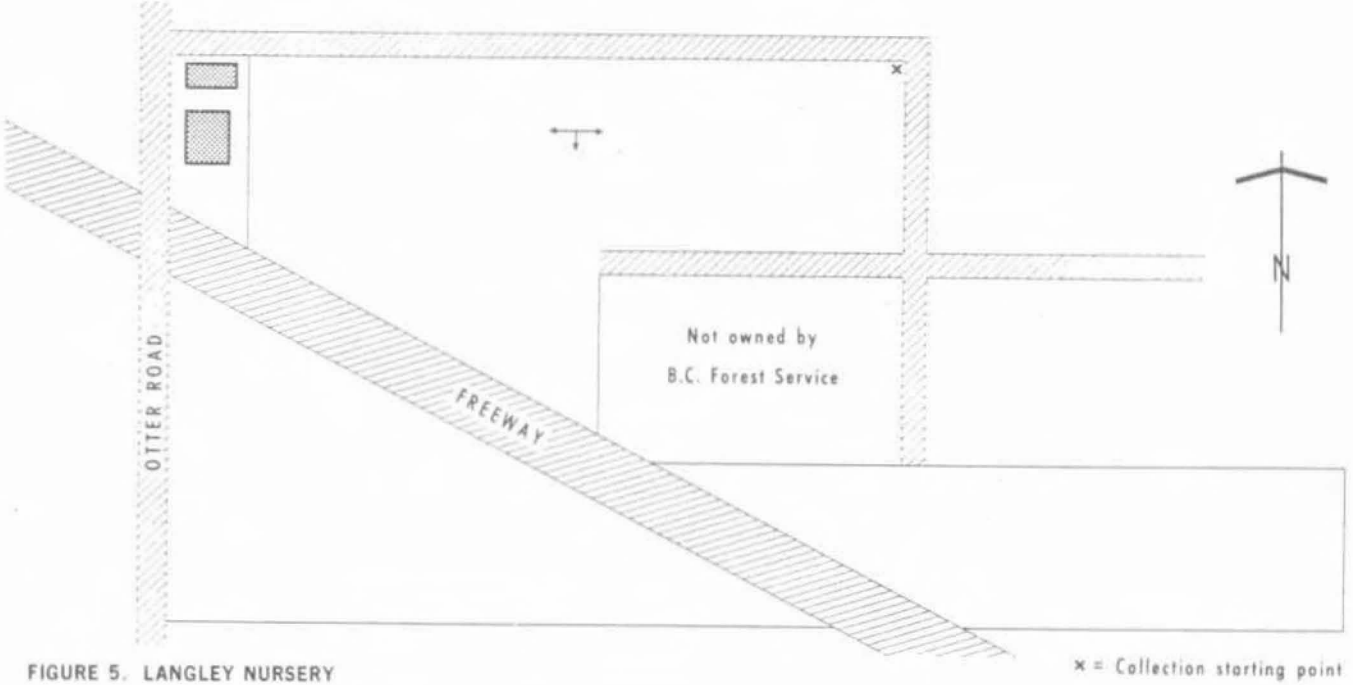

FIGURE 5. LANGLEY NURSERY

Table 9. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil in sampling areas one, four, and five at the Green Timbers Nursery.

	Area 1	Area 4	Area 5			
	Pseudotsuga menziesii	*Pseudotsuga menziesii*	*Pseudotsuga menziesii*	*Picea glauca* (interior)	*Picea sitchensis*	*Tsuga heterophylla*
Seedling age:	2-0	1-0	2-0	2-0	2-0	2-0
Number of samples	16	24	3	1	6	4
Nematodes						
Non-stylet-bearing	95	208	200	90	119	141
Stylet-bearing						
Aphelenchoides sp.	87	17	101	54	52	77
Aphelenchus sp.	1	23	3	18	6	14
Diptherophora sp.	1	0	0	0	0	0
Ditylenchus sp.	2	1	5	0	0	0
Dorylaimida (unidentified)	54	39	170	54	135	127
Mononchus sp.	4	2	12	0	3	5
Neotylenchus sp.	42	29	30	0	19	22
Paratylenchus sp.	0	1	5	0	0	0
Pratylenchus sp.	0	1	3	0	0	0
Tylenchus davainii	3	0	0	0	0	0
Tylenchus emarginatus	1683	154	838	1578	1147	552
Tylenchus spp.	15	14	92	0	41	8
Xiphinema bakeri	6	4	14	0	20	2

Table 10. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil in sampling areas six, seven, eight, and nine at the Green Timbers nursery.

	Area 6	Area 7	Area 8	Area 9
	Pseudotsuga menziesii	Pseudotsuga menziesii	Pseudotsuga menziesii	Pseudotsuga menziesii
Seedling age:	1-0	1-0	2-0	2-0
Number of samples:	7	8	13	13
Nematodes				
Non-stylet-bearing	119	102	71	56
Stylet-bearing				
Aphelenchoides sp.	28	9	75	63
Aphelenchus sp.	9	3	4	0
Criconemoides sp.	2	0	0	0
Ditylenchus sp.	0	2	52	5
Dorylaimida (unidentified)	0	36	16	17
Mononchus sp.	0	4	7	0
Neotylenchidae (unidentified)	0	0	0	12
Neotylenchus sp.	0	32	99	125
Paratylenchus sp.	57	2	0	0
Pratylenchus sp.	123	0	0	1
Trichodorus sp.	0	2	0	0
Tylenchus davainii	0	0	0	0
Tylenchus emarginatus	0	421	1688	1726
Tylenchus spp.	16	45	306	150
Xiphinema bakeri	0	21	15	20

Table 11. Summary table of areas one, and four to nine at Green Timbers, and the Langley nursery.

	Green Timbers					Langley
	Pseudotsuga menziesii		Picea sitchensis	Picea glauca (interior)	Tsuga heterophylla	Fallow
Seedling age:	1-0	2-0	2-0	2-0	2-0	
Number of samples:	39	55	6	1	4	10
Nematodes						
Non-stylet-bearing	143	106	119	90	141	483
Stylet-bearing						
Aphelenchoides sp.	18	82	52	54	77	49
Aphelenchus sp.	12	2	6	18	14	145
Criconemoides sp.	1	0	0	0	0	0
Diphtherophora sp.	0	0	0	0	0	0
Ditylenchus sp.	1	16	0	0	0	2
Dorylaimida (unidentified)	25	64	135	54	127	152
Heterodera sp. (larvae)	0	0	0	0	0	1
Meloidogyne sp. (larvae)	0	0	0	0	0	5
Mononchus sp.	2	6	3	0	5	4
Neotylenchidae (unidentified)	0	3	0	0	0	0
Neotylenchus sp.	20	74	19	0	22	3
Paratylenchus sp.	20	1	0	0	0	72
Pratylenchus sp.	41	1	0	0	0	196
Trichodorus sp.	1	0	0	0	0	0
Tylenchus davainii	0	1	0	0	0	16
Tylenchus emarginatus	192	1484	1147	1578	552	0
Tylenchus spp.	25	141	41	0	8	4
Xiphinema bakeri	8	14	20	0	2	0
Xiphinema sp.	0	0	0	0	0	2

Alouette Nursery

At the time of sampling, April 2, 1968, the Alouette nursery consisted of two fields (Figure 6). Sampling area 1 had been used for transplants and area 2, which had been recently cleared of trees and plowed, was fallow. Composite samples were collected on an 80 x 40 ft grid, i.e., four cores were taken at 80 ft intervals in a row with 40 ft between rows.

Three kinds of plant-parasitic nematodes; i.e., Paratylenchus sp., Tylenchus emarginatus and Xiphinema bakeri were found in low numbers at the nursery (Table 12). At present they probably do not present a threat to seedling production, however, this could change with increased production of seedlings, especially since X. bakeri and the fungus component of the corky root disease of Douglas-fir seedlings are present. The nursery should be re-checked in the future to determine the population levels of nematodes such as X. bakeri.

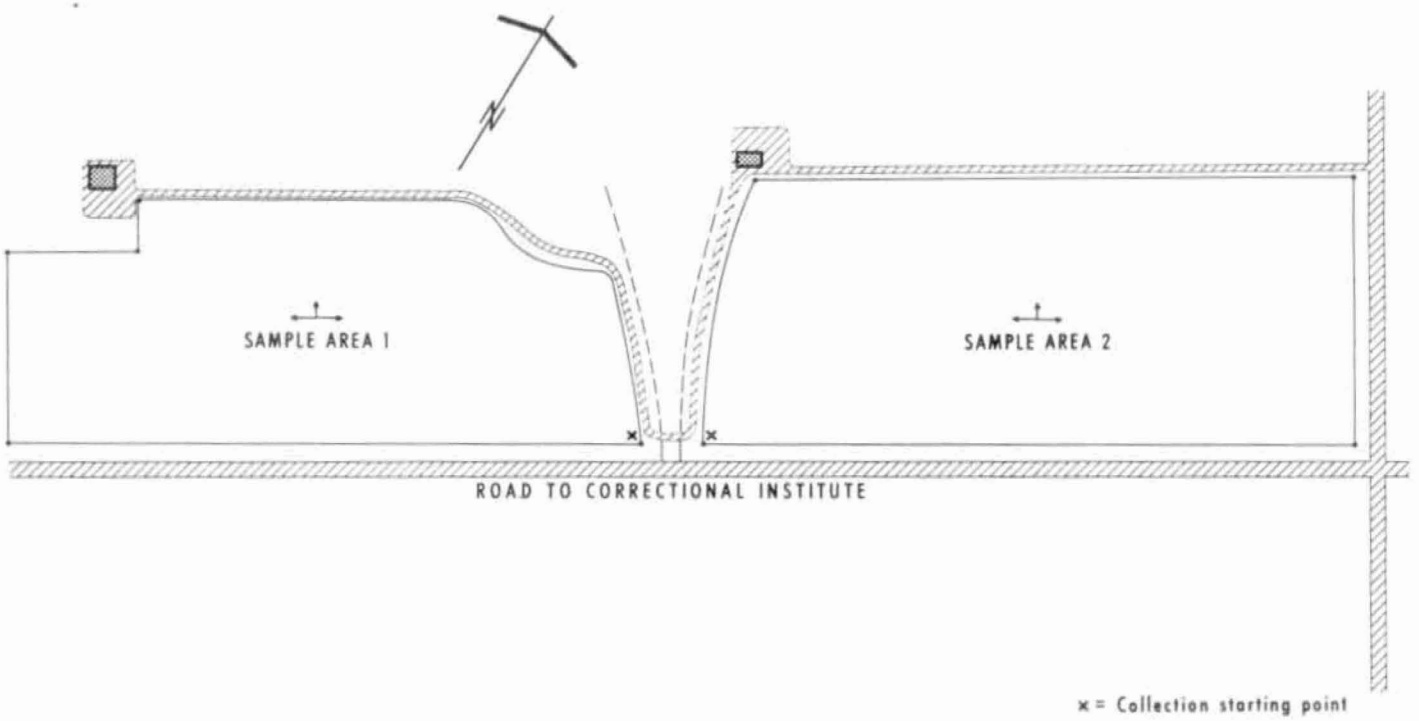

FIGURE 6. ALOUETTE NURSERY

Table 12. Summary table of areas one and two at the Alouette nursery.

	Fallow			*Picea sitchensis* (Area 1)
	Area 1	Area 2	Mean	
Seedling age:	-	-	-	2-2
Number of samples:	2	5	-	2
Nematodes				
Non-stylet-bearing	173	141	157	75
Stylet-bearing				
Aphelenchoides sp.	27	16	22	8
Aphelenchus sp.	0	8	4	0
Diphtherophora sp.	6	1	4	0
Ditylenchus sp.	6	8	7	2
Dorylaimida (unidentified)	24	4	14	26
Mononchus sp.	6	5	6	11
Neotylenchus sp.	0	0	0	4
Paratylenchus sp.	6	2	4	0
Tylenchus davainii	0	1	1	0
Tylenchus emarginatus	32	0	16	4
Tylenchus spp.	15	7	12	8
Xiphinema bakeri	0	1	1	0

Chilliwack Nursery

Four separate nursery areas (fields) were sampled at Chilliwack: Borden 1, Slesse 1, Slesse 2 and the "new field" area. The latter (Figure 7) was under development at the time of sampling and only one part was in seedbeds. A 20 x 20 ft grid was used to collect soil samples from the first three fields. The "new field" was sampled on a 40 x 20 ft pattern; i.e., cores were collected at 40 ft intervals within seedbeds, with 20 ft (every fourth row of seedbeds) between samples. Sampling was done on March 11, 1968.

There was no visual nematode damage at the Borden field. The plant-parasitic nematodes present were: Trichodorus sp., Tylenchus emarginatus and Xiphinema bakeri (Table 13). The population of T. emarginatus was very high in the interior spruce seedbeds. If root rot or nutritional-like problems occur in the future, nematodes could be involved.

Tylenchus emarginatus and Xiphinema bakeri were associated with Douglas-fir at the Slesse 1 field. The corky root disease was severe, particularly in those parts of the field where large numbers of X. bakeri were found. Pratylenchus sp., a root endoparasite, was also present, but in very low numbers.

Although T. emarginatus and X. bakeri were found at Slesse 2, no damage was evident and no corky root was observed. Perhaps the numbers were too small to be important. Insignificant numbers of a Paratylenchus sp. were also present.

No plant-parasitic nematodes were obtained from the "new field" samples. This area should be checked again in the future.

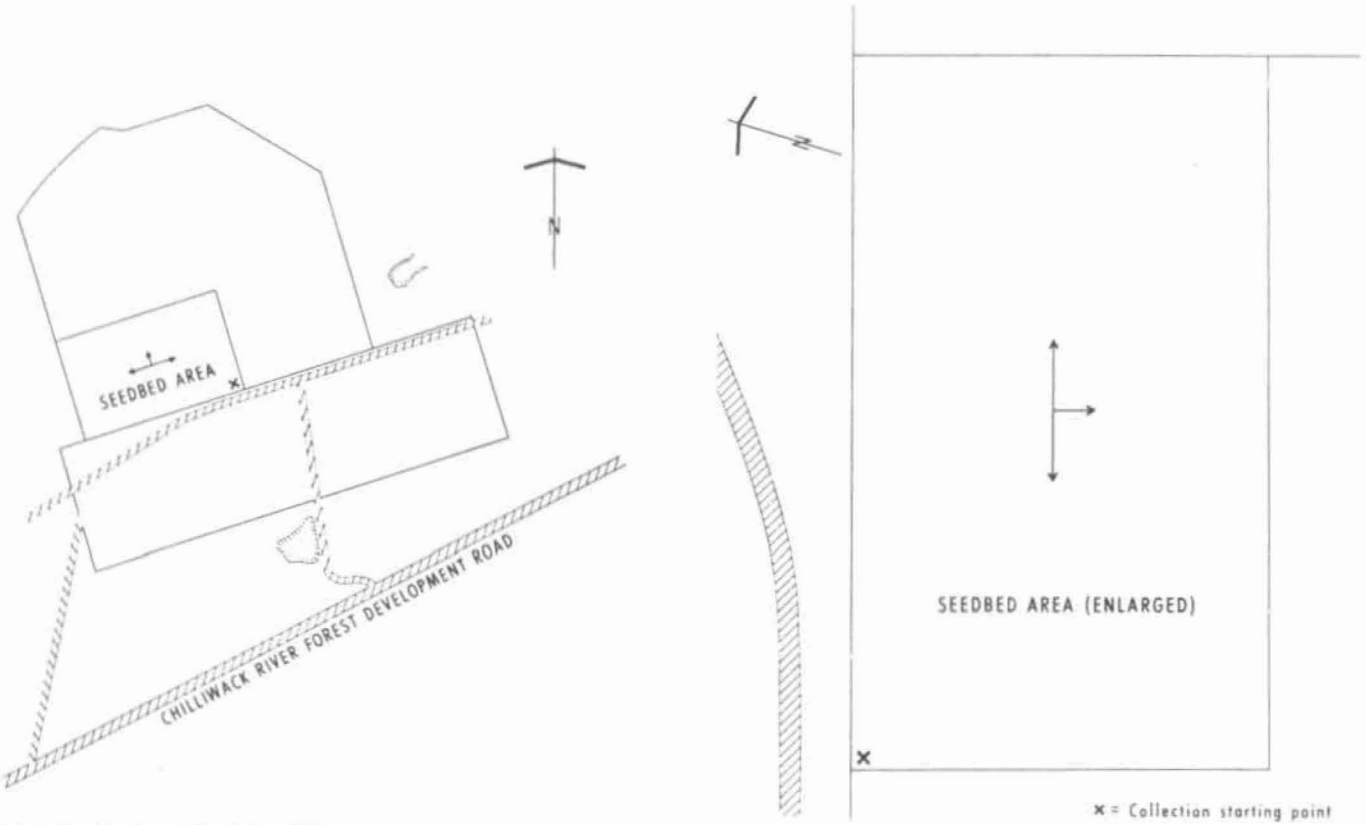

FIGURE 7. CHILLIWACK NURSERY

Table 13. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil at the nursery fields at Chilliwack.

	Borden			Slesse 1	Slesse 2		New Field
	Pseudotsuga menziesii		Picea glauca (interior)	Pseudotsuga menziesii	Pseudotsuga menziesii		Pseudotsuga menziesii
Seedling age:	2-0	2-2	2-0	2-0	1-0	2-0	1-0
Number of samples:	8	2	2	6	8	3	11
Nematodes							
Non-stylet-bearing	348	301	140	171	94	77	50
Stylet-bearing							
Aphelenchoides sp.	158	8	0	31	4	18	8
Aphelenchus sp.	86	87	47	54	54	33	0
Diphtherophora sp.	0	0	0	0	0	0	1
Ditylenchus sp.	4	0	8	2	0	0	6
Dorylaimida (unidentified)	809	505	445	276	28	71	38
Mononchus sp.	34	0	25	11	11	23	24
Neotylenchus sp.	15	19	0	24	2	1	11
Paratylenchus sp.	0	0	0	0	1	4	0
Pratylenchus sp.	0	0	0	2	0	0	0
Trichodorus sp.	0	8	8	0	0	0	0
Tylenchus davainii	0	29	0	20	1	0	0
Tylenchus emarginatus	1193	959	2988	106	20	5	0
Tylenchus spp.	81	39	10	31	12	27	14
Xiphinema bakeri	12	0	28	37	1	19	0

Rayleigh Nursery

The Rayleigh nursery comprises about 33 acres of former agricultural land. Soil samples were taken on a 20 x 20 ft grid on May 7, 1968.

Paratylenchus sp. and a Tetylenchus sp. are the two most commonly occurring plant-parasitic nematodes (Tables 14, 15, and 16). This was the only nursery where Tetylenchus were found. Populations of Paratylenchus were highest in sampling area 2 (Figure 8) where they were associated with interior spruce. The fallow portion of this area still contained large numbers of Paratylenchus because seedlings had been lifted the preceding spring. The numbers of the Xiphinema sp. were too low to have any significance. Tylenchus davainii could also be important but this will not be known until more is learned about the nematode's biology. The Heterodera sp. (Table 16) is probably H. avenae, the oat cyst nematode.

Although the populations of Paratylenchus and Tetylenchus are probably large enough to cause some damage, it is difficult to define any disease condition because of the damaging alkaline soil conditions at the nursery.

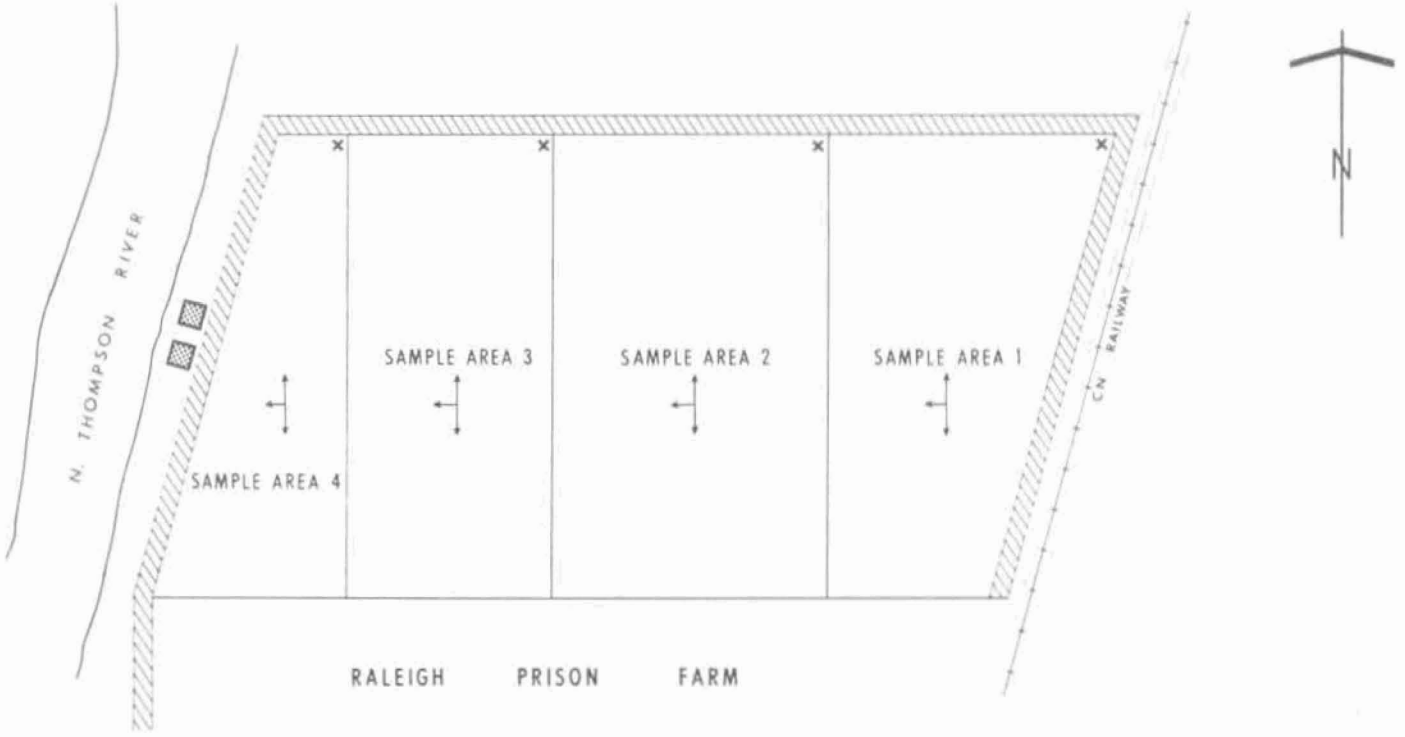

FIGURE 8. RAYLEIGH NURSERY

Table 14. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil in sampling areas one, two, and three at Rayleigh nursery.

	Area 1			Area 2		Area 3		
	Fallow	*Pseudotsuga menziesii*	*Picea glauca* (interior)	Fallow	*Picea glauca* (interior)	Fallow	*Picea glauca* (interior)	*Picea glauca* (interior)
Seedling age:	-	1-0	1-0	-	1-0	-	2-0	2-1
Number of samples:	-	3	14	16	3	18	1	2
Nematodes								
Non-stylet-bearing	197	441	219	216	414	158	319	263
Stylet-bearing								
Aphelenchoides sp.	49	39	46	54	13	53	54	63
Aphelenchus sp.	51	75	28	59	20	38	0	13
Diphtherophora sp.	0	0	0	0	0	0	0	3
Ditylenchus sp.	16	20	12	35	61	10	14	0
Dorylaimida (unidentified)	64	49	60	96	183	79	109	128
Neotylenchus sp.	4	0	0	0	0	1	0	0
Paratylenchus sp.	62	0	90	363	661	15	7	0
Tetylenchus sp.	18	17	8	11	10	4	27	12
Tylenchus davainii	4	0	4	67	40	6	0	16
Tylenchus spp.	25	90	13	44	43	58	41	40
Xiphinema sp.	0	0	0	1	4	0	0	0

Table 15. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil in sampling area four at the Rayleigh nursery.

	Pseudotsuga menziesii	*Picea glauca* (interior)	*Picea glauca* (interior)	*Picea glauca* (interior)	*Pinus contorta*	Fallow
Seedling age:	2-0	2-0	2-0	3-1-1	2-0	-
Number of samples:	1	1	1	1	1	12
Nematodes						
Non-stylet-bearing	490	171	604	970	1176	229
Stylet-bearing						
Aphelenchoides sp.	24	44	76	85	67	74
Aphelenchus sp.	70	6	48	51	10	21
Ditylenchus sp.	0	0	0	18	29	8
Dorylaimida (unidentified)	140	184	9	323	231	99
Heterodera sp. (larvae)	0	0	0	0	0	1
Paratylenchus sp.	0	0	0	0	0	16
Tetylenchus sp.	24	63	28	18	97	26
Tylenchus davainii	0	0	0	18	10	19
Tylenchus spp.	24	51	9	120	59	60

Table 16. Summary table of areas one to four at the Rayleigh nursery.

	Pseudotsuga menziesii		*Picea glauca* (interior)				*Pinus contorta*	Fallow
Seedling age:	1-0	2-0	1-0	2-0	2-1	3-1-1	2-0	-
Number of samples:	3	1	17	2	3	1	1	51
Nematodes								
Non-stylet-bearing	441	490	317	245	434	970	1176	200
Stylet-bearing								
Aphelenchoides sp.	39	24	30	49	70	85	67	58
Aphelenchus sp.	75	70	24	3	31	51	10	42
Diphtherophora sp.	0	0	0	0	2	0	0	0
Ditylenchus sp.	20	0	37	7	0	18	29	17
Dorylaimida	49	140	122	147	69	323	231	85
Heterodera sp. (larvae)	0	0	0	0	0	0	0	1
Neotylenchus sp.	0	0	0	0	0	0	0	1
Paratylenchus sp.	0	0	376	4	0	0	0	114
Tetylenchus sp.	17	24	9	45	20	18	97	15
Tylenchus davainii	0	0	22	0	8	18	10	24
Tylenchus spp.	90	24	28	46	25	120	59	47
Xiphinema sp.	0	0	2	0	0	0	0	0

Red Rock Nursery

At the time of sampling (May 29, 1968), about 45 of the possible 110 to 115 acres of the Red Rock nursery were in production (Figure 9). The nursery is situated on recently cleared land. To date no nematode problems have been reported. The soil samples were collected in a 40 x 40 ft grid.

Plant-parasitic nematodes were almost non-existent at the nursery (Tables 17, 18, and 19). Only a few root parasitic Rotylenchus sp. (Table 18) were found. The Heterodera sp. is probably H. avenae, the oat cyst nematode. The nursery should be checked at some future date to determine if the Rotylenchus sp. has increased, or if other nematodes have been introduced.

Telkwa Nursery

The nursery at Telkwa covers about 5.5 acres. Soil samples were collected on June 19, 1968, on a 20 x 20 ft grid.

Nematodes were not present in large enough numbers to be of concern (Table 19). Tylenchus davainii and T. emarginatus were the only plant-parasites in the samples. Because the nursery has been in production several years, it seems unlikely that these populations will develop further.

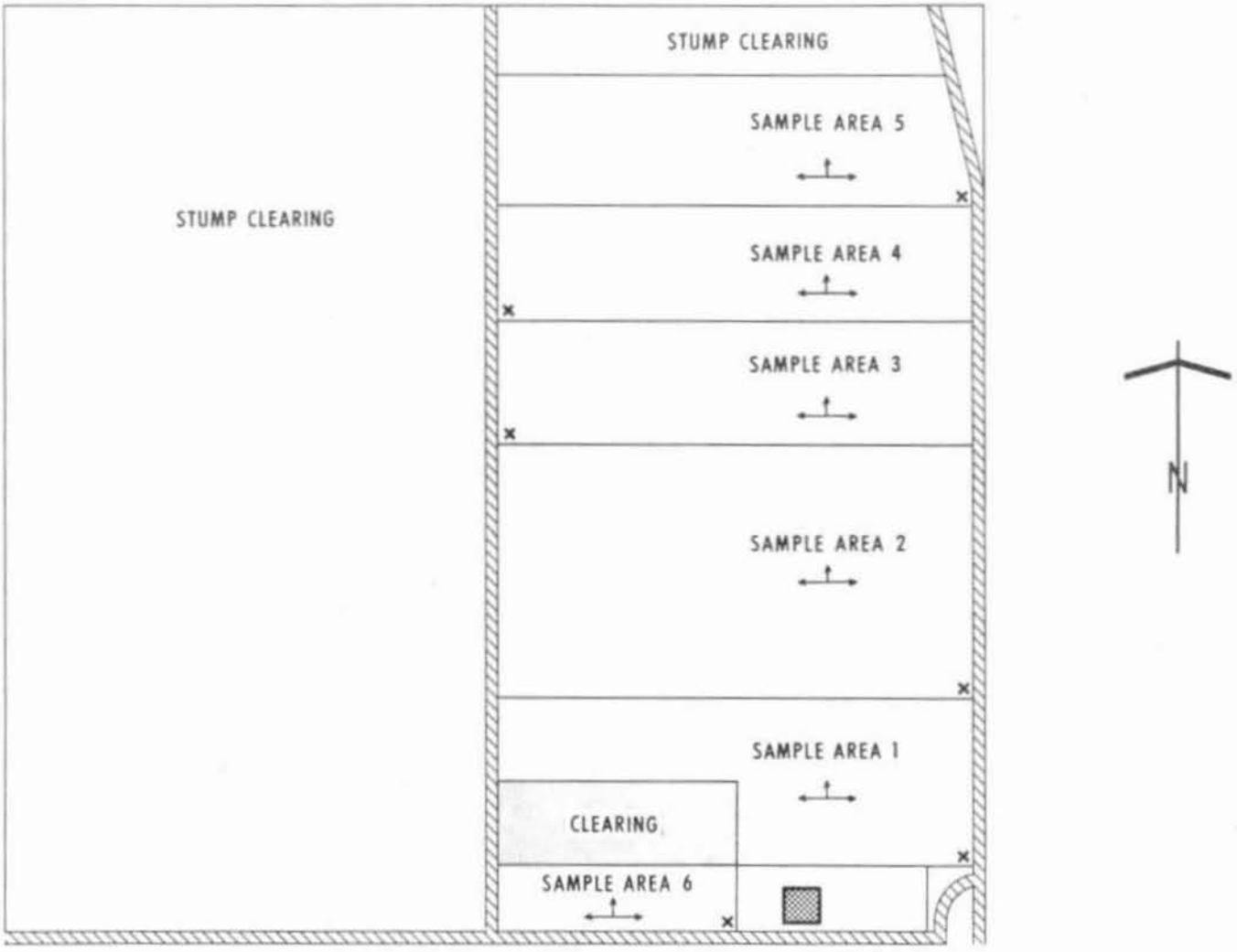

FIGURE 9. RED ROCK NURSERY

Table 17. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil in sampling areas one, two, and three at the Red Rock nursery.

	Area 1		Area 2		Area 3
	Pseudotsuga menziesii	*Picea glauca* (interior)	Fallow	*Picea glauca* (interior)	*Picea glauca* (interior)
Seedling age:	1-0	1-0	-	Just sown	Just sown
Number of samples:	1	7	2	3	5
Nematodes					
Non-stylet-bearing	68	40	20	38	44
Stylet-bearing					
Aphelenchoides sp.	0	2	14	5	1
Aphelenchus sp.	37	12	3	7	4
Ditylenchus sp.	19	1	0	2	1
Dorylaimida (unidentified)	0	5	0	0	0
Mononchus sp.	0	4	0	0	1
Tylenchus spp.	0	0	5	3	12

Table 18. Tree species, seedling age, number of samples, and mean number of nematodes in 400 grams of soil in sampling areas four, five, and six at the Red Rock nursery.

	Area 4	Area 5		Area 6
	Picea glauca (interior)	*Pseudotsuga menziesii*	*Picea glauca* (interior)	Fallow
Seedling age:	Just sown	Just sown	Just sown	-
Number of samples:	5	5	4	5
Nematodes				
Non-stylet-bearing	73	142	41	77
Stylet-bearing				
Aphelenchoides sp.	8	8	17	12
Aphelenchus sp.	3	0	0	14
Ditylenchus sp.	0	1	0	1
Dorylaimida (unidentified)	2	9	3	8
Heterodera sp. (larva)	0	1	0	0
Mononchus sp.	8	5	8	3
Rotylenchus sp.	2	0	0	1
Tylenchus spp.	1	9	1	5

Table 19. Summary table of areas one to six at Red Rock, and at the Telkwa nursery.

	Red Rock					Telkwa				
	Pseudotsuga menziesii		*Picea glauca* (interior)		Fallow	*Pinus contorta*	*Picea glauca* (interior)			Fallow
Seedling age:	Just sown	1-0	Just sown	1-0	-	2-1	1-0	2-0	2-1	-
Number of samples:	5	1	17	7	7	1	7	4	5	1
Nematodes										
Non-stylet-bearing	142	68	49	40	49	16	172	6232	206	287
Stylet-bearing										
Aphelenchoides sp.	8	0	8	2	13	0	1	0	5	9
Aphelenchus sp.	0	37	3	12	8	8	55	661	34	70
Ditylenchus sp.	1	19	1	1	1	8	5	122	1	18
Dorylaimida (unidentified)	9	0	9	5	4	0	28	364	57	78
Heterodera sp. (larva)	1	0	0	0	0	0	0	0	0	0
Mononchus sp.	5	0	4	4	1	0	0	0	0	0
Rotylenchus sp.	0	0	1	0	1	0	0	0	0	0
Tylenchus davainii	0	0	0	0	0	8	5	0	6	0
Tylenchus emarginatus	0	0	0	0	0	0	0	0	3	0
Tylenchus spp.	9	0	4	0	5	0	0	31	6	0

Discussion

It is difficult to interpret the results of a survey such as reported here because so little is known about nematode-tree seedling relationships. Numerous factors; e.g. presence or absence of other pathogens, climate, soil type, etc., must be considered before a degree of importance can be attached to a specific nematode population level. An intuitive interpretation of the results is presented now, and the results of more precise field and laboratory studies will follow when obtained.

The most apparent relationship found during the survey was between Xiphinema bakeri and the corky root disease of Douglas-fir seedlings. It seems likely that in the future this disease will occur in all the coastal nurseries, except possibly at Koksilah and Snowdon Creek (a transplant nursery), when Douglas-fir is in continuous production. Crop rotation, fallowing, chemical control, or a combination of these, should alleviate the problem.

The only other potentially serious nematode infestations in the nurseries are Paratylenchus and Pratylenchus at Koksilah, and Tetylenchus and Paratylenchus at Rayleigh. Since nothing is known about the hosts--parasites relationships, no control practices can be suggested. Future studies should help clarify these problems. Those nurseries without obvious nematode problems should be surveyed again in the future to determine if the nematode populations have altered.

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