LETTERS TO THE EDITOR

The Editor
New Zealand Ecological Society
Dear Sir,

In a recent letter to the Editor,[1] Gadgil, Knight, Mead and Will raise an important point, which has been discussed in previous correspondence,[2] but about which there remains a difference of opinion that can only be resolved by the presentation of more data. Although it may not be possible to settle this difference at present, it is important to clarify the issue and promote its discussion.

The point to which I allude is whether or not, in typical New Zealand forest soils (yellow brown earths), "removal of surface litter *and the top few cm. of soil* may remove the majority of plant nutrients".[3] More specifically, whether or not most readers would assume from Figure 2 in "An Ecological Approach to New Zealand's Future"[3] that there is a greater total of nutrients in the litter than in the soil, and whether or not this assumption is true or false.[1]

This matter of the difference between the "nutrient concentrations" profile and the "total quantities" profile merits careful consideration. In personal correspondence, and in their recent published letter[1] Gadgil *et al.* have presented the data of Miller and Hurst[4] to illustrate the differences between the two methods of presentation

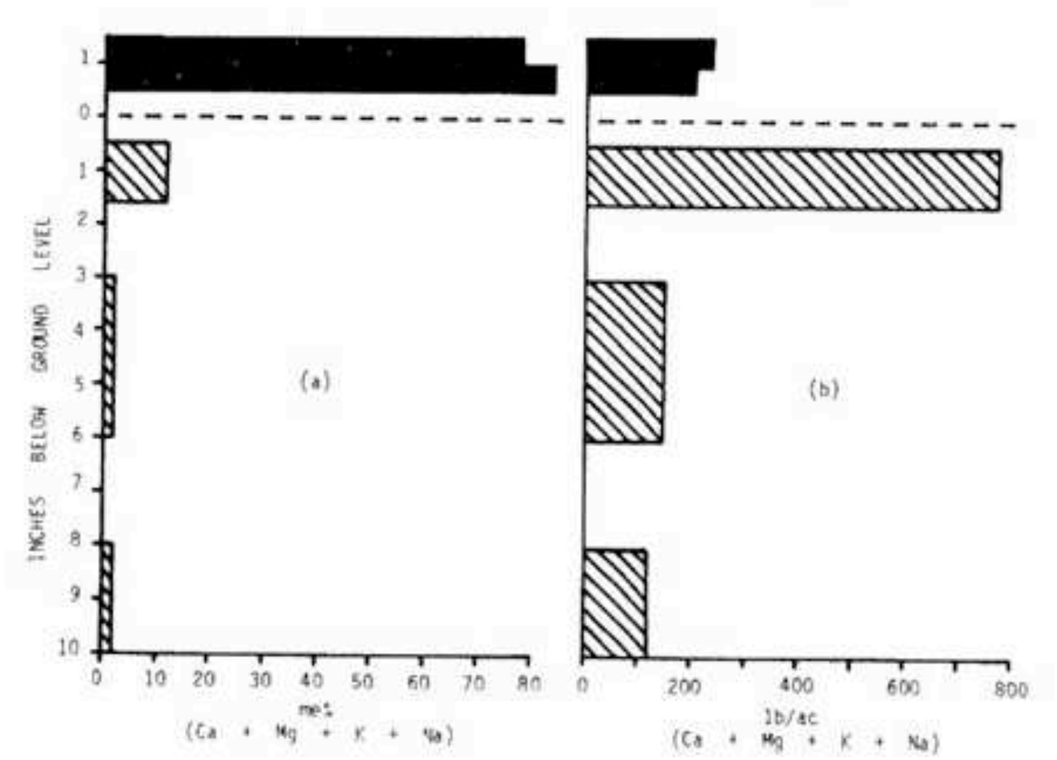

FIGURE 1. *Soil profile under Hard Beech at Silverstream.*
(a) Lengths of bars proportional to concentration (me %).
(b) Lengths of bars proportional to 'amount'—based on correction for bulk density. The figure is based on the work of Miller (1963) and was provided by Gadgil, Knight, Mead and Will (pers. comm.).

(Figs. 1(a) and 1(b) herewith). The "concentrations" profile (Fig. 1(a)) is directly comparable with Fig. 2 in "An Ecological Approach . . . ." and adds a little weight to my contention that that profile is "typical". The "totals" profile (Fig. 1(b)) gives the same information transformed to allow for the differences in bulk density between the different soil horizons and the litter.[5] It may be noted that Fig. 1(b) apparently substantiates the statement that "removal of the surface litter *and the top few cm. of soil* may remove the majority of plant nutrients[3]" although, as stressed by Gadgil *et al.*[1], it demonstrates also the reduced significance of the litter in this context.[6]

But there is another, more important, point. Nutrient concentrations are normally based on air-dried soil sieved to pass a 2 mm mesh (the "fines"); bulk density estimates are based on the weight of the total (unsieved) soil dried at 105°C. Where soil samples contain much lithic material greater than 2 mm in diameter, such as is the case in many of the soils in the upland areas of New Zealand, to simply "correct" a nutrient concentration based on the fines by multiplying by bulk density will lead to overestimation of the nutrient weight on a per unit area basis. Thus, while a profile of concentrations alone may be of limited application, a figure derived by "correcting" for bulk density, but making no allowance for the inert fraction, may actually be in error. The point may be illustrated by reference to the distributions of exchangeable Ca and K given in Table 1.[7] Although detailed discussion of data such as these is beyond the scope of this correspondence, it is pertinent that in these soils—which are not very stony by New Zealand standards—estimates of the quantities of individual nutrients per unit area based on bulk density conversions alone are much higher than estimates based on the fines. I consider the latter estimate to be nearer the truth. Table 1 also illustrates a further point; when quantities in litter and their quantity there equals or exceeds that in in some cases the litter may actually contain more of a particular element than does the underlying soil.

Lest it be thought that Table 1 is a biased, extreme, overseas example, based on unpublished data, I draw the reader's attention to Stevens[8] work on a chronosequence of soils in Westland. In 12 of the 16 soils described by Stevens the actual quantities (g/m^2) of one or more of the exchangeable bases (Ca, Mg, K, Na) are greater in the litter than they are in the surface soils. In some cases of soils where a deep organic layer has accumulated under Rimu-Kamahi forest (e.g. Soil M1) *all* the exchangeable bases are in greater quantity in the litter and their quantity there equals or exceeds that in the whole of the remainder of the soil profile.

Finally, and I wish to stress this, that data I have presented do not prove that in typical New Zealand forest soils there is a greater total of nutrients in the litter than in the soil. Rather, they suggest that there

TABLE 1. Concentrations (ppm) and estimates of quantities (Kg/ha) for (a) exch. Ca and (b) exch. K in the litter and surface soils (0-5 cm) of forest ecosystems in the Snowy Mountains of south eastern Australia.[7] The first estimate of Kg/ha (1) is obtained by correcting the ppm column for bulk density; the second estimate (2) is based only on the fines.

(a) Exchangeable Calcium

Soil type (substrate)	Surface Soil (0-5 cm)			F/H Litter	
	1	2	3	4	5
	ppm	Kg/ha(1)	Kg/ha(2)	ppm	Kg/ha(2)
(1) Siltstone	1243	1006	174	1672	27
(2) Granite	411	320	82	3654	190
(3) Basalt	169	91	34	1511	68

(b) Exchangeable Potassium

	ppm	Kg/ha(1)	Kg/ha(2)	ppm	Kg/ha(2)
(1) Siltstone	144	116	20	614	10
(2) Granite	150	117	30	495	26
(3) Basalt	150	81	30	373	17

are forests in which this is the case; there are others in which it is not. What the typical situation is (with regard to "totals" if not to "concentrations") remains to be established. I have searched the literature and I incline to the view that it is not possible to say what is "true" or what is "false" in this respect. Arguments over Fig. 2 are of archival interest only now, but the scientific importance of this subject, and its implications for forestry practice, make it worthy of more detailed attention. Sampling aside, the practical problems are not formidable; they boil down to not throwing the stones away.

Yours, etc.

John Ogden

Research School of Pacific Studies
Department of Biogeography and Geomorphology
The Australian National University
Canberra
Australia.

NOTES AND REFERENCES

[1] Gadgil, R. L., Knight, P. J., Mead, D. M. and Will, G. M. 1975. Letters to the Editor. *Proc. N.Z. Ecol. Soc.*, 22, 124.

[2] See 'Corrigendum to An Ecological Approach to New Zealand's Future', *Proc. N.Z. Ecol. Soc.*, 21, 88-91. (Letter from Gadgil, Knight, Mead and Will, and reply by Ogden). Also see Will, G. M. in *N.Z. Soil News*, 22(4), 101-2, and reply by Bull, P. C. in *N.Z. Soil News*, 22(5), 139. An extensive reply to Will's original letter, dealing with most of the points raised again by Gadgil *et al.* in (1) above, was submitted to Soil News by myself in October 1974, but publication was declined. Copies of this are available from the Editor, N.Z. Ecological Society, and some of the salient points are presented here.

[3] From the legend to Fig. 2 in: Fordham, R. A. and Ogden, J. 1974. An Ecological Approach to New Zealand's Future. Supplement to *Proc. N.Z. Ecol. Soc.*, 21, (but with my present emphasis).

[4] Miller, R. B. 1963a. Plant Nutrients in Hard Beech. I. The immobilisation of nutrients. *N.Z. Journal of Science*, 6, 365-377.

Miller, R. B. 1963b. Plant nutrients in Hard Beech. II. Seasonal variation of leaf composition. *N.Z. Journal of Science*, 6, 378-387.

Miller, R. B. 1963c. Plant nutrients in Hard Beech. III. The cycle of nutrients. *N.Z. Journal of Science*, 6, 388-413.

Miller, R. B. and Hurst, F. B. 1957. The quantity and nutrient content of Hard Beech litter. *N.Z. For. Res. Notes*, No. 8, 14 pp.

[5] I am unable to derive the whole of Fig. 1(b) from the published data. Miller (1963(c), Table 14, p. 405) gives lbs/acre of nutrients only for leaves, twigs and the A horizon, not the whole profile. No bulk density figures are given. Presumably the lower profile data are available in an unpublished form.

[6] Comparison of the two diagrams does, however, reveal the main criticism which can be levelled against Fig. 2, namely that the original statement in the legend (about "amounts") did not follow logically from the diagram (based on "concentrations"). This criticism I mentioned in my (unpublished) letter to Soil News and attempted to rectify in my "Corrigendum".

[7] Based on data of Park, G. N. (Pers. comm.). Park, G. N. 1975. Nutrient Dynamics and Secondary Ecosystem Development. *Ph.D. Thesis*, Australian National University, contains much evidence in support of the view that litter and surface soils are of paramount importance in the nutrient dynamics and long-term stability of forest ecosystems.

[8] Stevens, P. R. 1968. A chronosequence of soils near the Franz Josef Glacier. *Ph.D. Thesis*, University of Canterbury, New Zealand. In particular, Table 14B, pp. 276-280.

The Editor
New Zealand Ecological Society

Dear Sir,

An end to this correspondence is surely timely but may we make three brief points.

1. We have never questioned that "the removal of surface litter and the top few cm of soil may remove the majority of plant nutrients". We did question the average reader's interpretation of Fig. 2 in "An Ecological Approach to New Zealand's Future" in which *concentrations* rather than *amounts* were shown. In Dr Ogden's Figure 1 above we feel we have illustrated this points and we are pleased that he agrees.

2. Unfortunately we have not been as successful in getting recognition of the difference between *total* nutrients (as used to describe litter) and *exchangeable* nutrients (as used to describe a particular but usually small fraction of the total in soils).

Our diagram presented as Figure 1 in Dr Ogden's letter illustrates the importance of comparing amounts rather than concentrations but in addition it should be pointed out that it still compares *total* nutrients in the litter with *exchangeable* nutrients in the soil. Unless this is realised it can be very misleading. In his Table 1 Dr Ogden compares exchangeable nutrients in both soil and litter. As soil and litter differ so markedly in their physical nature and chemical properties we do not feel that any meaningful result can be arrived at by comparing *exchangeable* nutrients in the soil with *exchangeable* nutrients in the litter.

3. Dr Ogden's letter rightly draws attention to the need to consider stones where they occur; but his examples if not "biassed" and "extreme" are certainly atypical. In his earlier letter he described how he arrived at a chemical composition "typical of New Zealand forest soils" and named the 10 yellow brown earths whose properties he used. Descriptions of these 10 soils are given in N.Z. Soil Bureau, 1968, and none of them are described as containing any stones in the top 5 cm. Other forest soils certainly do contain stones but when discussing a typical New Zealand forest soil we feel reference to Australian soils with up to 80% stones is not really relevant.

We fear that our original point of concern—misinterpretations due to unjustified extrapolation of data—may have been lost in a sea of words.

Yours, etc.

R. L. Gadgil
P. J. Knight
D. J. Mead
G. M. Will

Forest Research Institute
Private Bag, Rotorua.

REFERENCE

N.Z. Soil Bureau, 1968. Soils of New Zealand Part 3. *N.Z. Soil Bur. Bull.* 26 (3).

The Editor
New Zealand Ecological Society

Dear Sir,

Volumes 21 and 22 of the Proceedings of the New Zealand Ecological Society contain correspondence[1, 2, 3] regarding nutrient relationships in forest soils in New Zealand with particular reference to Figure 2 of "An Ecological Approach to New Zealand's Future".[4] The latest letter in this correspondence[3] contains an implied claim that while *concentrations* of nutrients in a forest litter are higher than that in the mineral soil, *amounts* of nutrients are always considerably less. Data from the study of Miller[5] are used to support this claim. I believe that most readers would assume from the very definite manner in which this claim is made, that this is a universal characteristic of New Zealand forest soils. This is not so.

During recent soil surveys on the West Coast of the South Island, a considerable number of soil profiles were sampled under a forest cover. Organic horizons (litter) were sampled, as well as the mineral soil. The results of chemical analyses from these samples provide the most extensive chemical data on New Zealand's indigenous forest soils currently available. In order to try and introduce a wider perspective into the discussion, I would therefore like to briefly summarise these results.

The analyses summarised here are those from 24 soil profiles of 22 different soil types. All soils were located in the Grey Valley and all were under beech-podocarp forest. Weights of nutrients in soils have been calculated using an assumed bulk density of 1.1 g cm^{-3}. Weights of nutrients in the litter have been calculated using an assumed bulk density of either 0.12, 0.20, or 0.40 gm cm^{-3} depending on the extent of litter decomposition as shown by loss on ignition values. These assumed bulk density values are similar to those obtained by Mr M. Levett of Lincoln College working on similar soils in the Grey Valley. Gadgil *et al*[3] confine their discussion of soil results to topsoil levels and this will be done here. Comparison of litter nutrient weights with topsoil weights seems reasonable as field observations have shown that almost all tree rooting in these soils occurs in either the litter or the A horizon. Soil nutrient concentrations are based on the following measurements: nitrogen, total N; phosphorus, 0.5 M H_2SO_4 P fraction; calcium, magnesium, potassium, HCl-soluble fraction. It should be noted that HCl-soluble Ca, Mg, and K levels always exceed exchangeable Ca, Mg and K, often quite considerably.

Considering all 24 profiles, concentrations of nutrients in the litter are always higher than in the A horizon, for all elements. However, weights of nutrients show a rather different pattern. Thus mean litter nitrogen, magnesium and potassium weights are respectively about 60%, 40% and 25% of mean A horizon weights, whereas mean litter phosphorus and calcium weights are about 200% and 150% of mean A horizon weights. If one uses exchangeable cations as Gadgil *et al*[3] have done,

mean litter nutrient weights exceed mean A horizon weights for all three nutrients (Ca, Mg and K).

If one considers individual soils, the differences between soil and litter nutrient weights are sometimes even more marked. Thus in the Waiiti steepland soil (SB 8894) weights of nutrients in the litter and A horizon respectively are as follows: nitrogen, litter 7490 kg/ha, soil 2420 kg/ha; phosphorus, 240, 18; calcium, 260, 51; magnesium, 1420, 270; potassium 340, 600. This soil has a litter depth of 60 cm and an A horizon depth of 30 cm. Several other examples of specific soils could be cited where litter nutrient weights exceed those in the A horizon for one or more nutrients. Conversely examples could also be given where A horizon nutrient weights exceed litter nutrient weights.

Gadgil *et al*[3] have stated: "We believe most readers would assume from Figure 2 that there is a greater total of nutrients in the litter than in the soil. This assumption is false". It is clear from the preceding discussion that the relative weight of nutrients in the litter and topsoil of forest soils varies between different soils. For some soils, litter nutrient weights exceed soil weights; in others, soil nutrient weights exceed litter weights. The above statement by Gadgil *et al* is therefore not always true, although it certainly will be for some forest soils.

Yours, etc.

J. A. Adams

Soil Bureau, DSIR
Private Bag, Lower Hutt.

REFERENCES

[1] Gadgil, Ruth L.; Mead, D. J.; Knight, P. J. and Will, G. M. 1974. *Proceedings of the New Zealand Ecological Society* 21: 88.

[2] Ogden, J. 1974. *Proceedings of the New Zealand Ecological Society* 21: 89-91.

[3] Gadgil, Ruth L.; Knight, P. J.; Mead, D. J. and Will, G. M. 1975. *Proceedings of the New Zealand Ecological Society* 22: 124.

[4] Fordham, R. A. and Ogden, J. 1974. An ecological approach to New Zealand's future. Supplement to *Proceedings of the New Zealand Ecological Society* 21: 32 pp.

[5] Miller, R. B. 1963. Plant nutrients in Hard Beech III. The cycle of nutrients. *New Zealand Journal of Science* 6: 388-413.