UNIVERSITY OF IDAHO
COLLEGE OF FORESTRY-WILDLIFE
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NITROGEN COMPOUNDS IN STREAMS AS AFFECTED BY AERIAL FERTILIZATION OF NORTHERN IDAHO FORESTS

by

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Nitrogen Compounds in Streams as Affected by Aerial Fertilization of Northern Idaho Forests[1]

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Aerial application of commercial fertilizer to forest lands for the purpose of stimulating tree growth is rapidly gaining acceptance as a management tool. Concern has been voiced, however, that such treatment may result in eutrophication of water in streams of the affected area, even leading to pollution of domestic water supplies of local communities. These undesirable side-effects of fertilization programs have been noted in certain agricultural situations.

There have been studies made elsewhere in the northwest relating to water quality as influenced by forest fertilization operations (Klock, 1971, Malueg, Powers and Krawczyk, 1972). Because of the many environmental differences, results of these investigations cannot readily be used to predict changes in water quality which might occur after fertilizer applications to forests of the Inland Empire.

The work reported here was undertaken to provide specific information relating to the impact of aerial fertilization on water quality of streams associated with three forest sites in northern Idaho.

Sites

In a trial of aerial fertilization potential for stimulating forest growth in northern Idaho, the State of Idaho Department of Public Lands contracted for treatment of three small watersheds in 1972. Urea fertilizer was applied by helicopter to these lands at a rate of 200 lbs. nitrogen per acre (see cover photo).

The Twenty-mile site (near Bonners Ferry) encompasses 182 acres, sloping 25 percent to the south and southwest. The stand here consists mainly of sixty to seventy-year- old Douglas-fir and lodgepole pine, with smaller components of grand fir, larch, and cedar. Wishbone Creek flows through the area and drains into Twenty-mile Creek just below the fertilizer treatment zone. This latter creek is tapped for domestic water by the small community of Naples.

The second experimental site (Hollywood, near the town of Pierce) involves 127 acres. Slopes vary from 10 to 50%, with aspects generally northwest and southeast. The 30 year-old stand consists of Douglas-fir (55%), grand fir (35%) with the remainder being larch and western white pine. A chemical thinning treatment had been applied on this site in 1971, but was largely unsuccessful. Two small watercourses (Creeks 1 and 2) arise in the treated area and drain into Quartz Creek (off the site).

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At Crystal Peak, near St. Maries, a 115 acre area received treatment. This site is mountainous, has an average slope of 40% with all aspects represented. The 50 year-old timber stand is 98% grand fir, the remainder being Douglas-fir, cedar and larch. An intermittent fork of Mica Creek arises from a spring located on the area and flows out of it.

The Twenty-mile and Hollywood areas were fertilized in the spring of 1972; the Crystal Peak site was treated in the fall of 1972. The helicopter pilot was directed to leave a 50-foot buffer strip on both sides of all streams. As will be noted later, this objective was not properly achieved.

Procedures

Collection points for sampling of water for analysis were as follows:

Twenty-mile Site—Upper Wishbone Creek (above the fertilized area); Lower Wishbone Creek (below the fertilized area); and Twenty-mile Creek at a point 4 miles downstream from the fertilized area where the creek is tapped for domestic water supplies by the town of Naples.

Hollywood Site—Creek 1 (at point just below fertilized area); Creek 2 (at point just below fertilized area); Upper Quartz Creek (point on Quartz Creek above junctions with Creeks 1 and 2); and Lower Quartz Creek (point below junctions with Creeks 1 and 2).

Crystal Peak Site—Upper Mica Creek (on fertilized area at spring where creek arises); and Lower Mica Creek (at point just below fertilized area).

Water samples were taken in plastic containers at intervals and frozen until analysis. Determinations made included urea-nitrogen (Newell, **et. al.**, 1967), ammonium-nitrogen (Chapman and Pratt, 1961), and nitrate-nitrogen, utilizing an Orion specific ion electrode according to manufacturers directions.

Results

Twenty-mile Site—Prior to fertilization of this site which took place on the morning of May 20th, level of urea nitrogen in waters was negligable (Figure 1). By the evening of May 20 (12 hours after treatment) urea-nitrogen in Lower Wishbone Creek had risen to approximately 1 ppm. Ground observers noted that the proposed buffer strip the watercourse was penetrated during fertilizer application, and some of the urea pellets fell directly in the stream. This, then, would account for the sudden increase in the urea-nitrogen level. A rise in urea-nitrogen was also noted in upper Wishbone Creek. Apparently some pellets were dropped in the zone immediately above the treated area and affected the water sample taken there. An increase in urea-nitrogen was noted the same evening in Twenty-mile Creek itself, with the level rising from the trace found May 19 to about 0.2 ppm.

By noon of May 21 (the day after fertilizer was applied), urea-nitrogen levels had dropped drastically, even Lower Wishbone Creek registered less than 0.3 ppm. There were only traces of urea-nitrogen found in samples from all three sampling points on May 30. On June 7 and again on December 19, urea-nitrogen in Lower Wishbone Creek was found to be 0.3 ppm. The urea-nitrogen in Twenty-mile Creek remained at a trace level, however.

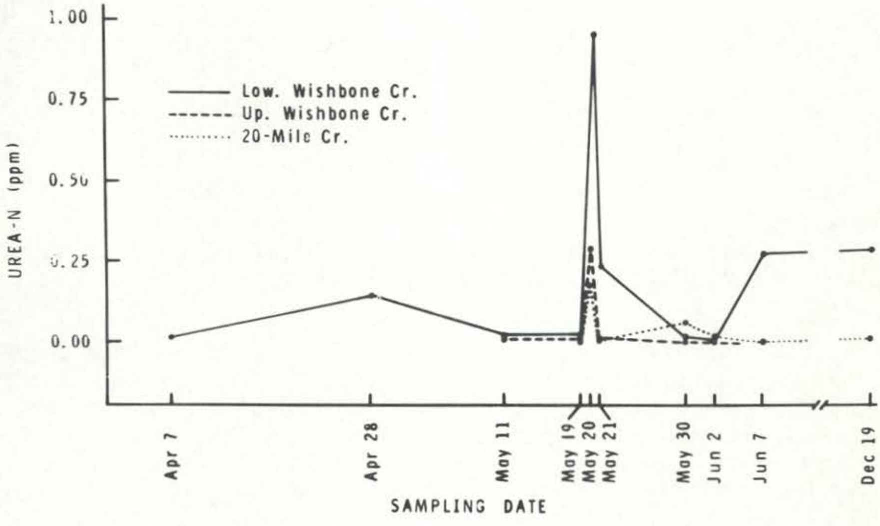

Figure 1.
Urea-nitrogen levels in water samples collected at Twenty-mile aerial fertilization site. Fertilizer was applied on May 20, 1972.

Ammonium-nitrogen level in creeks of the Twenty-mile site was unaffected by treatment. On no sampling date did analysis reveal more than 0.1 ppm of this component.

Figure 2 illustrates graphically the status of nitrate-nitrogen in the creeks on the various sampling dates. A rather erratic picture is presented because factors other than the fertilizer treatment would affect this component. Environmental conditions at a particular time will regulate the rate of conversion of other compounds of nitrogen to nitrate in both soil and water. Then too, some nitrate is brought to earth in precipitation. Thus the increases in nitrate-nitrogen which occurred cannot readily be attributed to treatment. It must be noted also, that the actual level of nitrate-nitrogen, regardless of fluctuations, never exceeded 0.25 ppm.

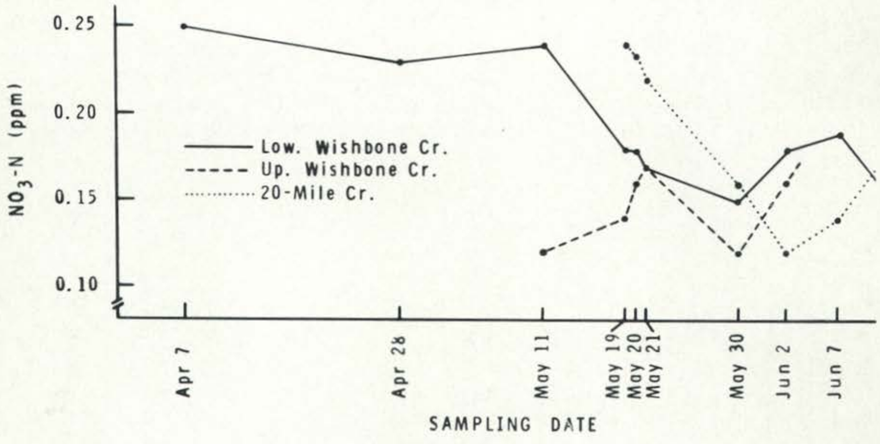

Figure 2.
Nitrate-nitrogen levels in water samples collected at Twenty-mile aerial fertilization site. Fertilizer was applied on May 20, 1972.

Hollywood Site—At this location, it proved impossible to obtain water samples prior to the day of fertilization (May 23). However, Upper Quartz Creek, unaffected by treatment, showed only a trace of urea-nitrogen when sampled after the operation (Figure 3). One can assume that the urea-nitrogen levels in Creeks 1 and 2 and Lower Quartz Creek would also have been minimal had no fertilization taken place. However, the urea-nitrogen levels in these creeks were sharply higher than that found for Upper Quartz Creek when sampled on May 23 shortly after the urea had been dropped from the helicopter. The level in Lower Quartz Creek was also high in comparison to that found for Upper Quartz Creek. Again, pilot error resulting in direct placement of urea in the streams was undoubtedly responsible for the values found. Within a day or two, urea-nitrogen levels in the affected streams had decreased markedly. On December 20, urea-nitrogen levels in Creek 2 and Lower Quartz Creek approximated that of Upper Quartz Creek (practically undetectable quantities), and Creek 1 registered 0.75 ppm. urea-nitrogen.

Only traces of ammonium-nitrogen were found in water samples collected throughout the study period on the Hollywood site. No pattern of nitrate-nitrogen accumulation which would relate to the fertilization operation was found. The largest quantities of this component were detected on December 20 (Figure 4). On this date, a sample from Upper Quartz Creek, which could not have been affected by the fertilizer treatment, contained the most nitrate-nitrogen. Were fertilization a factor, one would expect much higher nitrate-nitrogen values in samples from the other collecting points.

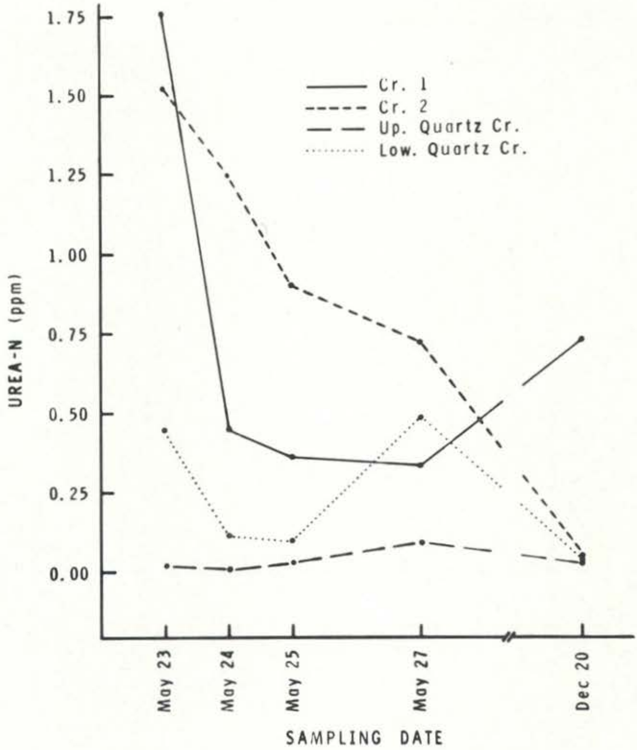

Figure 3.
Urea-nitrogen levels in water samples collected at Hollywood aerial fertilization site. Fertilizer was applied on May 23, 1972.

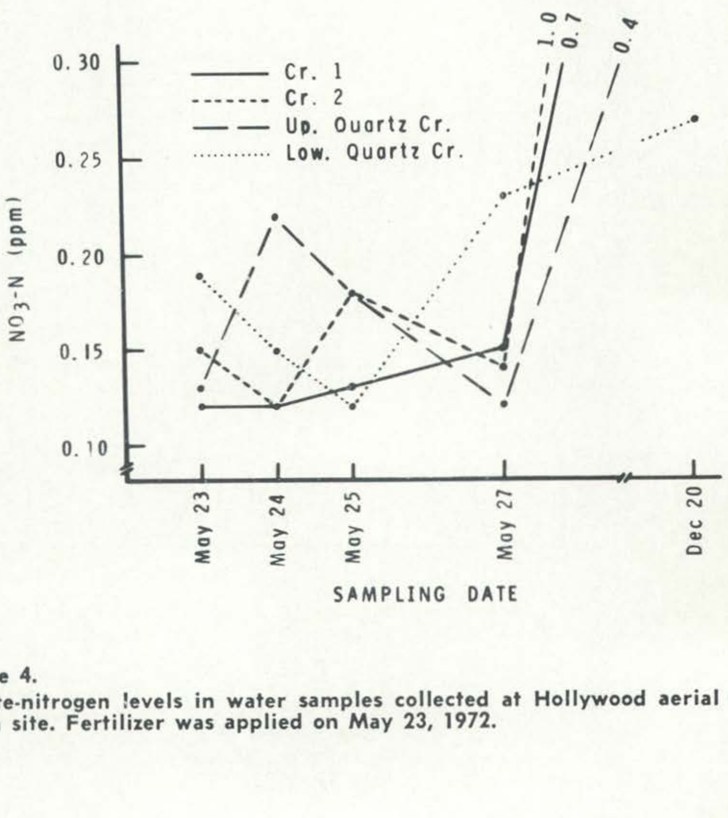

Figure 4.
Nitrate-nitrogen levels in water samples collected at Hollywood aerial fertilization site. Fertilizer was applied on May 23, 1972.

Crystal Peak Site—Mica Creek arises from a spring within the treatment zone and flows off the area. A sharp rise in urea-nitrogen level was detected immediately after aerial fertilization on September 29 in samples taken near the spring (Figure 5). On the other hand, only a trace of urea-nitrogen was found in water from Lower Mica Creek on the same date. Three days later, urea-nitrogen in water from both sampling sites was a trace level, and remained so throughout October.

No ammonium nitrogen was found in any water samples taken at Crystal Peak. Some fluctuation in nitrate-nitrogen levels occurred (Figure 6), but values after fertilization were of the same order of magnitude as values found before treatment.

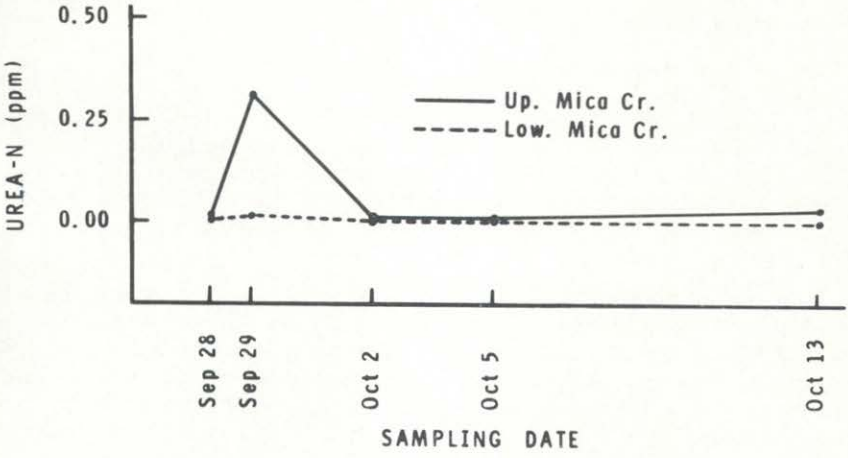

Figure 5.
Urea-nitrogen levels in water samples collected at Crystal Peak aerial fertilization site. Fertilizer was applied on September 29, 1972.

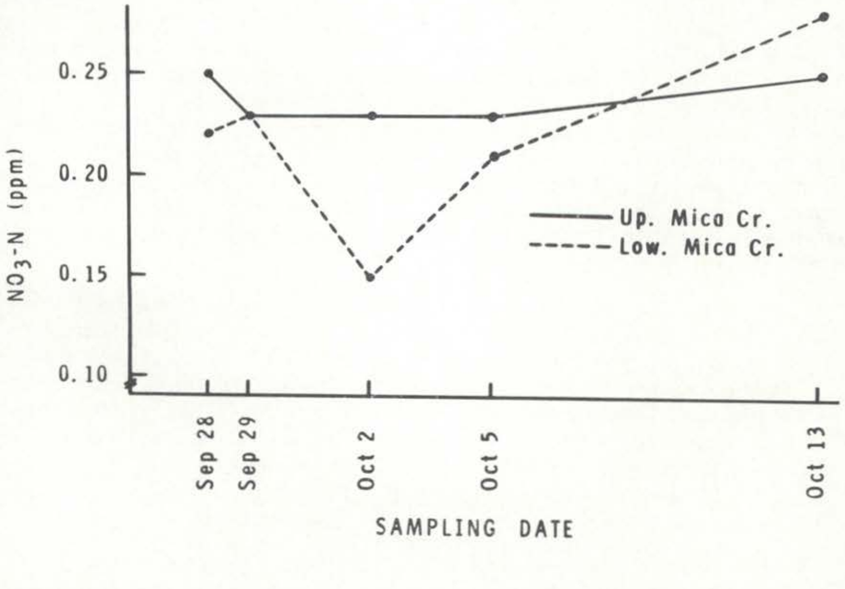

Figure 6.
Nitrate-nitrogen levels in water samples collected at Crystal Peak aerial fertilization site. Fertilizer was applied on September 29, 1972.

Discussion and Conclusions

On each of the fertilized sites, a sharp increase in urea-nitrogen in creeks can be noted immediately after treatment. The higher levels were maintained only briefly, and within a day or two a precipitous drop occurred. The temporary increase can be attributed to fertilizer falling directly into streams as it was dispensed from the helicopter, rather than to runoff of material from the land surface. Closer attention to buffer zones along water courses when fertilizing from the air would alleviate this particular problem.

From the pollution standpoint, no significance or importance should be attached to the short-lived rise in urea-nitrogen levels. The increase only appears large in comparison to the base levels detected. In actual quantity, urea-nitrogen in the most extreme example (Creek 1 on the Hollywood site) did not even reach 2 ppm. In studies made elsewhere, minnows exposed to 17.1 ppm. urea-nitrogen for 24 hours were not affected adversely (Calif. State Water Quality Board, 1963).

Ammonium-nitrogen in these waters presents no problem. In most samples this component was present only in trace amounts or else was actually undetectable.

Considerable fluctuation in nitrate-nitrogen levels in water samples was observed. Most of these changes were minor, and cannot readily be attributed to the treatment. They occurred even in Upper Quartz Creek, for example, which was outside the fertilized zone at Hollywood. A host of environmental factors (temperature, precipitation, etc.) act to influence the nitrate nitrogen level at any time. Again, as in the case of urea-nitrogen, nitrate-nitrogen levels appear high in certain instances only when compared to the extremely low base levels found in these waters. Ten ppm. may be taken as the upper limit for nitrate-nitrogen in unpolluted waters (Calif. State Water Quality Board, 1963). The quantity of nitrate-nitrogen found in samples taken during the present study was below the stated limit by a factor of at least 10, and in most cases the factor ranged from 50 to almost 100.

In reference to the sum total of all forms of inorganic nitrogen allowable in waters classified as unpolluted, a figure of 10 ppm is again cited (Federal Water Pollution Control Administration, 1968). Analysis of waters from the three sites fertilized shows that on no sampling date within the study period was this value even approached. In the light of the data presented, it may be concluded that thus far these fertilization operations have created no water pollution problem.

Summary

Urea, ammonium, and nitrate-nitrogen were monitored in samples collected at intervals from streams on and adjacent to three forest sites in northern Idaho. Two of these small watersheds were aerially fertilized with urea at a rate of 200 lbs. nitrogen per acre in the spring of 1972; the third was treated similarly in the fall of the same year.

A short-term increase of urea-nitrogen in water samples occurred immediately after fertilization; this rise was attributed to direct placement of urea in creeks through pilot error. Fluctuations of nitrate-nitrogen levels in water were observed, but these evidently were caused by variations in the natural environment rather than by fertilizer treatment.

Inorganic nitrogen levels in creeks on all three sites remained well within acceptable water purity standards throughout the study period.

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