NUTRIENT FLUX ON UNDISTURBED HARDWOOD WATERSHEDS IN EASTERN KENTUCKY[1/]

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Abstract.--The quality and quantity of streamflow eminating from two second-order watersheds, 81.75 and 93.76 hectares in area, were measured from 1972 - 1984. The watersheds, located on the Cumberland Plateau of southeastern Kentucky, supported relatively undisturbed stands of 55 - 60 years old mixed hardwoods. In addition to streamflow, the quality and quantity of incident and throughfall precipitation received on the study areas were also monitored. Nutrient fluxes examined were Ca, Mg, Na, K, NO_3-N, and SO_4. Cation inputs, derived from incident precipitation, were ranked Ca> K> Na> Mg, while anions were SO_4 > NO_3-N. Cation inputs based on throughfall were ranked K >Ca> Na> Mg and anions were SO_4 > NO_3-N. Cation outputs ranked Ca> Mg> Na> K, with the anions SO_4 > NO_3-N. Nutrient fluxes generally exhibited strong seasonal variations, with the exception of NO_3-N. Cation fluxes based on incident precipitation inputs were consistently negative throughout the year, with minimal values occurring during the growing season. Cation fluxes based on throughfall inputs were divided, Ca and K were positive while Mg and Na were negative. The anions were consistent, regardless of type of precipitation input, with NO_3-N exhibiting positive fluxes and SO_4 negative. The quality of precipitation was substantially enriched while passing through the forest canopy. It is very likely that dust from nearby surface mining activities contributes to this precipitation enrichment process.

Keywords: nutrient cycling, water quality, hardwoods

INTRODUCTION

The inputs and outputs of nutrients within a forested watershed ecosystem are governed by complex cyclic mechanisms, which at the present, are not fully understood. Increased interest has developed in this nutrient cycling phenomenon in recent years, as evidenced by numerous published reports (Likens et al. 1977, Patric and Smith 1975). Considerable variation in nutrient fluxes has been found between geographic regions and vegetation complexes. Temporal fluctuations are also quite evident.

Concern has been expressed over the possible effects of man-caused perturbations of forested ecosystems on nutrient fluxes. The much publicized Hubbard Brook study (Likens et al. 1970) focused attention on the possible ramifications of clearcut harvesting of northern hardwood forests on nutrient releases. Although this study was atypical, in terms of conventional forest harvesting practices, it led a number of people and organizations to question forest harvesting activities in general. Subsequent studies of more conventional harvesting activities in the northeastern and eastern hardwood forests have indicated slight to moderate disruption of the biogeochemical cycling on forested watersheds (Swank and Douglass 1977, Hornbeck and Kropelin 1982).

Some degree of nutrient flushing, as a result of forest removal, also is cause for concern over possible site impoverishment due to the reduction of system nutrient pools.

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Practices that remove large quantities of biomass (whole tree harvesting) or suppress regrowth after cutting (Pierce et al. 1972) are likely to have an effect on site productivity.

In order to evaluate the effects of various forest perturbations on nutrient cycling, baseline or background flux values must be determined in various geographic and vegetative regions. This study was designed to provide gross nutrient fluxes on several undisturbed hardwood forested watersheds in eastern Kentucky. Nutrient concentrations in incident and throughfall precipitation were also compared to gain some appreciation of the effect of dust from nearby stripmines on the quality of incoming precipitation. The nutrients evaluated were: calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), nitrate nitrogen (NO_3-N), and sulfate (SO_4).

STUDY AREA

The study was conducted at Robinson Forest, a 6,000 ha research and teaching facility of the University of Kentucky. The Forest is located in Breathitt, Knott, and Perry Counties of eastern Kentucky, approximately 40 kilometers south of Jackson. It is within the Cumberland Plateau physiographic province and, more specifically, in the Mountains and Eastern Coalfields physiographic region. This extensive plateau is characterized by steeply-sloping hills (35 - 70 percent gradients) with well-defined ridges and narrow valley bottoms. Elevations generally range from 260 meters above m.s.l. along the main stream channels to 460 meters on the ridge peaks.

The Cumberland Plateau in eastern Kentucky is generally underlain with rocks of the Pennsylvanian geologic period. The Breathitt Formation (mid-Pennsylvanian), which dominates the area, is composed of alternating layers of sandstones, siltstones, shales, and coal (Welch 1958). This formation has weathered to form a dendritic drainage pattern.

Soils on the slopes have developed in coluvium of variable thickness, overlying alternating layers of resistant and less-resistant rock. This has resulted in complex, benchy, and/or dissected slopes. The soils are quite variable in depth, ranging from very shallow near rock outcrops to several meters or more near the uphill sides of benches. An intensive soils study conducted on an adjacent watershed indicated an average soil depth of 1.4 meters (Smith 1982). The predominant soils found on the study areas are the Jefferson, Shelocta, Gilpin, Steinsberg and Pope series (Hutchins et al. 1976, Graves et al. 1977, Smith 1982). These soils are of generally medium to heavy texture and, from the standpoint of water transmission ability and storage capacity, are hydrologically shallow (Smith 1982). Vertical internal drainage is generally restricted by impermeable or slowly permeable strata, resulting in rather rapid lateral subsurface drainage during storm events (Coltharp et al. 1978, Coltharp and Springer 1980).

The vegetation is typical of the mixed hardwood forests indigenous to the area (Carpenter and Rumsey 1976). Oaks (Quercus spp.), hickories (Carya spp.), and yellow-poplar (Liriodendron tulipifera L.) are the principal hardwood species, with Virginia pine (Pinus virginiana Mill.), shortleaf pine (Pinus echinata Mill.) and pitch pine (Pinus rigida Mill.) common near cliffs and narrow, droughty ridges. The hardwoods cover about 95+ percent of the area, with the conifers occupying less than five percent.

The climate of the area is best described as temperate (Hill 1976). Mean annual temperature is approximately 13°C, with a growing season of 170 days. Mean annual precipitation is 125 cm, rather uniformly distributed throughout the year. Low intensity, long duration rainstorms predominate during the winter months and short duration, high intensity convectional storms occur during the summer months. Snow contributes less than five percent of the total annual precipitation volume.

The two watersheds used in this study, Falling Rock and Little Millseat, are 93.5 and 81.7 hectares in area, respectively. Both are covered by relatively undisturbed mixed hardwood stands approximately 60 years old. The entire area was "high graded" during the mid-1920's but all signs of disturbance have disappeared over the years. Both watersheds support second-order streams. The average annual water yield is 66 cm, with approximately 80 percent of the volume produced during the dormant season (November - April). Descriptive physical parameters of both watersheds are as follows:

Physical Parameters	Falling Rock	Little Millseat
Area (ha)	93.50	81.70
Perimeter (km)	3.72	4.45
Aspect	NW	SE
Shape	Oval	Long,narrow
Stream Order	2	2
Drainage Density	2.93	3.54
Channel Length (m)	670	1100
Channel Slope (%)	3.20	2.80
Mean Elevation (m)	381	379
50% Area-Elevation (m)1/	382	378
Average Basin Slope (%)	42.70	45.00

1/50% of the basin area above this elevation.

The general study area, Robinson Forest, is almost completely surrounded by surface mining activity (coal) and is thus likely impacted by atmospheric inputs of dust. The Forest is virtually a forested island in a sea of stripmines. There are no coal-fired power plants in the immediate area, but plants located in south central Kentucky and eastern Tennessee could affect the watersheds (Henderson 1978).

METHODS

The overall period of study extended from January, 1972 through December, 1984. Quantitative measurements of precipitation and streamflow were obtained on a continuous basis during this interval. Total incoming precipitation was measured with weighing-type recording precipitation gauges with 20.32 cm diameter orifices, located on each watershed. Total outgoing streamflow was continuously measured by means of broad-crested v-notch weirs with 3:1 sideslopes, equipped with FW-1 waterstage recorders.

Incident precipitation quality was sampled from August, 1975 through December, 1984, by means of an automatic wet deposition gauge. Throughfall quality was sampled from August, 1975 through November, 1977 by a system of collectors placed under the canopy of an area adjacent to the Little Millseat watershed (Shearer et al. 1977). The collectors consisted of 20.32 cm diameter polyethylene funnels, rubber stoppers and 3.78 liter glass containers. The funnels and glass containers were washed, acid rinsed, and double rinsed in distilled, deionized water, then sealed with an adhesive polyfilm. They were placed in the sample locations immediately prior to a precipitation event and removed as soon as the event was over. Thus, these collectors only sampled wet deposition, i.e., incoming precipitation, wash-off and leached materials, not direct dry deposition. Both types of precipitation samples, incident and throughfall, were refrigerated until analyzed in our watershed lab at the University.

Weekly "grab samples" were obtained immediately above the weir on each watershed for water quality determinations. Monthly inputs of each nutrient in incident precipitation (kg/ha) were determined by multiplying the average monthly concentration (mg/l) times the net monthly precipitation volume (l/ha). Throughfall values were determined by multiplying average monthly throughfall concentrations times net precipitation volumes. Net precipitation volumes were obtained by applying the appropriate seasonal interception equations of Helvey and Patric (1965) to incident precipitation values. The equations used were:

<u>Growing Season</u> $I = 0.083\ (P) + 0.036\ (n)$

<u>Dormant Season</u> $I = 0.059\ (P) + 0.020\ (n)$

I = Interception loss
P = precipitation
n = number of storms

Monthly outputs of each nutrient (kg/ha) were determined by multiplying average monthly nutrient concentrations in streamflow times the monthly streamflow volumes (l/ha).

Input and output samples were analyzed for Ca, Mg, Na, K, NO_3-N and SO_4. Atomic absorption spectroscopy was used to determine cation concentrations. Sulfate was measured turbidi-metrically using a spectrophotometer. Nitrate nitrogen concentrations were determined by a nitrate reductase procedure developed by Lowe and Gillespie (1975).

RESULTS AND DISCUSSION

Precipitation and streamflow, the two principal mechanisms of ionic transport into and out of a forested watershed ecosystem, were very similar for Falling Rock and Little Millseat watersheds during the study period (table 1). Precipitation was relatively uniform throughout the year with maximum values occurring in late winter and early spring, and minimum values occurring in mid-fall. Streamflow exhibited similar, but much more accentuated, seasonal trends. Annual values for precipitation ranged from 80.87 to 157.86 cm on Falling Rock and from 77.90 to 164.16 cm on Little Millseat. Streamflow (yield) varied from 34.06 to 100.13 cm on Falling Rock and from 44.83 to 105.28 cm on Little Millseat.

The concentration of nutrients in precipitation is an important factor in determining nutrient cycling within a watershed system and fluxes from the system. Nutrient concentrations were determined for incident and throughfall precipitation and are presented in table 2. The relative order of cation concentrations in incident precipitation for both watersheds was Ca > K > Na > Mg. The order for cations in throughfall precipitation was K > Ca > Na > Mg. Anion inputs in both incident and throughfall precipitation were in the order of SO_4 > NO_3-N. An examination of table 2 indicates an obvious enrichment of incident precipitation as it passes through the forest canopy. The cations were increased 6.33, 3.27, 2.41 and 1.23 times for Mg, K, Ca and Na, respectively. NO_3-N was increased 1.91 times and sulfate 1.11 times. Nutrient concentrations measured during the growing season, for both incident and throughfall precipitation, were generally greater than during the dormant season. Two exceptions to this were noted: Mg was slightly

Table 1.--Monthly mean precipitation and streamflow for Falling Rock and Little Millseat watersheds, 1972-1984.

Month	Falling Rock		Little Millseat	
	Precip.	Streamflow	Precip.	Streamflow
	(cm)			
Jan	10.06	9.37	10.52	10.41
Feb	8.79	7.90	8.84	7.71
Mar	12.60	11.23	12.78	11.86
Apr	10.77	10.31	11.15	10.74
May	12.37	6.27	12.32	6.93
Jun	10.34	2.74	10.82	3.53
Jul	11.20	1.09	11.40	1.30
Aug	9.78	1.17	9.80	1.70
Sep	8.64	0.84	9.09	1.04
Oct	7.80	1.57	8.23	1.78
Nov	9.45	3.20	10.01	3.84
Dec	10.26	6.65	10.44	8.10

Table 2.--Monthly mean nutrient concentrations in incident and throughfall precipitation on the study areas.

Month	Ca	Mg	Na	K	NO_3-N	SO_4
	mg/l					
	Incident					
Jan	0.25	0.01	0.05	0.47	0.26	2.15
Feb	1.74	0.18	0.21	0.35	0.39	3.10
Mar	0.26	0.05	0.08	1.03	0.31	3.22
Apr	1.11	0.12	0.23	0.81	0.52	8.75
May	0.81	0.02	0.34	0.33	0.34	4.30
Jun	0.72	0.01	0.22	1.51	0.16	5.90
Jul	0.82	0.03	0.24	2.76	0.29	5.40
Aug	2.28	0.13	1.49	0.47	0.22	12.57
Sep	1.07	0.03	2.56	0.42	0.14	5.52
Oct	1.23	0.08	2.27	0.24	0.44	6.50
Nov	0.06	0.01	0.01	0.19	0.23	4.30
Dec	0.50	0.01	0.17	0.70	0.71	5.60
D.S.1/	0.65	0.06	0.12	0.59	0.40	4.52
G.S.2/	1.15	0.05	1.19	0.95	0.26	6.70
$\bar{x}$/mon.	0.90	0.06	0.66	0.77	0.33	5.61
	Throughfall					
Jan	0.38	0.03	0.01	0.28	0.34	3.42
Feb	2.05	0.22	0.21	0.87	0.40	2.66
Mar	0.94	0.12	0.13	0.54	0.47	4.55
Apr	2.60	0.56	0.41	3.48	1.92	8.30
May	4.79	1.09	0.33	8.37	1.17	7.06
Jun	1.63	0.22	0.59	2.29	0.20	3.16
Jul	2.04	0.32	0.35	2.05	0.14	4.13
Aug	3.85	0.61	2.58	3.57	0.48	11.51
Sep	2.11	0.19	2.36	2.79	0.10	6.63
Oct	3.43	0.81	2.54	3.63	0.47	9.68
Nov	0.83	0.18	0.14	1.32	0.75	5.12
Dec	1.35	0.19	0.11	1.00	1.12	8.18
D.S.	1.36	0.22	0.17	1.25	0.83	5.37
G.S.	2.97	0.54	1.46	3.78	0.43	7.03
$\bar{x}$/mon.	2.17	0.38	0.81	2.52	0.63	6.20

1/Dormant season: November - April
2/Growing season: May - October

lower during the growing season and NO_3-N was considerable lower for incident values; only NO_3-N was lower for the throughfall values. The higher values occurring during the growing season are likely attributable to the presence of leaf surfaces, which collect dry particulate fallout and impacted materials, and ionic materials leached from the leaves. There is still a degree of uncertainty relative to the contribution of wash-off of dry deposition and impaction materials accumulated on leaf surfaces and materials leached from within the leaf structure. Since this study examined relatively gross inputs and outputs of nutrients no measurements were made to distinguish between these canopy components.

Mean monthly inputs, outputs and flux values in kg/ha, for the study watersheds are presented in table 3. The input values, both incident and throughfall, were derived by using net precipitation amounts (Helvey and Patric 1965) times the concentrations. This procedure, of correcting for interception using published equations, differs from most studies found in the literature. Other studies have either measured throughfall and stemflow and made the appropriate adjustments or ignored the interception factor. The quantative precipitation values used in this study represent precipitation received at the surface of the soil. The quality of stemflow and litter leachate were not determined.

Examination of table 3 indicates that the mean monthly fluxes of cations, based on incident precipitation quality, are negative for both watersheds. The anions are split, NO_3-N is positive and SO_4 is negative. The enrichment of the precipitation as it passes through the canopy is again rather obvious, as indicated by the throughfall values. The most dramatic enrichment was that of K which increased over thirtyfold. This may be due to high K content in the leaves, which is highly leachable. The seasonality of the mean monthly nutrient fluxes is presented in figure 1. The cation fluxes exhibit very similar seasonal patterns, i.e., maximum values in early spring and minimal values during late summer - early fall period. NO_3-N flux remained positive throughout the year and did not exhibit any pronounced seasonal trend. SO_4 exhibited a seasonal trend similar to that of the cations, but the flux values were negative during winter and positive during the summer. Figure 1 also demonstrates the similarity of the flux values on the two watersheds.

Comparisons of mean monthly fluxes based on incident and throughfall values are presented in figure 2. Nutrient fluxes for Falling Rock and Little Millseat watersheds, because of their similarity, were averaged together for this comparison. As with figure 1, similar seasonal relationships are evident for fluxes based on incident precipitation values. However, the varying vertical scales for the different graphs tend to distort the curve shapes. The graph flux scales had to be changed from those used in figure 1 to accommodate the increased range of values produced by the addition of the

Table 3.--Mean monthly input, output and flux values for Falling Rock and Little Millseat watersheds, 1972-1984.

Nutrient	Falling Rock Input	Falling Rock Output	Falling Rock Flux	Little Millseat Input	Little Millseat Output	Little Millseat Flux
	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
Ca	0.39 1/	1.09	-0.70	0.39	1.28	-0.89
	1.89 2/	1.09	0.79	1.92	1.28	0.64
Mg	0.05	0.92	-0.87	0.05	1.07	-1.02
	0.33	0.92	-0.59	0.34	1.07	-0.73
Na	0.15	0.68	-0.53	0.15	0.71	-0.56
	0.64	0.68	-0.04	0.66	0.71	-0.05
K	0.07	0.65	-0.58	0.07	0.73	-0.66
	2.24	0.65	1.59	2.28	0.73	1.55
NO_3-N	0.35	0.06	0.29	0.36	0.06	0.30
	0.58	0.06	0.52	0.59	0.06	0.53
SO_4	5.65	6.19	-0.54	5.62	6.81	-1.19
	6.32	6.19	0.13	6.48	6.81	-0.33

1/ Incident precipitation
2/ Throughfall precipitation

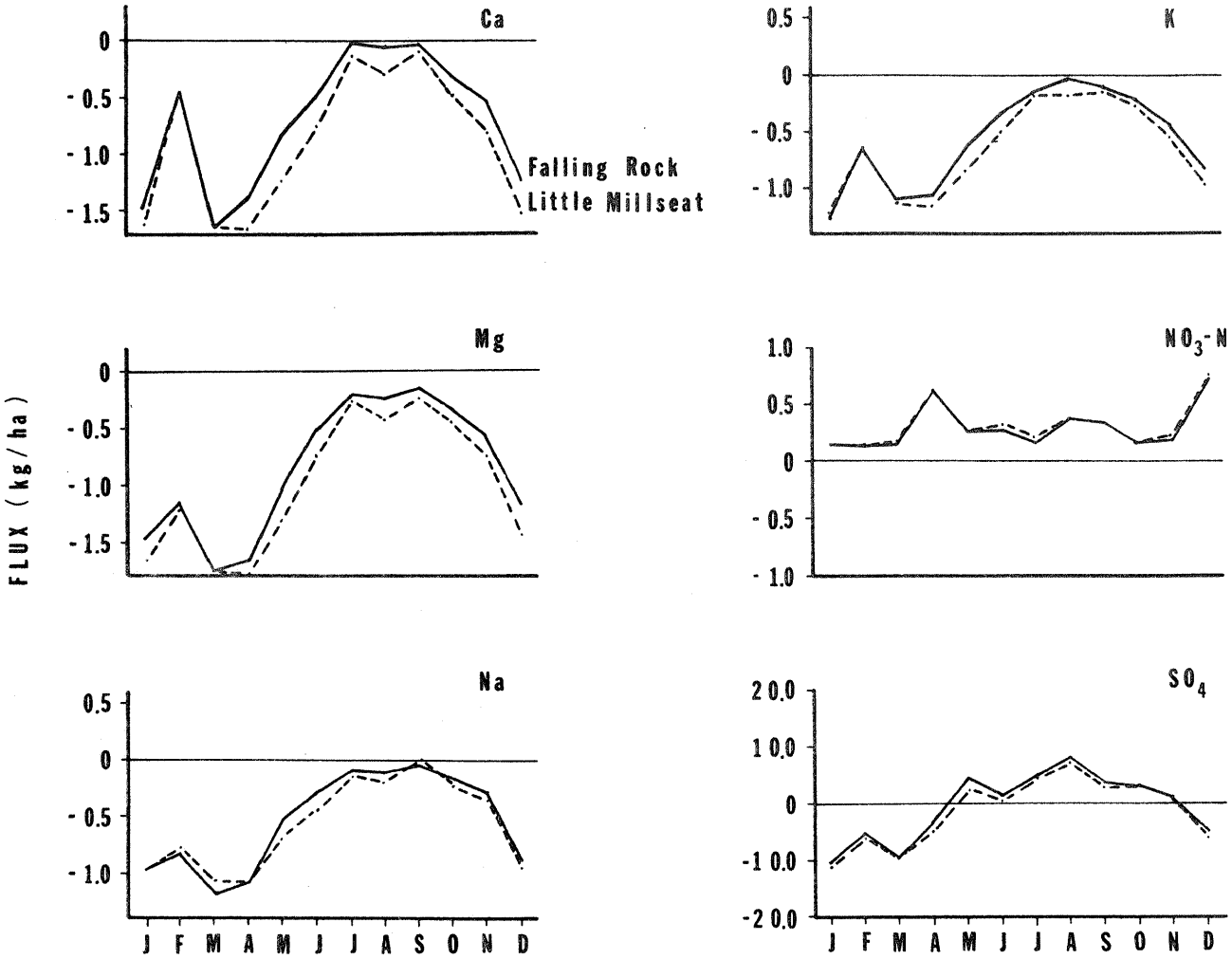

Figure 1.--Monthly mean nutrient fluxes for Falling Rock and Little Millseat Watersheds, based on input from incident precipitation.

throughfall fluxes. Most of the cation enrichment occurred during the growing season, as indicated earlier. Several sharp peaks were noted in the spring. Ca and K exhibited these peaks in May, while Mg produced a sub-peak at this time. NO_3-N displayed a most pronounced peak during April and a high secondary value for May. Na, however, did not display any degree of enrichment until later in the year, i.e., August -October. SO_4 did not exhibit any significant enrichment during the year, which may indicate that it is coming in primarily with precipitation rather than being washed from the leaves.

Mean annual input, output and flux values, based on incident and throughfall precipitation, for both watersheds are presented in table 4. As with the mean monthly flux values in table 3 the cations exhibited negative annual fluxes using values derived from incident precipitation. However, annual fluxes based on throughfall precipitation showed positive values for Ca and K. NO_3-N fluxes were positive for both precipitation inputs, while SO_4 was negative, except for a slightly positive value for throughfall on Falling Rock. Ca and K both showed significant enrichment values which accounts for their change from negative to positive flux values. SO_4 showed the smallest enrichment value of the cations and anions sampled but the largest total input values. These large SO_4 values may be partly due to the analytical technique[1/] used and partly due to the high SO_4 background levels in the local sedimentary rocks (possible dust effect). Data reported by personnel of the Northeastern Forest Experiment Station (Dyer 1982),

[1/]Manufacturer-supplied chemicals (powder pillows) varied from barium chloride to barium nitrate, resulting in some inconsistency in results.

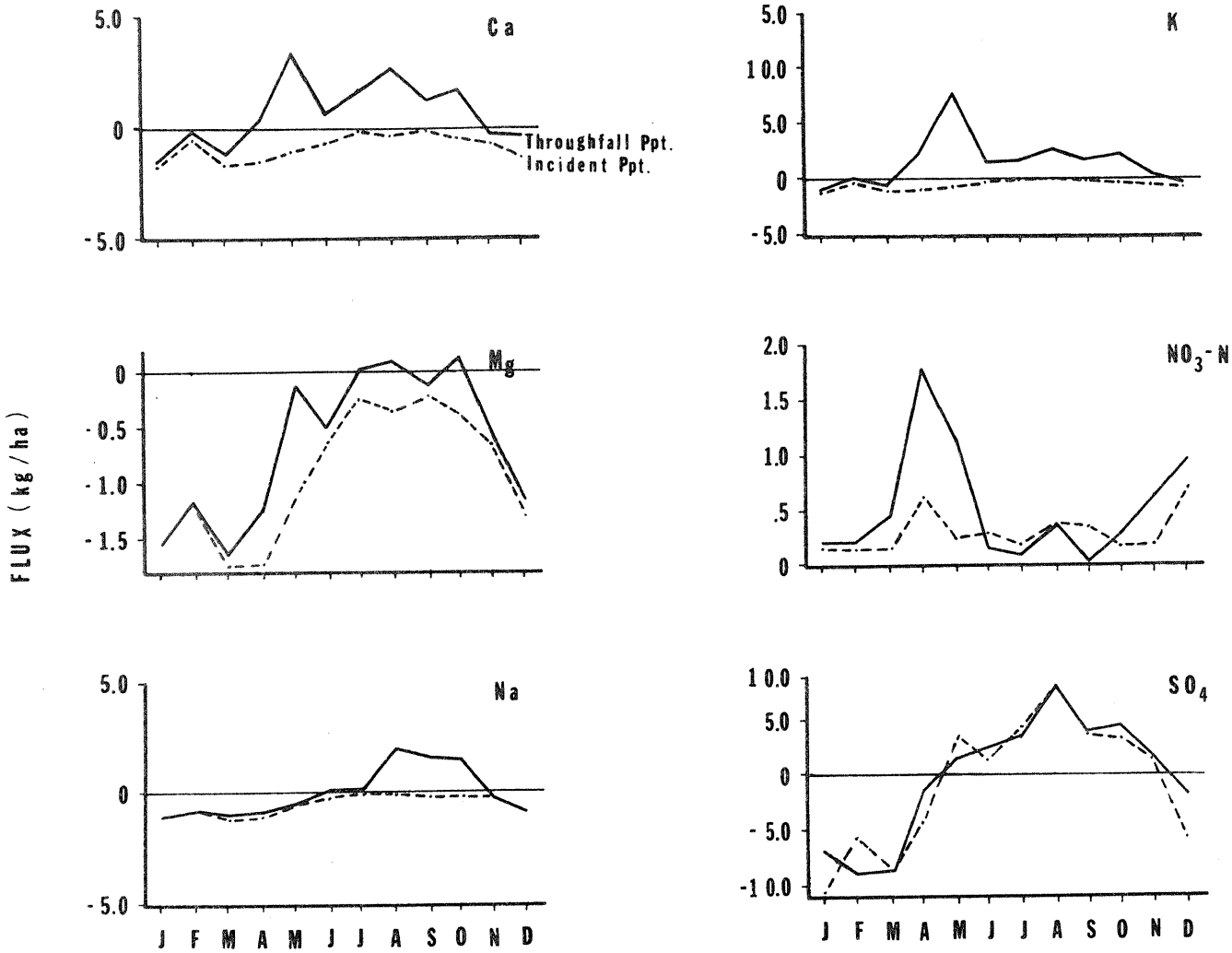

Figure 2.--Comparison of monthly mean nutrient fluxes based on incident and throughfall precipitation. Values for Falling Rock and Little Millseat were averaged together for this comparison.

obtained in the same general area, indicate similar high SO_4 levels in streamflow from unmined, forested areas. Although the levels of SO_4 are quite high in both precipitation and streamflow, the flux values are relatively low on a monthly, seasonal and yearly basis (tables 2, 3, and 4; figures 1 and 2).

Examination of data from several National Atmospheric Deposition Program (NADP) sites in central and eastern Kentucky supports the premise that local surface mines may be affecting atmospheric inputs to the study watersheds (table 5). NADP sites in Boyle, Letcher, and Rowan counties provided data for 1984, the only year for which records were available (National Atmospheric Deposition Program 1984). Boyle and Rowan counties have little or no surface mining, while Letcher County does. Most of the measured parameters are higher in incident precipitation in Letcher County than in the other two counties. Robinson Forest incident precipitation data are higher than Letcher county data by a factor of 2 - 3. The order of land surface disturbance for the areas used in this comparison are: area around Robinson Forest > Letcher County > Boyle County > Rowan County. This is the same order in which most of the incident precipitation parameters occur.

The results of this study were compared with those of similar studies in surrounding states and, as indicated in table 6, they did not differ greatly. There are however several notable exceptions. SO_4 inputs and outputs in our study were conspicuously higher than those from the other studies. Also, Ca and Mg values from Walker Branch, TN are much higher than those reported in our study. Several reasons for the higher SO_4 values reported in this study were suggested earlier. Henderson (1978) indicated that the elevated Ca and Mg values reported for Walker Branch were

Table 4.--Mean annual input, output and flux values for Falling Rock and Little Millseat watersheds, 1972-1984.

Nutrient	Falling Rock Input	Falling Rock Output	Falling Rock Flux	Little Millseat Input	Little Millseat Output	Little Millseat Flux
	kg/ha			kg/ha		
Ca	5.21 1/	13.14	-7.90	5.35	15.42	-9.90
	22.61 2/	13.14	9.47	23.07	15.42	7.65
Mg	0.75	11.00	-10.25	0.78	12.79	-12.01
	4.05	11.00	-6.95	3.99	12.79	-8.80
Na	2.04	8.17	-6.13	2.12	8.57	-6.45
	7.71	8.17	-0.46	7.93	8.57	-0.64
K	0.90	7.76	-6.86	0.92	8.70	-7.78
	26.86	7.76	19.10	27.33	8.70	18.63
NO_3-N	3.86	0.69	3.17	3.98	0.63	3.35
	6.95	0.69	6.26	7.10	0.63	6.47
SO_4	71.68	74.32	-2.64	73.82	81.71	-7.89
	74.77	74.32	-0.45	76.21	81.71	-5.50

1/ Incident precipitation
2/ Throughfall precipitation

attributable to the dolomitic bedrock underlying the area.

SUMMARY

Nutrient fluxes were determined for two undisturbed hardwood forested watersheds in eastern Kentucky, for the period 1972 - 1984. Concentrations of selected cations and anions were measured in precipitation and streamflow and monthly, seasonal and annual fluxes obtained. Both incident and throughfall precipitation quality were sampled. Substantial enrichment of the precipitation occurred as it passed through the forest canopy, with the exception of SO_4, which exhibited only slight enrichment. Although interception was not measured in this study, incoming precipitation values were adjusted for it, using published equations. The ranking of cations received in incident precipitation was Ca> K> Na> Mg; for throughfall it was K> Ca> Na> Mg. Anion input ranked SO_4> NO_3-N in both incident and throughfall precipitation. The cation output values (streamflow) were ranked Ca> Mg > Na> K, while the anions were ranked SO_4> NO_3-N. Most of the nutrient loadings reported in this study are comparable to those in studies reported in surrounding states. The one notable exception is SO_4. The magnitude of nutrient enrichment of precipitation passing through the forest canopy strongly suggests the influence of local surface mining activities on nutrient fluxes.

Table 5.--Comparison of incident precipitation parameters from NADP sites in Boyle, Letcher, and Rowan counties with those from Falling Rock and Little Millseat watersheds (1984).

Parameter	Measurement Site				
	Rowan	Boyle	Letcher	Falling Rock	Little Millseat
	kg/ha				
Ca	1.40	1.80	2.49	5.21	5.35
Mg	0.29	0.34	0.38	0.75	0.78
Na	0.88	1.03	0.91	2.04	2.12
K	0.25	0.33	0.37	0.90	0.92
NO_3-N	2.62	2.91	3.35	3.86	3.98
SO_4	18.66	22.15	24.35	71.68	73.82

Table 6.--Comparison of annual nutrient input and output values for Falling Rock and Little Millseat watersheds with results of studies in surrounding states.

Ca	Mg	Na	K	NO_3-N	SO_4	Study Location
---------- kg/ha ----------						
Input (incident precipitation):						
5.21	0.75	2.04	0.90	3.86	71.68	Falling Rock, KY
5.35	0.78	2.12	0.92	3.98	73.82	Little Millseat, KY
12.00	2.00	4.00	3.00	3.85	54.30	Walker Branch, TN1/
15.73	2.94	3.89	2.99	4.61	-	Walker Branch, TN2/
11.10	1.70	-	12.10	-	-	Pope County, IL3/
6.33	0.86	3.63	4.13	2.23	-	Ozarks, MO4/
4.20	0.80	6.30	4.70	-	-	Coweeta, NC5/
4.88	1.11	3.52	1.62	2.88	-	Coweeta, NC2/
4.80	1.00	4.00	2.00	2.45	-	Coweeta, NC1/
Output (streamflow):						
13.14	11.00	8.17	7.76	0.69	74.32	Falling Rock, KY
15.42	12.79	8.57	8.70	0.63	81.71	Little Millseat, KY
148.00	77.00	4.50	7.00	0.20	34.50	Walker Branch, TN1/
7.10	4.04	3.66	3.87	0.27	-	Ozarks, MO4/
5.70	2.50	7.80	4.20	-	-	Coweeta, NC5/
7.50	4.00	11.00	5.50	1.10	10.20	Coweeta, NC1/

1/Henderson, 1978
2/Swank and Henderson, 1976
3/Rolfe et al, 1978
4/Settergren et al, 1976
5/Best and Monk, 1975

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