SHORTER CONTRIBUTION

Nitrogen content of precipitation in a coastal Oregon forest opening

By R. F. TARRANT and K. C. LU, *Forest Service, U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon*

and

C. S. CHEN and W. B. BOLLEN, *Department of Microbiology, Oregon State University, Corvallis, Oregon*

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In studies of plant nutrient accretion and cycling in coastal Oregon forest ecosystems, we required an estimate of the amount of nitrogen brought down in precipitation.[1] No such information was available for the study area, although nutrient inputs in rainfall have been measured on the Washington coast about 160 km north of the location we sampled (Moodie, 1964) and again about 400 km north of our study site (Junge, 1958). However, neither of the two previous studies were made in a forest environment.

Our study was conducted at Cascade Head Experimental Forest on the Oregon coast at latitude 45°3′ N, longitude 123°55′ W. The sampling site was a cleared area of about 9 ha in a Sitka spruce (*Picea sitchensis*), Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*) forest type. Elevation of the site is about 200 m, 10 km from the Pacific Ocean. Average annual precipitation at Otis, the nearest official weather station at a lower elevation about 3 km distant, is 2,286 mm.

Precipitation was collected at monthly or bimonthly intervals (Table 1) over a 12-month period, June 1963 through May 1964. The sampling period was selected to coincide with the advent of new tree foliage and autumn-through-early-spring leaf- and needlefall. Our intention was to relate the data to other ecological phenomena which included measurement and analysis of litterfall. Polyethylene containers were randomly located at three points near the center of the cleared area. Three polyethylene funnels, having a total area of 0.093 m^2, were inserted through the lid of each container. Each funnel was fitted with a Pyrex, glass wool filter plug and a 10-mesh copper screen to keep coarse debris out of the collector. Two ml of toluene were added to each container to inhibit microbial action.

The volume of precipitation collected was measured to the nearest 1 ml. After being passed through Whatman No. 5 filter paper, the water was analyzed for nitrite nitrogen using 1-naphthylamine sulfanilic acid and sodium acetate buffer (American Public Health Association, 1955). Nitrate nitrogen was determined by the phenoldisulfonic method (Harper, 1947) which included special precautions to avoid loss of nitrate. Free ammonium was determined on 50 ml samples by distillation with phosphate buffer at pH 7.4 (Nichols & Foote, 1931). Organic nitrogen was determined on 50 ml samples by a semimicro modification of the standard Kjeldahl procedure; 25 ml of distillate were collected in 6 ml saturated boric acid and titrated with N/70 sulfuric acid, using methyl red—bromcresol green mixed indicator. All analyses were made in duplicate. Lower limits of detection (mg/l) were for NH_4–N, 0.01; NO_2–N, 0.002; NO_3–N and organic (Kjeldahl) N, 0.02.

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Table 1. *Nitrogen content of precipitation in a coastal Oregon forest opening—means of three observations*[a]

Sampling period, 1963–64	Total precipitation (mm)	NO_2–N (mg/l)	NO_3–N (mg/l)	Organic (Kjeldahl) N (mg/l)	Total N[b] (kg/ha)
June	72	.01	.10(±.02)	.29(±.03)	.29
July	75	.00	.00	.22(±.11)	.17
August	87	.00	.03	.00	.02
September	80	.01	.03	.03(±.03)	.06
October	484	.00	.00	.00	.00
November–December	511	.00	.00	.09(±.01)	.46
January–February	930	.01	.00	.00	.09
March–April	450	.01	.00	.08(±.04)	.40
May	192	.00	.00	.00	.00
Year's total	2 881				1.49

[a] All three observations were alike, within the limits of detection, except where the standard error is indicated in parentheses.
[b] No NH_4–N found at any time (level of detection = 0.01 mg/l).

A total of 2,881 mm of precipitation was collected during the sampling year (Table 1), more than 80 per cent of which fell during October through April. Almost all precipitation was in the form of rain, most of which was associated with storms originating at sea. Thus, chemical composition of the precipitation was influenced dominantly by oceanic rather than terrestrial sources of introduced matter.

We found very little NO_2–N or NO_3–N in precipitation, and no NH_4–N at any time. Other observers have also shown precipitation near the Pacific Northwest seacoast to be very low in NH_4–N and NO_3–N. Moodie (1964) analyzed precipitation collected over 49 consecutive months.[2] Of 49 samples, only 16 had more than trace amounts of NH_4–N and only 11 had more than trace amounts of NO_3–N. Average input over 4 years (kg/ha/year) was 0.29 for NH_4–N and 0.06 for NO_3–N.

In Junge's (1958) study, precipitation was collected over 3-month intervals as part of a nationwide measurement of NH_4–N and NO_3–N in precipitation. Over a 12-month period, he found NH_4–N only at the minimum detectable level (0.02 mg/l) in one sample; none in two samples; and 1.01 mg/l in the final sample. Contamination might be suspected in the latter sample because it was much higher than any other NH_4–N level observed for the same period over the United States, with the exception of similar or higher values in the heavily populated Southern California area. Junge's values for NO_3–N were 0.38, 0.09, 0.18, and 0.42 ppm, considerably higher than Moodie or we found. However, his values for the coastal Washington sampling site were almost always lower than those measured throughout continental United States. Thus, our study, and those cited above, appear to support Junge's observation that, because major sources for NO_3–N and NH_4–N are of terrestrial origin, values for these ions usually are low near the seacoast and over the ocean.

Of the total N estimated to have been deposited in precipitation in our sampling area, 87 per cent was in the organic form. This finding is much the same as that of Wilson (1959*a*), who found organic N concentrations ranging from 0.02 to 0.20 ppm in snow influenced strongly by the New Zealand coastal climate. The organic or "albuminoid" N fraction averaged 51 per cent of total N in the snow samples—ranging from about 17 to 87 per cent. Wilson concluded that some constituents of the snow may have come from airborne particles of sea foam which is rich in organic N. He later offered additional support for his hypothesis (Wilson, 1959*b*) which, he felt, might apply not only to New

[2] Unpublished data for 1964 and 1965 were obtained from C. D. Moodie, Washington State University.

Zealand but probably also to other areas with rough oceans to their windward.

Our data neither support nor deny Wilson's hypothesis. We did note that highest concentrations of organic N were measured in months when on-shore storm activity was at a minimum. No organic N was found during the period of greatest storm activity, January–February. In view of the time of year in which organic N maxima prevailed, we believe that the major source of organic N measured was from pollen or other locally generated, airborne organic debris. Thus, we conclude that the 1.49 kg/ha/year total N in precipitation at the coastal Oregon site we sampled did not constitute a significant accretion to the nitrogen economy of the forest ecosystem under study.

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