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# Soil Nematodes in Successional Stages of Douglas-fir Forests

## Introduction

Clearcutting forests is perceived to result in loss of biodiversity (Boyle 1992). Information on the impact of clearcutting on soil invertebrates is essentially lacking. Nematodes are the most abundant invertebrate metazoans in soils and their trophic interactions with other groups of soil organisms have important influences on soil processes and plant health. They offer practical advantages as indicators of changes in soil ecological conditions (Bongers and Yeates 1988). We compared the abundance and taxonomic composition of soil nematodes in four successional (seral) stages of coastal Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) forests on southern Vancouver Island, British Columbia. The objective was to determine if nematode biodiversity was being maintained or restored during conversion of old-growth forests to second-growth stands.

## Methods

The four seral stages (R - regeneration, I - immature, M - mature, and O - old-growth stands), were replicated at three study sites, i.e. Victoria Watershed South (VWS; 48°34"N, 123°39"W), Victoria Watershed North (VWN; 48°38"N, 123°43"W), and the Koksilah watershed (KOK; 48°39"N, 123°46"W). In 1990, seral ages at the three sites were, respectively: regeneration 4, 6, and 5 years; immature 32, 42, and 43 years; mature 99, 93, and 77 years; and old-growth 245, 316, and 288 years. Detailed information on the sites, seral stages, and plots is given in Trofymow et al. (1997). In summer (July) and in winter (December) of 1993, three soil samples were taken from each of three nematode sampling plots per seral stage by means of a metal corer (5-cm internal diameter). In order to minimize variability in microhabitat, all samples were taken from under salal (*Gaultheria shallon*), which was common to all plots. Each core was divided into its organic (OH) and inorganic horizon (IH), and the three OH and IH soil samples were bulked separately, giving a total of 144 samples for nematode extraction. Nematodes were extracted from weighed subsamples of the bulked samples using a Baermann funnel method based on Sohlenius (1977), counted, and then processed (Seinhorst 1959, Hooper 1986) for identification. The variables measured were: nematode abundance, expressed as the number per g of dry weight of the subsample; % soil moisture of the subsample on a dry weight basis; and soil bulk density, calculated as the ratio of dry weight of a bulked sample to the fresh (field) volume of that sample. The latter was computed from the known dimensions of the cylindrical core. Analyses of variance with randomized blocks were computed using seral stage, season, and soil horizon as factors and site as the blocking factor. The data were then subjected to Student-Newman-Keuls' (SNK) test (Snedecor and Cochran 1980) for differences among the four stand ages for each combination of site, season, and soil horizon. Abundance of nematodes per $m^2$ to a standard soil depth of 10 cm was computed for each seral stage from the known diameter of the corer and depths of soil cores obtained. The nematodes were identified to genera/species, and assigned to feeding categories according to Yeates et al. (1993). Two indices of diversity were calculated: the Shannon-Wiener Index of generic diversity (Pielou 1975) and the Maturity Index of Bongers (1990) as modified by Yeates (1994).

## Results and Discussion

In both summer and winter, nematode abundance (mean numbers per g of dry weight of soil; means are of 3 plots/seral stage) varied with stand age, with regeneration having the lowest and old-growth the highest abundance (Figure 1). Intermediate

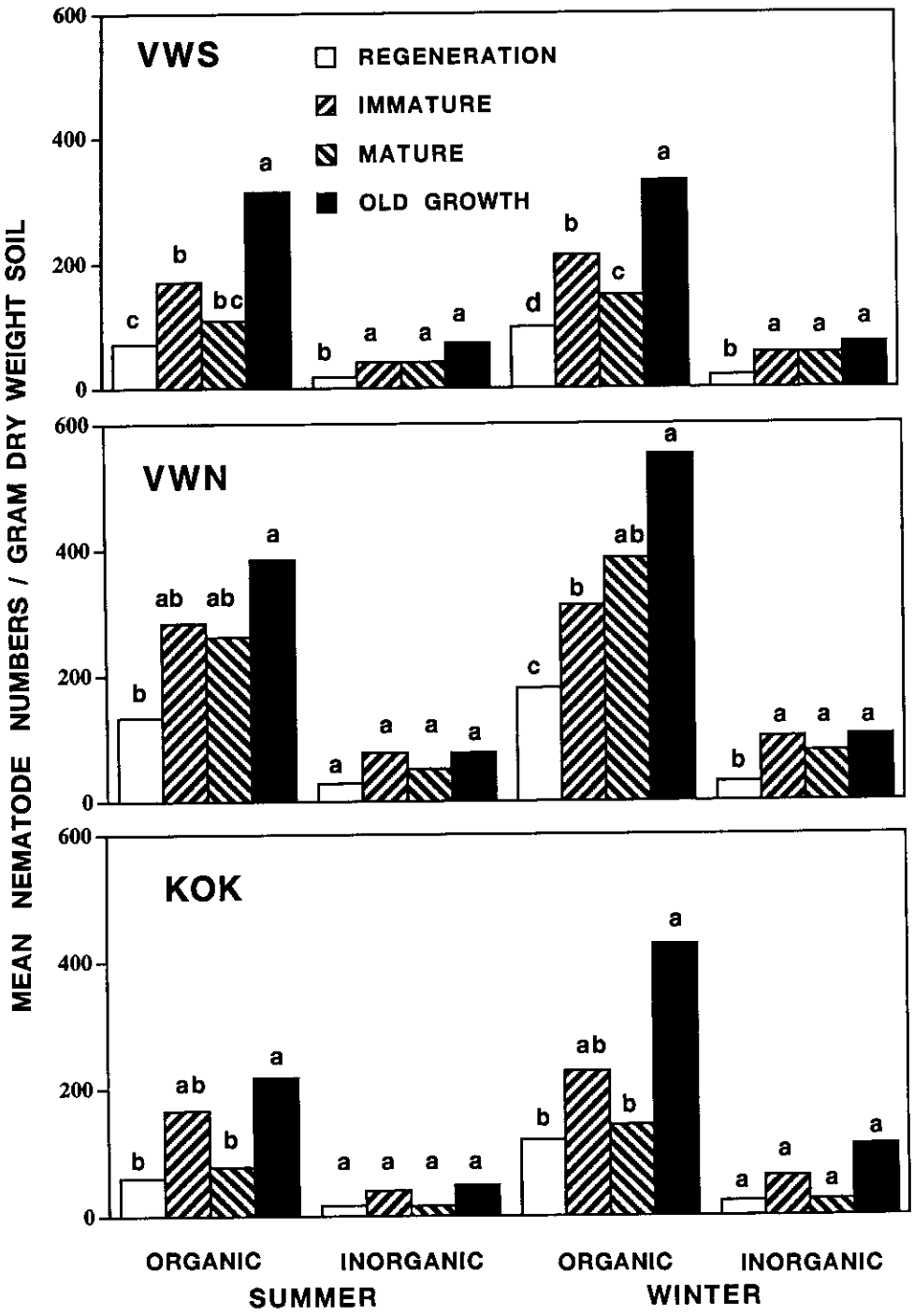


Figure 1. Mean nematode numbers per gram dry weight of soil for each of the 48 categories represented by three sites, four seral stages, two seasons, and two soil horizons. Letters within any group of the four seral stages represent results from SNK tests, and bars with the same letter within any such group are not significantly different ($P<0.05$). The three sites are: Victoria Watershed South (VWS) and North (VWN), and Koksilah (KOK).

numbers were found in immature and mature stands, but were generally higher in the former than in the latter. Abundance per $m^2$ to a standard 10-cm soil depth, averaged over site and season, showed a similar trend for seral stage: $2.33 \times 10^6$ (regeneration), $4.84 \times 10^6$ (immature), $4.15 \times 10^6$ (mature), and $7.49 \times 10^6$ (old-growth). The overall indication, therefore, is that population levels of nematodes will be restored as the younger forests attain old-growth characteristics. Consistently more nematodes were found in winter than in summer, particularly in OH, and considerably more nematodes in OH than in IH. Site, seral stage, and soil horizon all significantly affected nematode numbers when both percent soil moisture and soil bulk density were included as covariates, although only percent moisture was significant. With percent moisture included, season was not significant; when percent moisture was not included, season was significant. Therefore, the higher soil moisture level in winter (commonly 55-65% for OH and 25-30% for IH samples) than in summer (commonly 35-50% for OH and 15-20% for IH) appears to be an important factor for the higher nematode abundance in winter.

A total of 7,641 nematodes were identified from the 144 samples. Among these, 40 nematode genera/species were found, of which 23 (or 57.5%) were common to all seral stages, and, of the remaining 17 genera/species, 11, 9, 13, and 16 were additionally found in regeneration, immature, mature and old-growth plots, respectively. The Shannon-Wiener Index values for seral stages—using relative generic abundances—were within a narrow range of 3.13-3.30. Bonger's Maturity Index values for seral stages were also very similar (range 3.10-3.15). When the genera were grouped by feeding habit, their numbers across seral stage were also very similar. All these results indicate that the nematode community changed little across seral stages.

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## Literature Cited

Bongers, T. 1990. The Maturity Index: an ecological measure of environmental disturbance based on nematode species composition. Oecologia 83: 14-19.

Bongers, T. and T.W. Yeates. 1988. Report on workshop: nematodes in natural systems; the use of nematodes in environmental studies. Pedobiologia 32: 88.

Boyle, T.J.B. 1992. Biodiversity of Canadian forests: current status and future challenges. For. Chron. 68: 444-453.

Hooper, D.J. 1986. Handling, fixing, staining and mounting nematodes. *In* J.F. Southey (ed.). Laboratory Methods for Work with Plant and Soil Nematodes. Reference Book 402, Ministry of Agriculture, Fisheries and Food, Her Majesty's Stationery Office, London.

Pielou, E.C. 1975. Ecological Diversity. John Wiley & Sons, New York.

Seinhorst, J.W. 1959. A rapid method for the transfer of nematodes from fixative to anhydrous glycerine. Nematologica 4: 67-69

Snedecor, G.W. and W.G. Cochran. 1980. Statistical methods, 7th Edition. Iowa State University Press, Ames, Iowa.

Sohlenius, B. 1977. Numbers, biomass, and respiration of Nematoda, Rotatoria and Tardigrada in a 120-year-old Scots pine forest at Ivantjdrnsheden, Central Sweden. Swed. Con. For. Proj., Tech. Rep. 9. 40 p.

Trofymow, J.A., G.L. Porter, B.A. Blackwell, V. Marshall, R. Arskey, and D. Pollard. 1997. Chronosequences selected for research into the effects of converting coastal British Columbia old-growth forests to managed forests: an establishment report. Inf. Rep. BC-X-374, Nat. Res. Can., Can. For. Ser., Pacific Forestry Centre, Victoria, BC.

Yeates, G.W. 1994. Modification and qualification of the nematode maturity index. Pedobiologia 38: 97-101.

Yeates, G.W., T. Bongers, R.G.M. de Goede, D.W. Freckman, and S.S. Georgieva. 1993. Feeding habits in soil nematode families and genera—an outline for soil ecologists. J. Nematol. 25: 315-331.