FINE-ROOT PRODUCTION, MORTALITY AND DECOMPOSITION IN FOREST ECOSYSTEMS* **

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Introduction

The quantification, in the field, of death and renewal in the fine roots and root material of forest ecosystems has, in most cases, been impossible because of the technical difficulties involved (cf. Whittaker & Marks 1975). Thus in many previous studies, rough estimates of the below-ground turnovers have been accepted in preference to no estimates at all (Lieth 1968, Newbould 1968, Head 1970).

Many such data, (cf. literature review in Bray 1963), have been obtained under the tacit assumption that the ratio of production to biomass (or standing crop) above ground must be similar to that below ground (Newbould 1967, 1968). Since the ratio of above-ground to below-ground production may differ considerable (even in the same species) in different forest communities (Persson 1975a, b, 1979), there is no evidence to support this assumption and serious underestimates may result from it (cf. Persson 1978a, b, 1980a).

Alternative fine-root production estimates based upon the summation of increments in root biomass throughout the year, must be regarded as underestimates since the sampling frequency employed can by no means be expected to cover all the increases and decreases that actually occur and since a considerable amount of fine-root biomass is constantly being transformed into necromass (dead fine-root tissue) which is usually not estimated or taken into account in the calculation (cf. Santantonio 1979). The fluctuations in the fine-root necromass may be considerable during the growing season (Reynolds 1970, Kummerow et al. 1978, Persson 1978a, 1979b, Santantonio 1979).

Two methods were adopted by the present author to investigate the temporal variation in fine-root death and renewal (cf. Flower-Ellis & Persson 1980) – (1) using data obtained by sequential core sampling and (2) measuring the ingrowth of new roots into root-free containers removed regularly. The root systems were then separated into one living (biomass) and one dead (necromass) fraction and these were subsequently confirmed and estimated.

In order to be able to carry out the extensive sampling programme necessary, certain other demands had to be made on the research area; these were: (1) the area should include an age series of forest stands having similar soil conditions and topography; (2) the structure of the specific forest ecosystem should be simple, e.g. only a few vascular species with distinctive morphological rooting features should be included; (3) the soil should be easily penetrated by sampling devices.

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Sweden, e.g. mixed coniferous forests on till, questionable. The sampling difficulties encountered on till substrate, on the other hand, are extreme, since adequate mechanical equipment is lacking, making extensive sampling practically impossible. Large soil blocks (monoliths) are at present the only possible method of sampling soil volumes from which the root fragments can be removed and weighted after a formidable amount of work (Persson 1975a). A large amount of space is required for the freezing of the excavated root material and this of course increases drastically with large sample sizes.

**Material and methods**

Since the methodological aspects of the sampling and the measurements of the excavated roots and root material have been thoroughly outlined in Persson 1978a, 1980a, Flower-Ellis & Persson 1980, only a resumé of the sampling methods will be given here.

Sampling was undertaken in two Scots pine (*Pinus sylvestris*) stands (18 and 120 years old in 1974, respectively; Flower-Ellis et al. 1976) located on sandy sediments of glacifluvial origin at Ivantjärnsheden in C. Sweden (60° 46' N, 16° 39' E). In the young stand (Ih II) two strata designated for the time-serial sampling of soil cores, viz. *Calluna* (I) and non-*Calluna* (II). These accounted in 1974 for 47.9 % and 52.1 % of the total area respectively (Persson 1975b). The sampling in the mature stand (Ih V) was unstratified.

The samples were removed with a long steel corer with an internal diameter at the hardened steel cutting edge of 6.7 cm (area 35.26 cm²). Random samples of 16 cores were made in Ih II in both strata, giving a total number of 416 cores. In Ih V a total number of 210 cores was removed. Sampling took place during the growing season at intervals of 2–3 weeks in Ih II and at intervals of 4–6 weeks in Ih V. The cores were stored in a deep-freezer until root sorting could take place.

As a complement to time-serial sampling of undisturbed soil cores, sampling of ingrowth cores (containers) was undertaken; in this case new roots had been allowed to grow into the ingrowth cores. The containers were placed in the holes left by the withdrawal of the soil cores with the help of the same sort of sampling device as that used for time serial sampling. They consisted of cylindrical net 'stockings' filled with sand of local origin and peat instead of raw humus at the F/H layer. The mesh size of the stockings was 7.5 mm, thus allowing the root tips to penetrate freely.

A total of 600 containers was inserted from August to the middle of September 1974 in Ih II and was equally distributed in four different experimental plots (Aronsson et al. 1977). The results presented in the present paper are restricted to the untreated plots (or the control). The total number of containers in Ih V was 200. Random samples of 9 cores (in the control) in Ih II and 10 in Ih V were removed on each sampling occasion, beginning in autumn 1975, and continuing throughout the growing seasons of 1976 and 1977. The surrounding roots and soil were removed, and sand sifted away and the samples were then stored in a deep-freezer until the final root sorting could be carried out.

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