WATERSHED CALIBRATION FOR ENVIRONMENTAL IMPACT ASSESSMENT

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ABSTRACT

This study reports on procedures for assessing environmental impact from water analysis. Since the spring of 1977 weekly water samples have been taken from two intermittent streams in southern Illinois. The two small, adjacent watersheds are primarily forested with upland hardwoods. Water samples are analyzed for nutrient content, sediment, pH and temperature. Stream flow data are also obtained on a continuous recording device. One of the watersheds has been designated treatment watershed, the other control. Regression equations relating water quality and quantity have been developed for the two watersheds. On the treatment watershed approximately 13 acres of timber are scheduled for clearcutting. Following harvesting, water measurements from the treatment watershed will be compared with estimated values. This paper deals with the pre-harvest calibration period and the data collection that will be used to develop predictive equations for assessing environmental impact of timber harvesting.

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Introduction

This paper reports on the development of a monitoring system to obtain baseline data for environmental impact assessment. The system utilizes water quality measurements to establish the relationship between two adjacent watersheds under natural, undisturbed conditions. Predictive equations are then derived from these baseline measurements for each parameter. Following timber harvesting, change in water quality on the cut watershed, as represented by a deviation from the predicted value, will be considered a measure of environmental impact.

Procedures

The study consists of collecting water samples from two adjacent watersheds located in southern Illinois. The treatment watershed has a total area of 13.8 hectares in which 53% or 7.3 hectares is scheduled for clearcutting. The area to be harvested is part of the Shawnee National Forest and has been designated for cutting. The control watershed consists of 72.9 hectares which is 89% forested.

A plywood weir was constructed on the treatment watershed to establish a temporary stream-gaging station. The weir was installed according to specifications by Whipkey (n.d.). Associated with the weir on the treatment watershed is a stilling well and continuous water level recorder. A stilling well and continuous recorder were also established on the control watershed.

Weekly visitations were made to the sites to measure flow and collect water quality data. Collection sites are located approximately 30 yards above the confluence of the streams from the treatment and control watershed. On-site field analysis was made for pH and specific conductance, and water temperature was recorded. Grab samples were obtained and returned to the laboratory for analysis for nitrates, potassium, calcium and suspended sediments. Nitrates were measured with a Hach chemical company kit; calcium and potassium concentrations were measured with an Atomic Adsorption Spectrophotometer. Suspended sediments were determined by the gravimetric method; filtering and weighing dry residue from a given quantity of water.

Results

Table 1 shows a summary of data collected during the period March - September 1977. Twenty weekly observations are given for all variables except pH. Only seven measurements were made for this variable because of equipment problems.

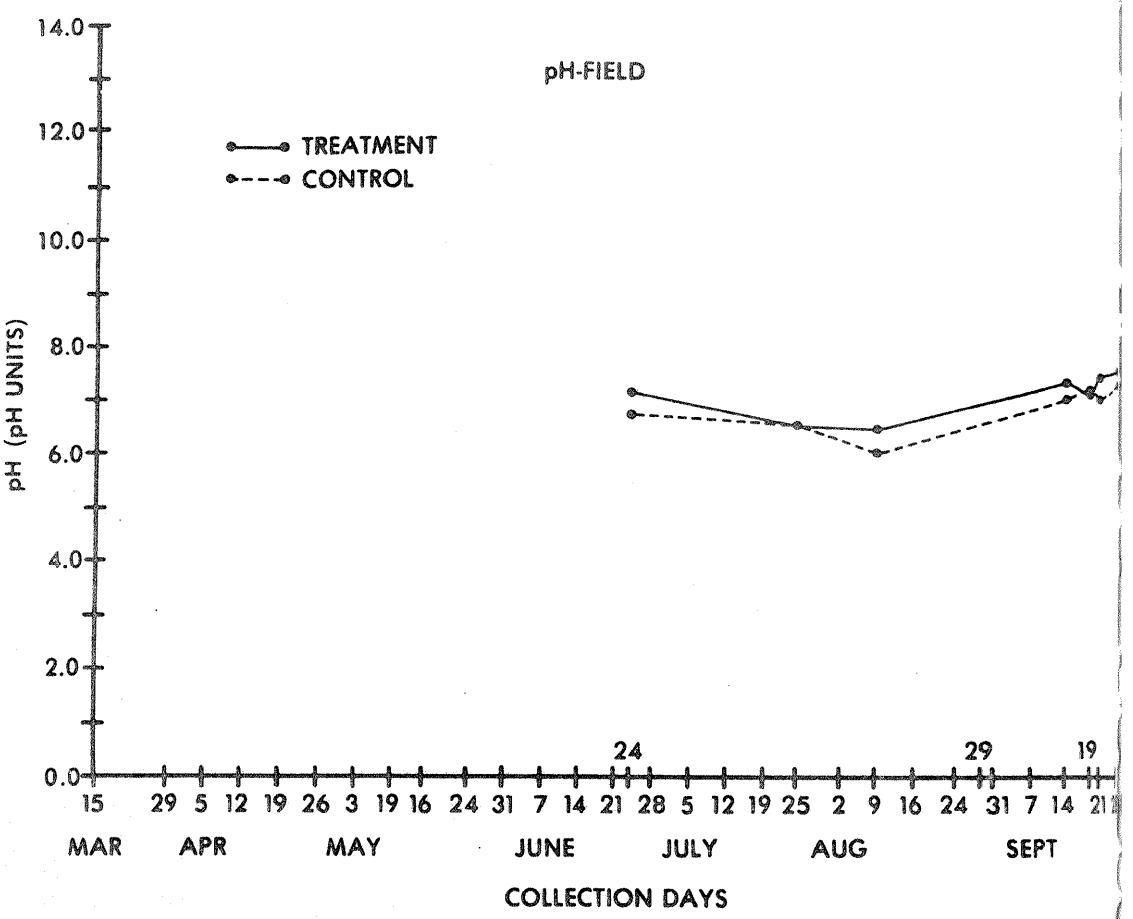
Field pH on the treatment watershed ranged slightly higher than on the control watershed. Specific conductance was higher on the control watershed with a range of 70-180 umhos/cm compared to 50-110 on control. Suspended sediment ranged from 0-284 mg/l. on the treatment watershed and 0-764 on control. Nitrate - nitrogen values are very small ranging from .02 to .84 ppm. Potassium ranged from 1.2 to 5.5 ppm. and calcium from 4.5 to 21.8 ppm.

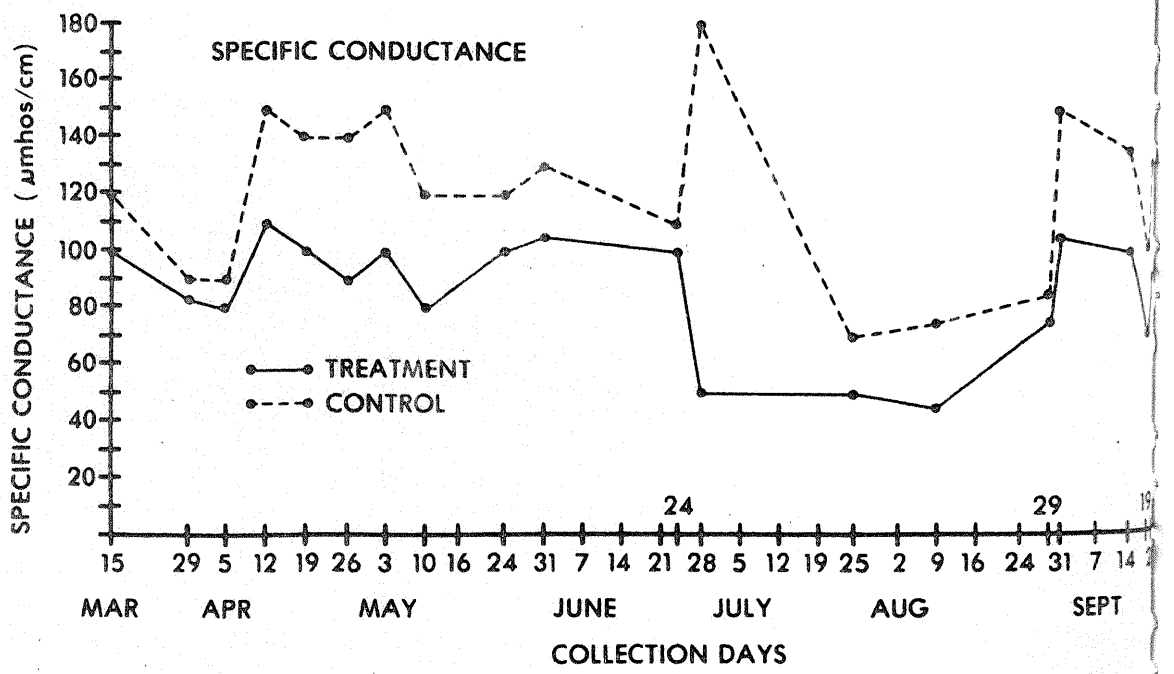
There was considerable weekly variation for all variables, and with the exception of specific conductance, neither watershed showed consistently higher results. For specific conductance, the control watershed was always higher. The following graphs show the relations between the two watersheds for measured variables.

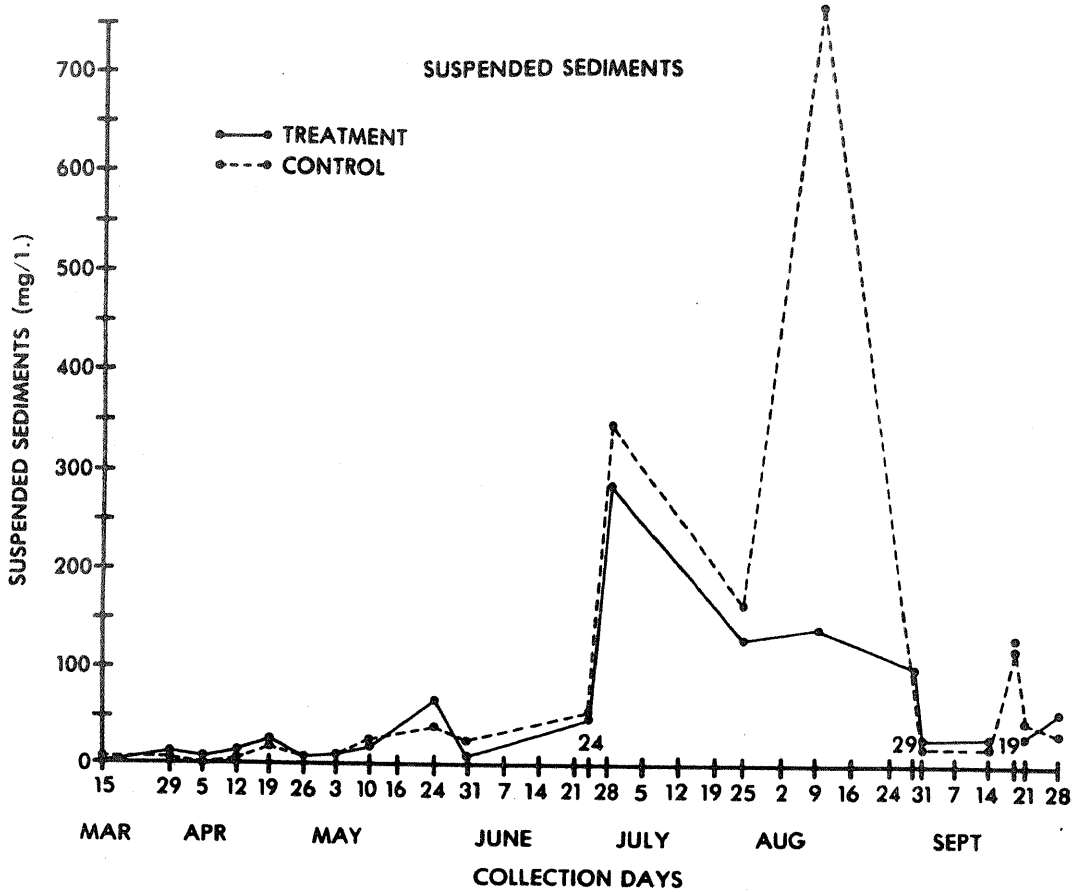
From measurement data regression equations were developed for each parameter. The treatment watershed variables are the dependent variables and water quality parameters from control watershed are independent variables. The equations are of the form $Y = a+bx$. The regression equations and their r^2 values are given in table 2.

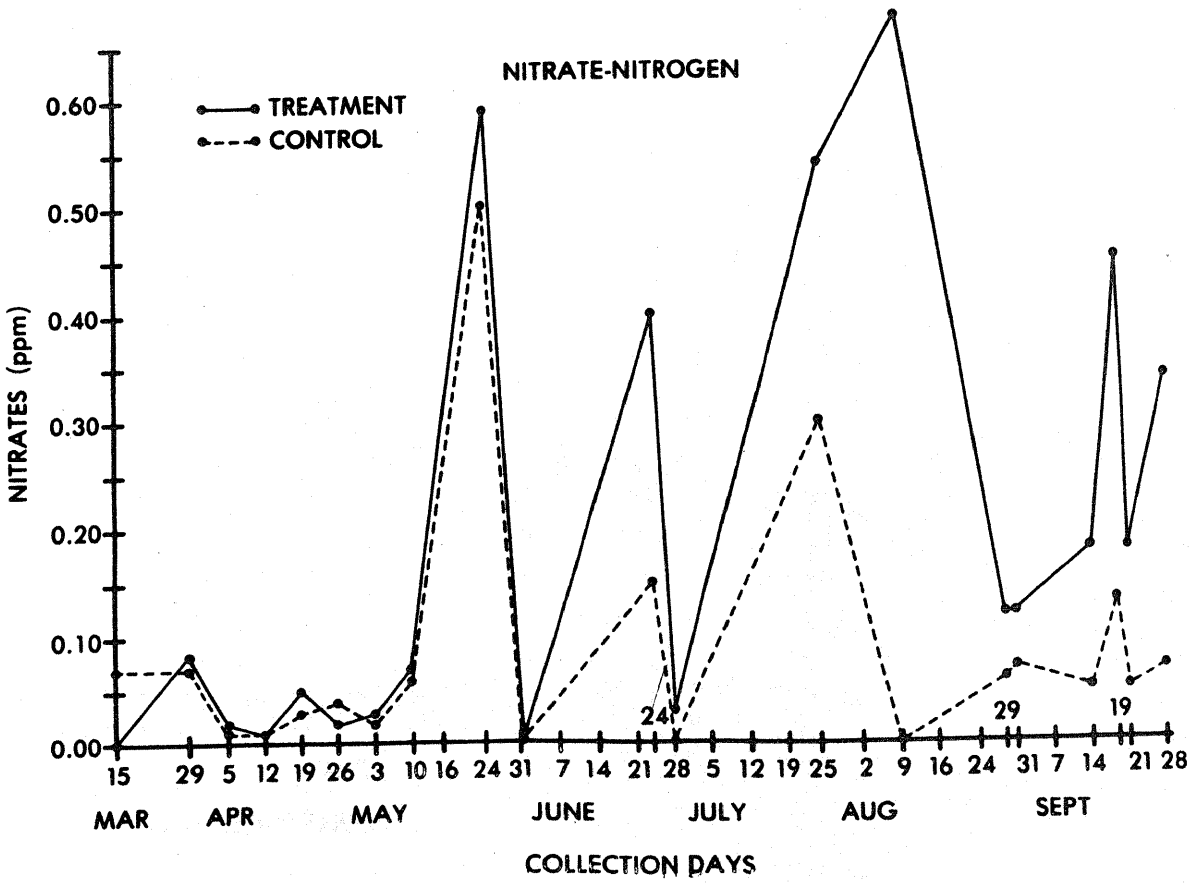
Discussion

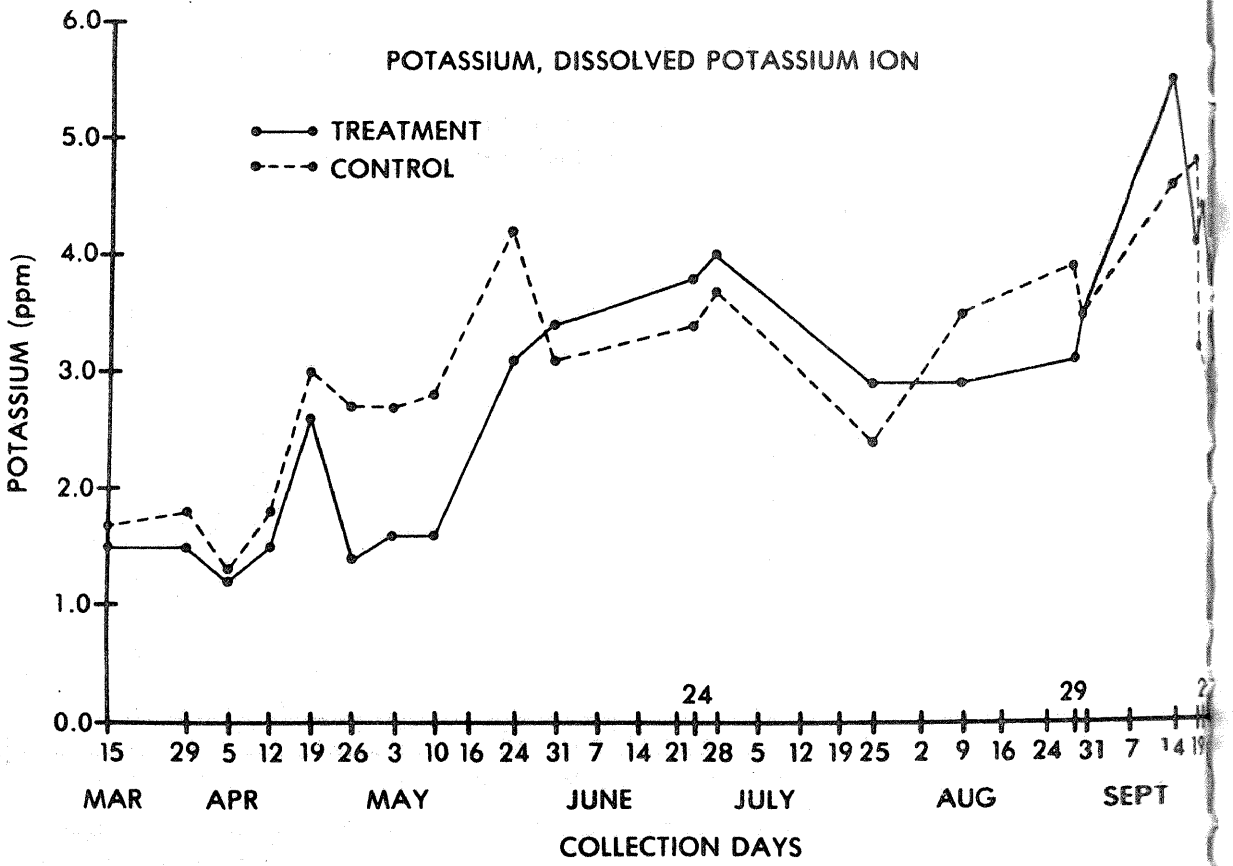
Some of the equations shown in table 2 are obviously better predictors than others. It is believed that instrumentation and procedures used were satisfactory and that measurement errors were minimized. In an attempt to improve r^2 values, a number of common transformations and equation forms were tried without notable success. The equations illustrate the variable, erratic nature of the watersheds. A few observations have considerable effect on the correlation between the two watersheds. For example, on the measurement of specific conductance an extreme value was recorded for the control watershed for one day. If this one observation is removed correlation between the watersheds increases from .45 to .85. Timber will be harvested from the treatment watershed during 1979. Baseline data will continue to be collected until this time. With additional observations hopefully better prediction equations will result so that the effect of timber harvest on the quality of water from this watershed can be measured with some confidence.


pH-FIELD
TREATMENT
CONTROL
pH (pH UNITS)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
15 29 5 12 19 26 3 19 16 24 31 7 14 21 28 5 12 19 25 2 9 16 24 31 7 14 21
24
29
19
MAR APR MAY JUNE JULY AUG SEPT
COLLECTION DAYS


SPECIFIC CONDUCTANCE
TREATMENT
CONTROL
SPECIFIC CONDUCTANCE (µmhos/cm)
180
160
140
120
100
80
60
40
20
15 29 5 12 19 26 3 10 16 24 31 7 14 21 28 5 12 19 25 2 9 16 24 31 7 14
24
29
MAR APR MAY JUNE JULY AUG SEPT
COLLECTION DAYS


SUSPENDED SEDIMENTS
TREATMENT
CONTROL
SUSPENDED SEDIMENTS (mg/1.)
700
600
500
400
300
200
100
0
24
29
19
15 29 5 12 19 26 3 10 16 24 31 7 14 21 28 5 12 19 25 2 9 16 24 31 7 14 21 28
MAR APR MAY JUNE JULY AUG SEPT
COLLECTION DAYS


NITRATE-NITROGEN
TREATMENT
CONTROL
NITRATES (ppm)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
24
29
19
15 29 5 12 19 26 3 10 16 24 31 7 14 21 28 5 12 19 25 2 9 16 24 31 7 14 21 28
MAR APR MAY JUNE JULY AUG SEPT
COLLECTION DAYS


POTASSIUM, DISSOLVED POTASSIUM ION
TREATMENT
CONTROL
POTASSIUM (ppm)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
15 29 5 12 19 26 3 10 16 24 31 7 14 21 28 5 12 19 25 2 9 16 24 31 7 14
24
29
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
COLLECTION DAYS

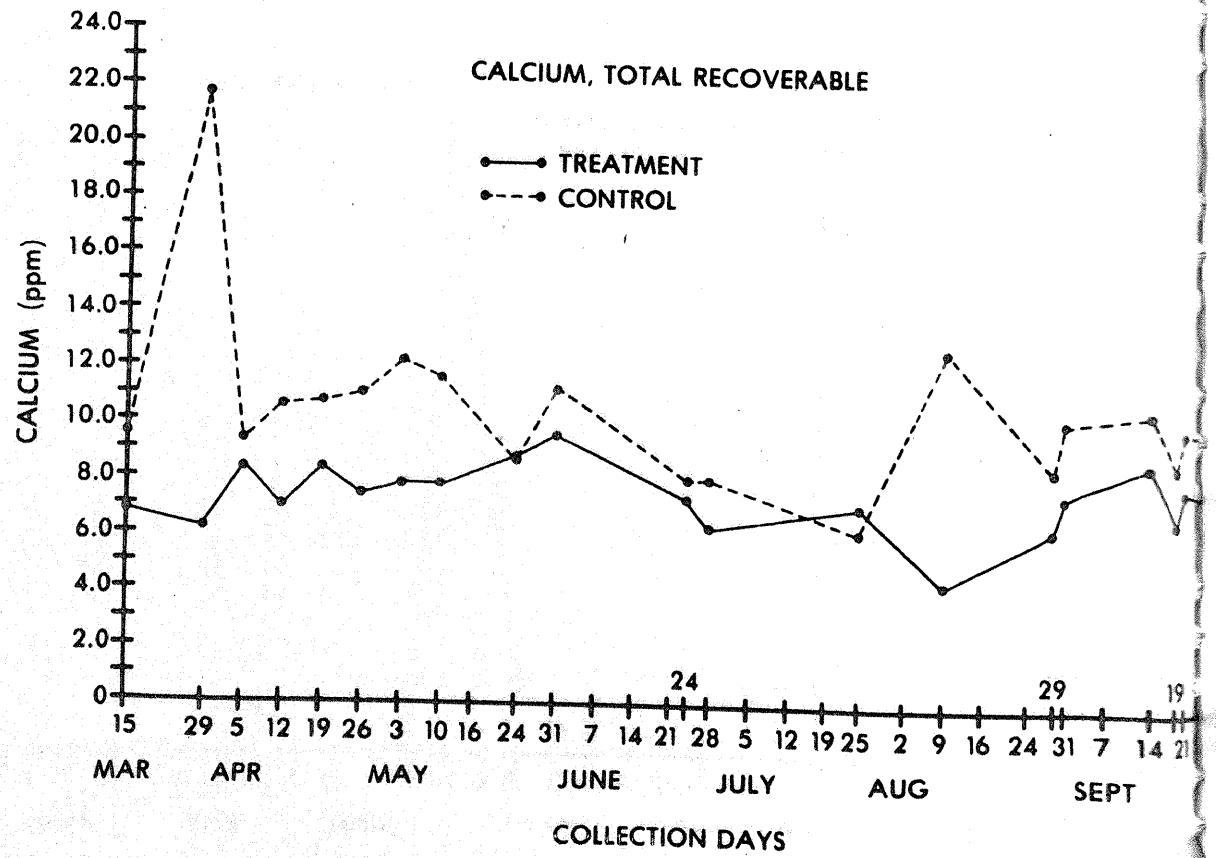

CALCIUM, TOTAL RECOVERABLE
TREATMENT
CONTROL
CALCIUM (ppm)
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0
15 29 5 12 19 26 3 10 16 24 31 7 14 21 28 5 12 19 25 2 9 16 24 31 7 14
24
29
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
COLLECTION DAYS

Table 1.

Summary of Water measurements during calibration period

Variable	Watershed Treatment Mean	Treatment -Range-	Watershed Control Mean	Control -Range-
pH	7.1	6.5 - 7.6	6.8	6.6 - 7.4
Specific conductance (Umhos/centimeter)	86.4	45 - 110	120.8	70 - 180
Suspended sediments (mg/l)	57.9	0 - 284	89.8	0 - 764
Nitrate - Nitrogen (ppm)	0.2	0 - 0.7	0.1	0 - 0.50
Potassium (ppm)	2.8	1.2 - 5.5	3.0	1.3 - 4.8
Calcium (ppm)	7.5	4.5 - 8.8	10.6	6.3 - 21.8
Flow Rate (CF/sec.)	.01	0 - 0.2	0.13	0 - 1.6

Table 2.

Regression equations relating control (C) to treatment (T) watershed

Variable	Equation	r^2
pH	T = 1.25767 + 0.85116C	0.80
Specific Conductance	T = 48.51862 + 0.31372C	0.21
Suspended Sediments	T = 34.16408 + 0.26391C	0.45
Nitrate-Nitrogen	T = 0.9807 + 1.15899C	0.40
Potassium	T = -0.27779 + 1.02069C	0.66
Calcium	T = 8.26427 + 0.07481C	0.20
Flow Rate	T = -0.00196 + 0.12799C	0.98

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