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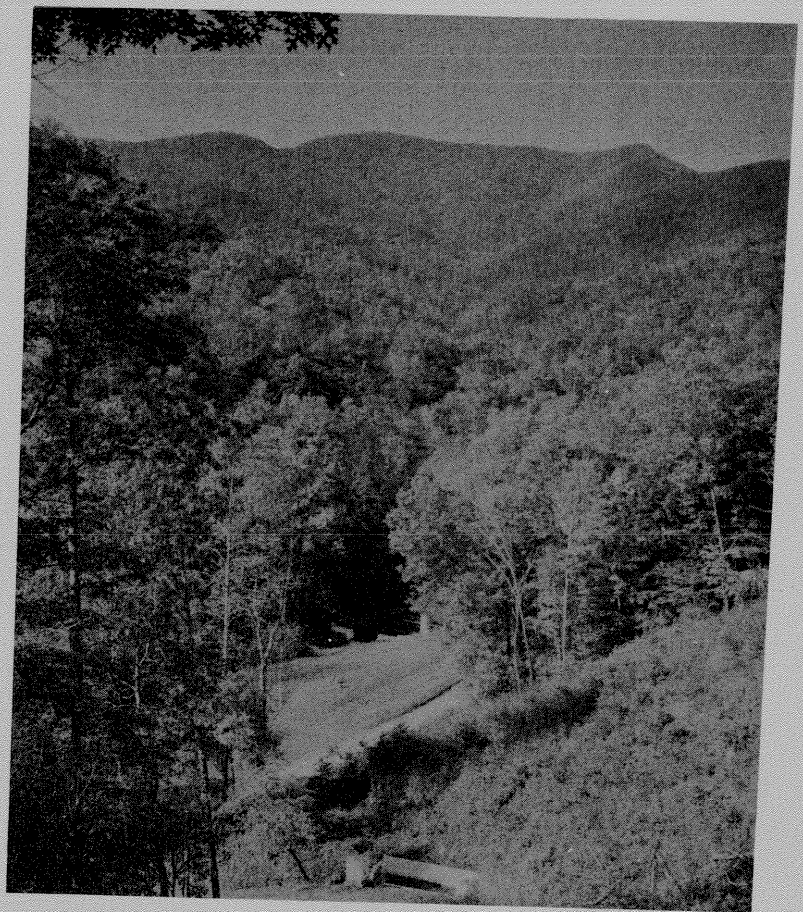
Annotated Bibliography of Publications on Watershed Management and Ecological Studies at Coweeta Hydrologic Laboratory, 1934,1984

Julia W. Gaskin, James E. Douglass,
and Wayne T. Swank , Compilers



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Southeastern Forest Experiment Station
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Annotated Bibliography of Publications on Watershed Management and Ecological Studies at Coweeta Hydrologic Laboratory, 1934-1984

Compiled and Annotated by

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Introduction

This bibliography is a modification and update of two previous compilations of research results at Coweeta. It was prepared at the request of scientists, educators, students, and land managers seeking information on published findings of the laboratory. The bibliography contains 470 citations, including a separate section on theses and dissertations. Papers were included if authored by Forest Service and other Federal scientists, university faculty and students or other individuals who conducted research in the Coweeta Basin, utilized Coweeta data in their analyses, or were partially supported either with funding or other assistance by the Southeastern Forest Experiment Station, which was originally called the Appalachian Forest Experiment Station. The bibliography spans 50 years of research at Coweeta from 1934 through part of 1984 and also includes earlier papers on forest influences written at the Appalachian Station before the establishment of Coweeta.

The citations are arranged alphabetically. We regret that reprints of publications cannot be furnished; many of them are still available from university libraries or from the senior author. Many types of papers are listed, including discussions of research problems and needs; reviews of research programs, objectives, and results; descriptions of instrumentation, analytical procedures, and experimental areas; reviews of research results from different geographical or technical fields; and presentations of original research results. Immediately following the bibliography is a subject index in which each citation is keyed by number to the subject category under which it falls. Some citations have been cross-referenced under several categories.

Because the emphasis in watershed management and forest ecology has shifted with the changing needs and problems of the times, a brief historical account of the program is included. Dr. Charles R. Hursh, who directed this research at the Station for many years, provided valuable information on the early history of forest hydrology in the Southeast, and his assistance is gratefully acknowledged.

The Research Program

Interest in forest influences on the environment in the Southeast began more than 80 years ago, when there was much verbal speculation about the effects of forests on climate and public health and on soil and streamflow. Editors and writers discussed these subjects with little or no consideration for accurate technical terminology. The U.S. Corps of Army Engineers, which had charge of flood control and levee operations, was critical of such writers, particularly when they made broad, unsupported statements about the effects of forests on streamflow. In a

widely read government publication issued in 1909, Major-General Chittenden of the Mississippi River Flood Control project forcefully stated that forests were of no significance in flood control. The framers of the Weeks Act of 1911, which led to the creation of the National Forests, did not concur in this view, and controversy reached a high pitch at the time of the disastrous 1927 flood on the Mississippi River. Almost everything written on the favorable effects of forests on streamflow was being questioned.

On July 1, 1921, the Appalachian Forest Experiment Station was established. When active research began in 1926, the program included silviculture, reforestation, and management of forests, as well as forest protection, forest economics, and streamflow and erosion control.

At that time, eastern forests were extensively grazed by livestock. Steep mountain land was cleared and planted with corn. Logging was done by subcontractors who had little regard for resulting damage to the forest or erosion from skid trails. Local farmers considered pine trees as weeds; depleted and abandoned fields in "broom sage" were called "pastures." Erosion on worn-out and abandoned land in the Southeast was regionwide. Such land was not wanted by private individuals and could be bought for delinquent taxes. Nevertheless, the rank and file of professional foresters at the time knew little about forest effects on climate and soil. They were ignorant of such streamflow variables as total water yield, maximum peak discharge, or minimum flow dependability.

Fortunately, E. N. Munns, of the Forest Service's Branch of Research, had observed and written about land erosion in California prior to his assignment to Washington. Supported by E. H. Clapp, then Chief of Forest Research, Mr. Munns became an effective advocate of better land use and of more in-depth research into forest influences on water yield. He believed that a start could be made through studies relating soil conditions to infiltration and surface stormflow. The Branch of Research requested a Civil Service examination for ecologists with Ph.D. degrees, and two applicants were selected. Dr. Hursh was employed by the Appalachian Station in 1926 and actively directed the Division of Forest Influences until his retirement in 1954.

The first goal of this research program was to define the characteristics of soil, water, and climate of forested land in the Southern Appalachians. At the time, there were no continuous data on streamflow from small drainages representing independent hydrologic units, and work was begun to obtain suitable data for hydrologic analysis.

Some of the earliest work dealt with erosion control and methods of soil stabilization along roadbanks and on abandoned agricultural land and with study of forest humus types of the region. At the

Bent Creek Experimental Forest, plots were established in 1932 to study surface runoff from five representative types of forested or agriculture cover, and an infiltrometer was first used successfully with artificial rainfall. These early studies led to an examination of water movement through the soil profile and to the need for complete watershed instrumentation to provide continuous measurements of streamflow and precipitation.

Dr. Hursh was detailed to visit existing Forest Service installations of lysimeters in operation in the Western States. On the basis of this experience, he sought suitable areas on which the Appalachian Station could conduct comprehensive studies on watershed management. Mr. John Byrne, Forest Supervisor of the Nantahala National Forest, suggested a number of possible sites, and the Coweeta drainage basin near Franklin, NC, was finally selected as the most suitable. In 1933, 3,900 acres (later increased to 5,750 acres) of the Nantahala National Forest were set aside as the Coweeta Experimental Forest. Station Director C. L. Forsling later issued instructions that no manipulations of the forest cover were to take place at Coweeta until after a period of standardization of the gauged watersheds. He assigned full responsibility for administration of the Coweeta basin to the Division of Forest Influences.

Thus, the stage was set for a greatly expanded program in watershed management research. Programs of the Civilian Conservation Corps (CCC) and the Public Works Administration during the depression years provided the manpower and funds for expansion of research activities. At Coweeta, a CCC camp was established at the entrance of the basin, and an intensive program of weir construction was started in 1934. A network of 56 standard rain gauges and numerous ground-water wells were established in the basin, and a period of watershed calibration began.

Although no staff appointments were made from the Civil Service register during the years when watershed work at Coweeta Experimental Forest was being established, any properly qualified person could be paid from emergency funds for a 3-month temporary period, and the assignment could be repeated indefinitely. Thus, it was possible to employ a number of graduates in engineering with training in hydrology. Some men with good research ability worked with the project under these terms for several years, and many of these men later rose to positions of importance in their profession.

By 1940, calibration of watersheds at Coweeta was far enough along on some catchments to begin treatments, and a period of experimentation began. Since 1940, a variety of watershed experiments have been conducted at Coweeta. The harmful effects on soil and water resources of mountain farming, woodland grazing, and unrestricted logging were documented in early studies. These early land use demonstrations were publicized in the highly

successful film "Waters of Coweeta." Water yield experiments designed to measure effects on streamflow of complete or partial forest cuttings and conversion from one type of cover to another have provided conclusive evidence that water yield is influenced by the type and characteristics of the vegetative cover. The knowledge gained in these early experiments was the basis for a pilot test of intensive multiresource management of Southern Appalachian forests and has provided guidelines for watershed management on public and private land alike. More recent experiments utilizing cable logging methods and advanced forest road designs have demonstrated improved methods for managing steep mountain lands to minimize damage to soil and water.

Coweeta research in the late 1950's explored the effects of soil-plant-atmosphere interactions on hydrological processes. By 1970, substantial progress had been made in water yield investigations and emphasis shifted from water quantity to water quality, including research on nonpoint-source pollution and the use of herbicides in management. At the same time, a major cooperative program of research on biogeochemical cycling in forest ecosystems was initiated with the Institute of Ecology at the University of Georgia. Funded by the National Science Foundation (NSF), this cooperative project become part of the Eastern Deciduous Forest Biome of the International Biological Program. Studies have focused on the responses of forested watersheds to various kinds of disturbances. Process-level studies of nutrient cycling on Coweeta's undisturbed watersheds provide the control for evaluating ecosystem responses to disturbances. A background of 16 years of ecosystem research supported by 50 years of hydrologic research at Coweeta enables an interdisciplinary team of Federal-university scientists to participate in the NSF-sponsored Long-Term Ecological Research program and the Man and Biosphere program of UNESCO.

1. **Abbott, D. T.; Crossley, D. A., Jr.** Woody litter decomposition following clear-cutting. Ecology 63: 35-42; 1982.

   Unconfined *Quercus prinus* woody litter of three size classes (0-1, 1-3, and 3-5 cm diameter) was placed on forest floors of a control hardwood watershed and on mesic and xeric sites of a clear-cut watershed at Coweeta. Exponential decay coefficients for mass loss on the control were .1524, .1728, and .0912 yr^{-1} for 0-1, 1-3, and 3-5 cm branches, respectively. Coefficients for 0-1, 1-3, and 3-5 cm branches were .1752, .0756, and .1644 yr^{-1} on the mesic site and .0456, .0948, and .0377 yr^{-1} on the xeric site. The effect of site differences on decomposition rate was greater than the effect of diameter, although an inverse relationship between diameter and decay coefficient is suggested. Time in the field, temperature, moisture, and microarthropod abundance also appeared to influence decomposition rate.

2. **Abbott, David T.; Seastedt, T. R.; Crossley, D. A., Jr.** The abundance, distribution and effects of clear-cutting on Cryptostigmata in the southern Appalachians. Environmental Entomology 9: 618-623; 1980.

   Oribatid mites were sampled from deep soil, soil cores, litter bags, and woody litter on a clearcut and adjacent control hardwood watershed at Coweeta. The inclusion of woody litter and deep soil samples caused the total number of genera found to reach 72, as opposed to the 37-42 genera range reported in other studies. The more common genera were assigned to three habitat types based on stratification data. The fauna was similar to those of other holarctic study sites. Sampling a greater variety of habitat types yielded a richer fauna than intensive sampling of a few habitat types. Clearcutting caused a reduction in numbers and a shift in faunal dominance. This effect is attributed to temperature-humidity phenomena rather than to food availability.

3. **Barr, Thomas C., Jr.** The North American *Pterostichus* of the subgenus *Cylindrocharis* Casey (Coleoptera, Carabidae). New York: American Museum of Natural History; 1971; Novitates 2445. 14 p.

   Cylindrocharis Casey, a subgenus of *Pterostichus* Bonelli, includes three species: *P. (C.) rostratus* (Newman), ranging from southeastern Canada to the southern Appalachian Mountains of Tennessee and North Carolina; *P. (C.) acutipes,* new species, from central Kentucky and Tennessee to the mountains of Tennessee, North Carolina, and northeast Georgia; and *P. hypogeus*, new species, from the Nantahala and Snowbird Mountains, North Carolina. The central Kentucky populations of *acutipes* are described as a distinct subspecies, *P. (C.) a. kentuckensis*.

4. **Barry, P. J.; McDowell, W. E.** Evaluation of southern pine beetle on the Wayah Ranger District, Nantahala National Forest, North Carolina. Rep. 71-1-2. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry, Division of Forest Pest Control; 1970. 4 p.

   An aerial photographic and ground survey of southern pine beetle, *Dendroctonus frontalis* Zimm. infestations was performed in August 1970 within the purchase boundary of the Wayah Ranger District of the Nantahala National Forest. Survey results revealed a continuing low beetle population over the 390,000-acre area. Even though a small nucleus of live beetles was found, it is unlikely that the southern pine beetle population will become a problem in this area during the remaining months of 1970.

5. **Benke, Arthur C.; Wallace, J. Bruce.** Trophic basis of production among net-spinning caddisflies in a southern Appalachian stream. Ecology 61: 108-118; 1980.

   Life histories and annual production were determined for six species of net-spinning caddisflies in a headwater stream of the Tallulah River in north Georgia. Five species in the family Hydropsychidae were univoltine, whereas the sixth, a member of the Philopotamidae, had at least two generations per year. Seventy-five percent of the annual production was concentrated in the two largest species, *Arctopsyche irrorata* and *Parapsyche cardis*.

   Analysis of gut contents indicated that detritus was the most important food source. However, almost 80 percent of all caddisfly production was attributed to animal food. Net-spinning caddisfly production in this mountain stream appears to be limited by the amount of high-quality food available in the seston.

6. **Best, G. Ronnie; Monk, C. D.** Cation flux in a hardwood forest and on eastern white pine watershed. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems; Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 847-861.

   The nutrient content of precipitation input, throughfall, litter flow through, soil percolation, and stream discharge was measured in a hardwood and in a white pine watershed.

Amounts of water passing through various levels of the forest ecosystems changed markedly from input to output, and leaching of cations from vegetation exhibited pronounced seasonal changes. Leaching of potassium, calcium, and magnesium was least during dormant winter months but increased with commencement of spring growth. Most potassium was leached from the leaves before leaf fall, but most calcium and magnesium losses occurred after leaf fall. A reduction of sodium in throughfall during the summer months was evident in white pines. Once the water became streamflow discharge, the cation load was similar to its original input level, giving evidence of the ability of the ecosystem to minimize external loss while maintaining a large internal flux.

7. **Biswell, H. H.; Hoover, M. D.** Appalachian hardwood trees browsed by cattle. Journal of Forestry 43: 675-676; 1945.

Cattle are selective in the tree species they browse. Percentage breakdowns by species are given for the foliage eaten by cattle on a 145-acre Appalachian watershed during 1941 and 1942. Herb utilization approached 100 percent after 1 year of grazing, and the grazing capacity of the watershed was reduced by 50 percent during 1 year of browsing.

8. **Black, P. E.; Clark, P. M.** Timber, water, and Stamp Creek. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1958. 12 p.

This illustrative brochure outlines the proper logging techniques used in a timber sale on the Chattahoochee National Forest, Stamp Creek, Ga. A satisfactory profit was realized by the logger without serious erosion or damage to the streams and fish.

9. **Black, Peter E.** Interception of rainfall by a hardwood canopy. University of Istanbul, Orman Fakültesi; Dergisi 9(2): 218-224; 1959.

Results of studying rainfall intercepted by cove hardwoods growing on an old field are discussed, and equations for determining throughfall during fall, winter, spring, and summer are presented. Estimates of the number of throughfall gages required for interception studies in similar stands are given.

10. **Boring, Lindsay R.; Monk, Carl D.; Swank, Wayne T.** Early regeneration of a clear-cut Southern Appalachian forest. Ecology 62: 1244-1253; 1981.

The components of hardwood forest regeneration on a southern Appalachian watershed were assessed during the first year following clear-cutting. First-year net primary production (NPP) on the clear-cut was 1955 kg/ha, representing 22 percent of the NPP of a nearby undisturbed hardwood forest. First-year nutrient pools in NPP for N, P, K, Mg, and Ca were estimated at 29 to 44 percent of those in the NPP of the control. The greatest NPP and nutrient pools were represented in descending order by hardwood sprouts, herbs, vines, and seedlings. The woody successional species had higher tissue concentrations of N and P than most other woody species. Herbs as a group had significantly higher foliar concentrations of K than woody species. Woody successional and herbaceous species collectively had higher biomass and elemental pools than other woody species. Following forest disturbance, these fast-growing species conserve substantial pools of nutrients in their biomass and initiate a rapid recovery of forest elemental cycling processes.

11. **Boyer, J. S.; Knipling, E. B.** Isopiestic technique for measuring leaf water potentials with a thermocouple psychrometer. Proceedings of the National Academy of Science 54(4): 1044-1051; 1965.

This new technique for determining rate of vapor flux between thermocouple and leaf is free of error caused by leaf resistance. The method can be used to measure leaf resistance directly and gives more accurate measurements of water potential than do other methods.

12. **Brater, E. F.** The unit hydrograph principle applied to small watersheds. Proceedings of the American Society of Civil Engineers 65: 1191-1215; 1939.

Tests of the applicability of the unit hydrograph principle on 22 small watersheds ranging from 4 to 1,877 acres lead the author to conclude that this method is one of the best practical devices for predicting flood flows.

13. **Brockman, Ellis R.; Todd, Robert L.** Fruiting myxobacters as viewed with a scanning electron microscope. International Journal of Systematic Bacteriology 24: 118-124; 1974.

Unfixed fruiting bodies of myxobacters have been viewed in great detail with a scanning electron microscope. Specimens of species of the genera *Myxococcus, Chondrococcus, Archangium, Stelangium, Melittangium, Cystobacter, Polyangium, Stigmatella,* and *Chondromyes* were examined. The desirability

of using the scanning electron microscope for the study of the gross morphology of myxobacter structures has been clearly demonstrated.

14. Burgess, Robert L.; Swank, Wayne T. Analysis of ecosystems in the Eastern Deciduous Forest Biome - U.S. International Biological Program. In: Proceedings of the Seventh World Forestry Congress; 1972 October 3-14; Buenos Aries, Argentina. Buenos Aries, Argentina: Librart, Department of Argentine Scientific Publications; 1972: 4920-4924.

The organization and research structures of the Eastern Deciduous Forest Biome are outlined with emphasis on the major research sites.

15. Cataneo, Robert. A method for estimating rainfall rate-radar reflectivity relationships. Journal of Applied Meteorology 8(5): 815-819; 1969.

Raindrop-size distributions obtained with the drop camera have been used to determine rainfall rate-radar reflectivity relationships for nine different locations throughout the world. Since the climates sampled were quite varied, an extrapolation of these Z-R relationships to other areas of the world with similar "drop-spectra climates" can be performed. Two climatic parameters, the mean annual percent of rain days that are thunderstorm days, and the mean annual relative humidity at 0.5 km above ground, were found to be highly correlated with the coefficient A and exponent b in the Z-R equation, $Z = AR^b$. Regression equations based on the two climatic parameters were determined, permitting an estimation of the Z-R relationship for any area once the parameters are obtained.

16. Cataneo, Robert; Stout, Glenn. Raindrop-size distributions in humid continental climates, and associated rainfall rate-radar reflectivity relationships. Journal of Applied Meteorology 7(5): 901-907; 1968.

Raindrop-size spectra obtained with the raindrop camera have been analyzed from two locations, Island Beach, N.J., and Franklin, N.C. The spectra were analyzed with respect to total number of drops per average rain rate per cubic meter of sample, geometic mean diameter, mode diameter, and the diameter of drops at which half the liquid water content lies above that diameter and half below. The results indicate that the distributions from both locations are quite similar. Rainfall rate-radar reflectivity relationships indicate that cold frontal rains, upslope rains, and tropical storm rains generally have smaller drops.

17. **Cataneo, Robert; Vercellino, David L.** Estimating rainfall rate-radar reflectivity relationships for individual storms. Journal of Applied Meteorology 2(1): 211-213; 1972.

In order to improve the accuracy with which radar estimates rainfall rates and amounts, a method has been developed whereby the rainfall rate-radar reflectivity relationships may be estimated for approaching precipitation. The estimating equation is based on atmospheric parameters which may be obtained in advance of precipitation, from standard radiosonde data. Comparisons are made between the present model and other methods concerning their effectiveness in determining appropriate rainfall rate-radar reflectivity relationships.

18. **Cornaby, B. W.; Gist, C. S.; Crossley, D. A., Jr.** Resource partitioning in leaf-litter faunas from hardwood and hardwood-converted-to-pine forests. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems; Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 588-597.

The structure and function of litter faunas were measured from the forest floors of two forest watersheds; mature hardwood (reference) and adjacent white pine, once hardwood (experimental) forests. The biomass of some 18 combined taxa of litter animals was about one-third lower, numerical abundances were about one-half lower, and standing crops of calcium and potassium were also lower in the pine plantation than in the hardwood system. These data were synthesized as models of the cryptozoans' food webs. In the hardwood watershed, 11 percent of the calcium and 3 percent of the potassium from annual leaf-litter input were processed by the litter animals. By contrast, 2 percent of the calcium and 28 percent of the potassium from annual litter input entered the food webs of the litter fauna in the white pine watershed.

19. **Cornaby, Barney, W.; Waide, Jack B.** Nitrogen fixation in decaying chestnut logs. Plant and Soil 39: 445-448; 1973.

Nitrogen fixation is shown to occur in decaying logs of American chestnut, *Castanea dentata* (Marsh.) Borkh., by acetylene reduction techniques, and its significance is considered in relation to log decomposition in forest ecosystems.

20. **Coulson, R. N.; Franklin, R. T.; Crossley, D. A., Jr.** A self-maintaining window trap for collecting flying insects. Entomological News 81: 164; 1970.

    An automatic drain system and the use of a preservative that is lighter than water are discussed as modifications of window flight traps.

21. **Coulson, Robert N.; Crossley, D. A., Jr.; Gist, Clayton, S.** Patterns of Coleoptera species diversity in contrasting white pine and coppice canopy communities. American Midland Naturalist 86: 145-151; 1971.

    The pattern of Coleoptera species diversity in coppice hardwoods and white pine canopy communities was investigated. The information-theory index H(s) and the index D were used to measure diversity. The distribution of individuals within species was measured by using redundancy and evenness indices.

    Diversity in the coppice was greater than in the white pine. The coppice canopy community followed a seasonal trend in diversity, evenness, and redundancy. Diversity in the white pine community did not follow an apparent seasonal trend. Considerably fewer species and individuals occurred in the white pine, which tended to magnify the importance of the appearance and disappearance of dominant species and thereby to obliterate any seasonal trend in diversity, redundancy, and evenness.

22. **Craddock, G. W.; Hursh, C. R.** Watersheds and how to care for them. In: Trees, Yearbook of Agriculture. Washington, D.C.: U.S. Department of Agriculture; 1949: 603-609.

    Hydrologic principles related to forest-land use as well as forest protection and management practices which influence the amount, quality, and timing of flow from forest land are discussed.

23. **Croft, A. R.; Hoover, M. D.** The relation of forests to our water supply. Journal of Forestry 49: 245-249; 1951.

    The authors use research findings to show how forest management practices affect the quality, quantity, and timing of water yield and discuss practical implications of forest management on the solution of water problems.

24. **Cromack, K., Jr.; Sollins, P.; Todd, R. L.; Crossley, D. A., Jr.; Fender, W. M.; Fogel, R.; Todd, A. W.** Soil microorganism - arthropod interactions: fungi as major calcium and sodium sources. In: Mattson, W. J., ed. The role of arthropods in forest ecosystems: New York; Heidelberg; Berlin: Springer-Verlag; 1977: 78-84.

The objective of this paper is to present evidence that terrestrial fungi may be important sources of Ca and Na for saprophagous arthropods and other soil animals. Calcium, but not Na, has been reported as essential for many fungi; both elements are essential for animals.

25. **Cromack, K., Jr.; Sollins, P.; Todd, R. L.; Fogel, R.; Todd, A. W.; Fender, W. M.; Crossley, M. E.; Crossley, D. A., Jr.** The role of oxalic acid and bicarbonate in calcium cycling by fungi and bacteria: some possible implications for soil animals. In: Lohm, U.; Persson, T., eds. Soil organisms as components of ecosystems; Proceedings of the sixth international soil zoology colloquium; 1976 June 21-25; Uppsala, Sweden. Ecological Bulletin 25. Uppsala, Sweden: Swedish Soil Science Society; 1977: 246-252.

Fungi can accumulate Ca in excess of their apparent physiological needs by release of oxalic acid to form the sparingly soluble Ca oxalate. Fungal release of oxalic acid may also form stable complexes with other metallic cations, which would influence both soil weathering processes and release of P from Fe and Al hydroxyphosphates. Bacteria and *Streptomyces* sp. can decompose Ca oxalate, which recycles the cation and permits formation of calcium bicarbonates or carbonates. Oxalate decomposing bacteria and actinomycetes were isolated from the digestive systems of oribatid mites, earthworms, a springtail and two immature aquatic detritivores, a mayfly and a stonefly. A proposed Ca cycle, operative by fungi, bacteria, and soil animals in the context of the soil ecosystem, is presented.

26. **Cromack, Kermit; Monk, Carl D.** Litter production, decomposition, and nutrient cycling in a mixed hardwood watershed and a white pine plantation. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems; Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 609-624.

Litter production and decomposition data were obtained for a mixed-hardwood watershed and for a white pine watershed.

Litterfall data were obtained for leaves, stems, flowers, acorns, and miscellaneous debris in the hardwood watershed and for needles, stems, and cones in the white pine watershed. Litterfall data obtained included biomass of litter; nitrogen, phosphorus, potassium, calcium, and magnesium contents in litter; and structural organic constituents of leaf litter. Litter decomposition data were obtained for weight loss rate and for loss rates of nutrients. Litter decomposition rates of chestnut oak, white oak, white pine, red maple, and dogwood were significantly correlated with senescent leaf carbon-to-nitrogen ratio and sclerophyll index; the sclerophyll index giving a better statistical estimate of decomposition rate.

27. **Cromack, Kermit; Todd, Robert L.; Monk, Carl D.** Patterns of basidiomycete nutrient accumulation in conifer and deciduous forest litter. Soil Biology and Biochemistry 7: 265-268; 1975.

Nutrient data were obtained for basidiomycete sporocarps, rhizomorphs and forest floor leaf litter samples collected from a white pine (*Pinus strobus* L.) watershed and from a mixed hardwood watershed at Coweeta Hydrologic Laboratory, North Carolina. Basidiocarps taken from the surface litter of both watersheds were fleshy representatives of Agaricacae, Cantharellaceae or Clavariaceae. Forest floor basidiocarp samples (cap + stalk) from both watersheds had significantly greater concentrations of Cu, K, Na, P and Zn than the leaf litter from which they were removed. Bulked rhizomorph samples from both watersheds contained significantly more Ca, K, Na and Sr than forest floor leaf litter. Polyporaceae growing on hardwood branches concentrated Al, Mo, P and Zn.

28. **Cromack, Kermit, Jr.; Sollins, Phillip; Graustein, William C.; Speidel, Karen; Todd, Allen W.; Spycher, Gody; Li, Ching Y.; Todd, Robert L.** Calcium oxalate accumulation and soil weathering in mats of hypogeous fungus *Hysterangium crassum*. Soil Biology and Biochemistry 11: 463-468; 1979.

Fungal mats of *Hysterangium crassum* Fischer occupied a mean of 9.6 percent of the upper 10 cm of soil developed under a 40- to 65-year-old stand of Douglas-fir in Oregon. This hypogeous basidiomycete exudes large amounts of oxalic acid, some of which precipitates with Ca in microscopic crystals of calcium oxalate. Soil oxalate concentration was significantly greater within fungal mats, and soil pH was significantly lower than in soil adjacent to mats. The quantity of Ca present as CaC_2O_4 is 0.5 the amount of exchangeable Ca in the soil and exceeds the mass of Ca lost annually in runoff.

29. **Crossley, D. A., Jr.** The role of terrestrial saprophagous arthropods in forest soils: current status of concepts. In: Mattson, W. J., ed. The role of arthropods in forest ecosystems. New York; Heidelberg; Berlin: Springer-Verlag; 1977: 49-56.

Soil arthropods are envisioned as accelerating (or delaying) nutrient release from decomposing organic matter. They may do this directly: by feeding upon organic matter and associated microflora; or indirectly: by channeling and mixing of the soil, improving substrate quality for microflora, inoculation of organic debris with microbes, selective grazing upon microflora, and preventing senescence of microfloral populations. It will be noted that these effects are largely anecdotal because most are difficult to quantify in a satisfactory or meaningful way.

30. **Crossley, D. A., Jr.; Callahan, J. T.; Gist, S. C.; Maudsley, J. R.; Waide, J. B.** Compartmentalization of arthropod communities in forest canopies at Coweeta. Journal of the Georgia Entomological Society 11: 44-49; 1976.

A compartment model is described for arraying arthropod biomasses of forest canopies into functional groups. Model inputs and outputs represent linkages to other processes within the watershed ecosystem. The compartment model is evaluated for its ability to contain standing crop and biomass information, using data obtained from sampling hardwood forest canopies in watersheds at Coweeta Hydrologic Laboratory.

31. **Crossley, D. A., Jr.; Coulson, Robert N.; Gist, Clayton S.** Trophic level effects on species diversity in arthropod communities of forest canopies. Environmental Entomology 2: 1097-1100; 1973.

Species diversity for arthropod communities inhabiting white pine and coppice canopies was measured using the Shannon Wiener information theory index, H(s), the Margalef index, D, and the Pielou evenness index, J'. The two insect orders Coleoptera and Hymenoptera were investigated. The general index H(s) was significantly higher for the more diverse coppice stand than for the white pine monoculture, and was significantly higher for Hymenoptera than for Coleoptera. The other two indices demonstrated that differences in diversity between watersheds were due to greater species richness in the coppice, while differences between insect orders were due to greater evenness of individuals in the Hymenoptera. Since the Coleoptera were principally herbivores and

the Hymenoptera predator-parasites, results can be interpreted in a trophic level context. It is suggested that, in a plant monoculture, low diversity is not propagated along food chains but rather is recovered at higher trophic levels.

32. **Crossley, D. A., Jr.; Gist, Clayton, S.** Use of radioisotopes in modeling soil microcommunities. In: Dindal, Daniel L., ed. Proceedings of the first soil microcommunities conference; 1971 October 18-20; Syracuse, NY. Springfield, VA: National Technical Information Service; 1973: 258-278.

Radioisotopes can be a powerful tool for increasing knowledge of soil communities since their use lends itself to mathematical modeling. This article discusses several radioisotope methods, their applications to studies of soil animals, and their use in constructing a variety of models.

33. **Crossley, D. A., Jr.; Swank, Wayne T.** Publications of the Coweeta forest ecosystem project. Athens, GA: University of Georgia; 1983. 23 p.

This listing includes research publications of the Coweeta Forest Ecosystem Project, a cooperative venture between scientists at Coweeta Hydrologic Laboratory, North Carolina, operated by the U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, and scientists at the University of Georgia's Institute of Ecology. The bibliography includes only open literature publications.

34. **Cushing, C. E.; McIntire, C. D.; Sedell, J. R.; Cummins, K. W.; Marshall, G. W.; Peterson, R. C.; Vannote, R. L.** Comparative study of physical-chemical variables of streams using multivariate analysis. Archiv fuer Hydrobiologie 89: 343-352; 1980.

As a step toward the development of a system to categorize streams, 15 physical-chemical variables from 34 stream stations in North America and Europe were subjected to cluster and discriminant analyses to determine if discrete "groupings" were present, and, if so, which variables were most closely related to the among group variability.

The log-transformed data provided five meaningful clusters of stream sites, but it was not possible to construct a simple and universally useful classification of running waters which includes physical, chemical, and biological aspects. Inclusion of biological variables is necessary to further assess the usefulness of the approach described here; work on this is in progress.

35. **Day, Frank P., Jr.; McGinty, Douglas T.** Mineral cycling strategies of two deciduous and two evergreen tree species on a southern Appalachian watershed. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems; Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 736-743.

In this study conducted at Coweeta, four tree species were compared in relation to biomass, production, and nutrient standing crops. The four species included a deciduous canopy tree (*Quercus prinus*), a deciduous subcanopy tree (*Cornus florida*), an evergreen canopy tree (*Tsuga canadensis*), and an evergreen subcanopy tree (*Rhododendron maximum*). The mineral-cycling strategies of these individual species were found to mesh together to form a network of cycles of varying lengths.

36. **Day, Frank P.; Monk, Carl D.** Net primary production and phenology on a Southern Appalachian watershed. American Journal of Botany 64: 1117-1125; 1977.

The major objective of the study was to measure above-ground net primary production (NPP) seasonally and relate it to phenological activity on a hardwood forest watershed at Coweeta Hydrologic Laboratory, North Carolina. NPP was estimated as the increase in biomass, estimated from regression equations on diameter. Diameter increases were measured by vernier tree bands. Phenological observations were made on bud break, leaf emergence, flowering, mature fruit, leaf senescence, and leaf fall. The species studied intensively were *Acer rubrum, Quercus prinus, Carya glabra, Cornus florida*, and *Liriodendron tulipifera*.

37. **Day, Frank P.; Monk, Carl D.** Seasonal nutrient dynamics in the vegetation on a Southern Appalachian watershed. American Journal of Botany 64: 1126-1139; 1977.

Nutrient dynamics in vegetation play an important role in determining the circulation and storage of nutrients in an ecosystem. The major objectives of this study were to estimate the plant nutrient pools on a hardwood forest watershed at Coweeta, on a seasonal basis and to relate any observed trends to seasonal productivity and phenology. Major conclusions of the study were (1) individual species and different plant components have nutrient storage-pool turnover times ranging from one year to several hundred years. Canopy species are important in long- and short-term nutrient cycles.

(2) Even though most of the annual nutrient uptake is recycled the same season, the total accumulation of nutrients is considerable in a mature forest stand.

38. **Day, Frank P., Jr.; Monk, Carl D.** Vegetation patterns on a southern Appalachian watershed. Ecology 55: 1064-1074; 1974.

The vegetation on a relatively undisturbed hardwood forest watershed at Coweeta was sampled, and estimates of density, basal area, and above-ground biomass were computed. These vegetational parameters and five topographic variables were used to analyze site-species relationships on the watershed. The primary analytical techniques used were correlation analysis and principal components ordination. Major changes in the vegetation since the introduction of chestnut blight were also examined.

Significant correlations were found between 13 major species and one or more of the topographic variables. Distance from the stream, distance from the water divide and elevation, were the important topographic factors determining species distribution at Coweeta.

39. **Deshefy, G. Scott.** Predator escape behavior by fall canker-worm larvae, *Alsophila pometaria* (Lepidoptera: Geometridae). Entomological News 90: 145-146; 1979.

Silk emission and dropping behavior in larvae of the fall cankerworm, *Alsophila pometaria*, enable the species to escape predation and ultimately reestablish contact with its tree host.

40. **Dils, R. E.** A guide to the Coweeta Hydrologic Laboratory. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1957. 40 p.

This report replaces the 1948 guidebook and summarizes the contributions of many researchers who have worked at Coweeta. The area and its water resources are described, and research methods and results are outlined.

41. **Dils, R. E.** Influence of forest cutting and mountain farming on some vegetation, surface soil and surface runoff characteristics. Stn. Pap. 24. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, 1953. 55 p.

Infiltration rates, organic matter content, density, and porosity of soils were all adversely affected by conversion

of a forested watershed at Coweeta to a mountain farm. Storm runoff volumes, peak discharge rates, flood peak frequencies, and overland flow were all increased. Mountain farming shortly proved to be uneconomical.

42. **Dissmeyer, George E.; Corbett, E. S.; Swank, W. T.** Summary of municipal watershed management surveys in the Eastern United States. In: Proceedings, municipal watershed management symposium; 1973. Gen. Tech. Rep. NE-13. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1975: 185-192.

    Results of an inventory of land uses, nature and extent of land management problems, and types of information needed for municipal watersheds are presented.

43. **Dissmeyer, George E.; Swank, Wayne T.** Municipal watershed management survey. Journal of American Water Works Association 68(2): 97-100; 1976.

    Based on survey data, this report provides a general summary of the nature and extent of land uses, management problems, and informational needs for municipal watersheds in the southeastern United States. Emphasis is placed on small and heavily forested watersheds and related forestry activities.

44. **Douglass, J. E.** Book Review - Small watershed experiments: an appraisal of concepts and research developments. Proceedings, Soil Science Society of America 37(4). [no page number]; 1973.

    Reviews the above-titled book by L. C. Ward.

45. **Douglass, J. E.** Environmental impacts of weed control alternatives on water. In: Holt, H. A.; Fisher, B. C., eds. Weed control in forest management: proceedings of the 1981 John S. Wright forestry conference; 1981 February 3-5; West Lafayette, IN. West Lafayette, IN: Purdue University; 1981: 220-230.

    All weed control methods increase water yield and rate of runoff from watersheds, but their effects on water quality can be grossly different. Properly applied, fire, chemical, and manual methods have least effect on water quality. Conversely, even the best of the mechanical methods increases erosion and thereby reduces water quality. Careful planning and quality workmanship are crucial when mechanical methods are used.

46. .**Douglass, J. E.; Cochrane, D. R.; Bailey, G. W.; Teasley, J. I,; Hill, D. W.** Low herbicide concentration found in streamflow after a grass cover is killed. Res. Note SE-108. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1969. 3 p.

Grass cover on an Appalachian watershed was sprayed with atrazine and paraquat and later with atrazine and 2,4-D. Although grass growing in the stream channel was sprayed, atrazine and paraquat levels in water samples were low. During a second application, a 10-foot strip on either side of the channel was left unsprayed; no increase in atrazine and no trace of 2,4-D were detected in streamflow.

47. **Douglass, J. E.; Goodwin, O. C.** Runoff and soil erosion from forest site preparation practices. In: U.S. forestry and water quality: what course in the 80's?: an analysis of environmental and economic issues: proceedings, 1980 June 19-20; Richmond, VA. Washington, DC: Water Pollution Control Federation; 1980: 50-74.

Soil losses and runoff were measured for 3 years after mechanical site preparation treatments were applied on 16 small watersheds in the North Carolina Piedmont. Treatments, which were replicated at four locations, ranged in intensity from a control (undisturbed forest) to KG blading, disking, and planting grass. Runoff increased with intensity of treatment and length of the ephemeral drainage network. Soil loss varied with percent ground cover and runoff volume. Erosion varied from 1.0 to 14,000 pounds per acre, depending on cover and the ephemeral channel network.

48. **Douglass, J. E.; Swift, L. W., Jr.** Forest Service studies of soil and nutrient losses caused by roads, logging, mechanical site preparation, and prescribed burning in the Southeast. In: Correll, David L., ed. Watershed research in eastern North America: a workshop to compare results; 1977 February 28 - March 3; Edgewater, MD. Edgewater, MD: Smithsonian Institution; 1977: 489-502.

New studies of soil and nutrient pollution of streams caused by woods roads, log skidding, mechanical site preparation, and prescribed burning are described for the Piedmont and Appalachian Mountains. Proportional samples for sediment and nutrient analysis are collected by 2-foot Coshocton wheels. Objectives of nonpoint-source pollution studies are to establish baseline levels of soil and nutrient loss, determine increases in losses due to certain forestry practices, and develop methods of estimating losses for other practices and other locations.

49. **Douglass, James E.** Annotated bibliography of publications on watershed management by the Southeastern Forest Experiment Station, 1928-1970. Res. Pap. SE-93. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1972. 47 p.

This bibliography contains annotated citations to all publications by the Southeastern Forest Experiment Station on watershed management from 1928 to 1970. Citations are indexed by subject category.

50. **Douglass, James E.** Effects of species and arrangement of forests on evapotranspiration. In: International symposium of forest hydrology; 1965 August 29 - September 10; University Park, PA. Oxford; New York: Pergamon Press; 1966: 451-461.

This paper reviews research concerned with the effects of plant species and arrangement on evapotranspiration. In general, grasses use less water than forest species because of the shallower rooting habits of grass; usually, differences in evapotranspiration which occur between forest species could not be detected except where rooting depths were unequal. Evapotranspiration varies with stand density and vegetative height, at least in humid regions, and evapotranspiration probably varies with slope and aspect as well.

51. **Douglass, James E.** Flood frequencies and bridge and culvert sizes for forested mountains of North Carolina. Gen. Tech. Rep. SE-4. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1974. 21 p.

Equations incorporating watershed area and maximum elevation were developed for discharges at recurrence intervals of 2.33, 5, 10, 20, 30, 40, and 50 years from forested land in the Blue Ridge Province of North Carolina. These equations accounted for 98 percent of the variation in discharge. Capacity tables for several types and sizes of culverts are presented to simplify problems in culvert design.

52. **Douglass, James E.** Man, water, and the forest. Forest Farmer 26(5): 6-7, 18, 20; 1967.

The interrelationships between man's activities, water, and the forest are discussed.

53. **Douglass, James E.** A method for determining the slope of neutron moisture meter calibration curves. Stn. Pap. 154.

Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1962. 6 p.

A new water-addition method is presented which allows a check of slope coefficients derived from gravimetric calibrations of neutron moisture probes. Coefficients obtained by the new method differed from those obtained by gravimetric calibration by as much as 36 percent. Differences were attributed to bias arising because drying temperatures used in gravimetric calibration failed to remove all bound water and because the gravimetric method failed to account for differences in neutron absorption between soils.

54. **Douglass, James E.** The potential for water yield augmentation from forest management in the Eastern United States. Water Resource Bulletin 19(3): 351-358; 1983.

High rainfall and extensive forests in the East combine to produce excellent potential for managing forest for increased water yield. Models are presented that allow prediction of streamflow increase from hardwood and pine forests and are being routinely applied in land management planning on National Forests in the Southeast. However, because of the diverse land ownership patterns and the economic objectives of owners, realizing the potential will be difficult at best. The opportunity for realizing the full potential appears greatest where the land is publicly owned.

55. **Douglass, James E.** Research at the Coweeta Hydrologic Laboratory. In: Conference proceedings - hydrologic activities in the South Carolina region; 1965 March 17-18; Clemson, SC. Clemson, SC: Clemson University; 1966: 11-17.

The first 30 years of research at the Coweeta Hydrologic Laboratory and plans for future research are discussed.

56. **Douglass, James E.** Silviculture for water yield. In: Town meeting forestry - issues for the 1980's; 1979 October 15-19; Boston, MA. Washington, DC: Society of American Foresters; 1979: 90-96.

A popular misconception exists that forests cannot be managed for improved water yield. To demonstrate the magnitude of the impact of forest management, the DYNAST-TM model is used to calculate expected changes in water yield from a 6,400-acre southern Appalachian watershed managed for different rotation lengths and size of forest openings.

57. **Douglass, James E.** Site preparation alternatives: quantifying their effects on soil and water resources. In: Proceedings, site preparation workshop, East; 1977 November 8-9; Raleigh, NC. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area State and Private Forestry; 1977: 43-45.

Reviews research underway to assess soil erosion from forest roads and soil and nutrient losses from mechanical site preparation and prescribed burning in the Piedmont.

58. **Douglass, James E.** Southeastern forests and the problem of non-point sources of water pollution. In: Ashton, P. M.; Underwood, R. C., eds. Nonpoint sources of water pollution: proceedings of the southeastern regional conference; 1975 May 1-2; Blacksburg, VA. Blacksburg, VA: Virginia Polytechnic Institute and State University; 1975: 29-44.

Amendments to the Federal Water Pollution Control Act require that non-point source pollution from forestry activities be controlled. Erosion is the most serious pollutant originating from forestry activities. Activities which destroy the forest floor and reduce the infiltration rate of soil cause accelerated erosion. Elevation of water temperature, changing the chemical composition of water and introduction of pesticides and herbicides into streams are other common forms of pollution. Pollution can be minimized by utilizing existing information. Quantification of pollution levels associated with alternative forestry practices and development of new techniques for minimizing non-point source pollution is needed.

59. **Douglass, James E.** State of the art in managing water resources on forest land. In: Proceedings, western North Carolina research-resource management conference; 1977 September 14-16; Asheville, NC. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1977: 56-60.

This paper deals specifically with the yield, timing, and quality of water flowing from forested watersheds of the southern Appalachians and how these parameters are changed by management activities.

60. **Douglass, James E.** A summary of some results from the Coweeta Hydrologic Laboratory. In: Hamilton, Lawrence S.; King, Peter N., eds. Tropical forested watersheds: hydrologic and soil response to major uses or conversions. Boulder, CO: Westview Press; Appendix B: 137-141; 1983.

The appendix in this book contains a summary of the effects of tree cutting and timber harvest at the Coweeta Hydrologic Laboratory on timing and distribution on water yield.

61. **Douglass, James E.** Variance of nuclear moisture measurements. Stn. Pap. 143. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1962. 11 p.

Several conclusions can be drawn concerning the use of nuclear equipment to measure moisture in Piedmont soils: (1) The error in measuring moisture content is particularly large in soils with varying texture. (2) Analysis of moisture losses, which utilizes covariance techniques to remove the textural effect, is more precise for detecting moisture differences than for determining total moisture content. (3) The error in moisture measurements increases as the range of clay content increases.

62. **Douglass, James E.** Volumetric calibration of neutron moisture probes. Proceedings, Soil Society of America 30(5): 541-544; 1966.

A volumetric method of estimating the slope (b coefficient) of the calibration curve for a neutron moisture probe is presented. Coefficients obtained for three probes did not differ significantly between soil series or between horizons within a series. Simply dividing the count rate in water by 100 gave a value virtually identical to the b coefficient determined volumetrically for these probes and soils. Agreement was excellent between measured outflow and outflow predicted from neutron measurements made with a volumetrically calibrated probe.

63. **Douglass, James E.** Watershed values important in land use planning on southern forests. Journal of Forestry 72: 617-621; 1974.

Forests cover 20 to 65 percent of the land in the major water resource regions of the South, and forest management practices regulate the volume and timing of streamflow from these lands. Although water quality is emerging as the major water problem, quantity and timing of streamflow are also important watershed values which should be considered in land use planning. Protection or improvement of hydrologic performance of forest soils will continue to be an important consideration in planning.

64. **Douglass, James E.** Watershed values important in planning. In: Optimizing the South's forest resources: proceedings of the Second Regional Technical Conference; 1974 March 11-15; Houston, TX. Washington, DC: Society of American Foresters; 1975: 59-73.

Forests cover 20 to 65 percent of the land in the major water resource regions of the South, and forest management practices control or regulate the volume and timing of streamflow from these lands. Although water quality is emerging as the major water problem, quantity and timing of streamflow are also important watershed values which should be considered in land use planning. Protection or improvement of hydrologic performance of forest soils will continue to be an important consideration in planning.

65. **Douglass, James E.; Fletcher, P. W.** Effect of removal of stream-bank vegetation upon water yield. Transactions, American Geophysical Union 28: 105-110; 1947.

This is a preliminary report on the results of removing stream-bank vegetation from Watershed 6 at the Coweeta Hydrologic Laboratory. Diurnal fluctuations in the streamflow were virtually eliminated. Cutting of riparian growth also resulted in an increase in yield of sufficient magnitude to be significant in water resource management.

66. **Douglass, James E.; Neary, Daniel G.** Coweeta Hydrologic Laboratory, 1934-2034: past, present, and future. In: The influence of man on the hydrological regime with special reference to representative and experimental basins: proceedings, Helsinki symposium; 1980 June; Helsinki. Publication 130. Washington, DC: International Association of Scientific Hydrology; 1980: 61-65.

Since 1934, the Coweeta Hydrologic Laboratory has served as a primary site for forest hydrological research in the USA. This paper describes the early and current research programs and discusses future research. Water quality and forest productivity are two areas of future concern because of increasing intensity of management and because of shorter rotations and greater utilization of biomass. The growing trend toward short-term studies relating alternative management practices to water quality will continue. Process-level ecosystem research will use the long-term data base of the Coweeta basin to study mineral cycling and evaluate the effects of alternative levels of biomass utilization on forest productivity.

67. Douglass, James E.; Seehorn, Monte E. Forest management impacts on cold water fisheries. In: Symposium on trout habitat research and management: proceedings; 1974 September 5-6, Cullowhee, NC. Boone, NC: Appalachian Consortium Press; 1975: 33-46.

Erosion is the mechanism likely to damage the aquatic resource when a forest is managed. Cutting forests increases streamflow when it is needed most, but conversion from hardwood to pine significantly reduces the size of the aquatic habitat. Herbicides and pesticides are constant threats, but this pollution can usually be prevented. More research is needed to assess the effects on the aquatic community of logging debris, channel clearing, increasing stream temperature from logging along the stream, and changing the nutrient budget of streams by fertilization or silvicultural practices.

68. Douglass, James E.; Swank, Wayne T. Effects of management practices on water quality and quantity: Coweeta Hydrologic Laboratory, North Carolina. In: Proceedings of the municipal watershed management symposium; 1973 September 11-12; University Park, PA; September 19-20; Durham, NH. Gen. Tech. Rep. NE-13. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Experiment Station; 1975: 1-13.

Results from nearly 40 years of watershed experiments at Coweeta are summarized. An equation is presented to predict the annual increase in streamflow from the percent basal area cut and from the theoretical extra-terrestrial radiation load for the watershed. Timing of the increased flow from watershed experiments depends on the magnitude of the increase, but results consistently show that much of the increase appears in the low-flow season. Two watershed experiments indicate that conversion of hardwoods to white pine substantially reduces monthly and annual streamflow. Conversion of a hardwood-covered watershed to grass produces up to 5.8 inches of increased flow per year. Although some increase in nutrient export occurs from forest cuttings and species conversions, the increase is well within drinking-water standards.

69. Douglass, James E.; Swank, Wayne T. Multiple use in southern Appalachian hardwoods - a ten-year case history. In: Proceedings of the sixteenth International Union of Forestry Research Organizations world congress; 1976 June 20 - July 2; Oslo, Norway. Vienna, Austria: IUFRO Secretariat; 1976: 425-436.

The multiple use concept of managing hardwood forests in the southern Appalachians for timber, water, wildlife, and recreation was pilot-tested on a 144-ha watershed in western North Carolina. Water, timber, and wildlife objectives of management were achieved, and responses of these resources during the first 10 years of management are discussed. Log dams designed to create riffles and pools caused the greatest conflict with other objectives by increasing turbidity of water, causing excessive channel and bank cutting, and probably adversely affecting trout, at least temporarily.

70. **Douglass, James E.; Swank, Wayne T.** Streamflow modification through management of eastern forests. Res. Pap. SE-94. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1972. 15 p.

Equations for predicting the first-year yield increase, duration of the increase, and the total volume of water which occurs from cutting forests are presented. The equations are based on 22 experimental cuttings of hardwood forests in the Appalachian Highlands. The paper also discusses the effects of forest cutting on the seasonal distribution of increased annual flow, stormflow peaks and volumes, and water-quality characteristics.

71. **Douglass, James E.; Van Lear, David H.** Prescribed burning and water quality at ephemeral streams in the Piedmont of South Carolina. Forest Science 29(1): 181-189; 1983.

Soil and nutrient export were monitored before and after two prescribed burns 18 months apart on four pairs of treatment and control watersheds. Burns were designed to prepare Piedmont pine stands for regeneration. The burns did not significantly affect storm runoff, sediment concentrations, or sediment export from the watersheds. No significant change in NO_3-N, NH_4-N, Ca, Mg, or K concentrations or export occurred after either burn. Sodium concentration before burning was significantly different for the burned-unburned watershed pairs but not significant after either prescribed burn. This difference was attributed to factors other than burning. It was concluded that the two prescribed burns did not change water quality of the streams studied.

72. **Douglass, James E.; Van Lear, David H.; Valverde, Carmen.** Stormflow changes after prescribed burning and clearcutting pine stands in South Carolina Piedmont. In: Jones, Earle P., Jr., ed. Proceedings of the second biennial southern silvicultural research conference; 1982 November 2-4; Atlanta, GA. Gen Tech. Rep. SE-24. Asheville, NC: U.S. Department of

Agriculture, Forest Service, Southeastern Forest Experiment Station; 1983: 454-460.

Four small pine-covered watersheds in the South Carolina Piedmont were prescribe-burned in September 1979 and clear-cut 3 months later. Peak discharge and stormflow increased significantly on three of the watersheds. Relative increases were greater than those reported for larger watersheds, but were smaller than those to be expected from mechanical site preparation. Time to peaking and duration of stormflow were not significantly affected.

73. **Drooz, A. T.; Fedde, G. F.; Copony, J. A.** Egg parasite of the elm spanworm is not *Telenomus alsophilae*. Environmental Entomology 5(3): 492-494; 1976.

When *Telenomus alsophilae* Viereck was reported as attacking eggs of the fall cankerworm, *Alsophila pometaria* (Harris), and the elm spanworm, *Ennomos subsignarius* (Hübner), differences in parasite ovipositional behavior on the eggs of the two hosts were observed. These observations, field and laboratory tests, and re-examination of specimens submitted for specific determination indicate that *T. alsophilae* attacks eggs of the fall cankerworm and *T.* n. sp. parasitizes eggs of the elm spanworm.

74. **Edwards, C. A.; Reichle, D. E.; Crossley, D. A., Jr.** The role of soil invertebrates in turnover of organic matter and nutrients. In: Reichle, D. E., ed. Analysis of temperate forest ecosystems. Berlin; Heidelberg; New York: Springer-Verlag; 1970; 147-172.

This chapter discusses the role of soil invertebrates in the breakdown of litter, woody materials, and roots. Various methods of studying litter are presented. Energy flow and nutrient cycles through soil populations and net production by animals of different trophic levels are also examined.

75. **Edwards, Lorraine.** The greening of a clearcut. Research Reporter 12(3): 6-8; 1979.

An article discussing research on clearcut regrowth, focusing on nutrient conservation and distribution.

76. **Evans, James O.; Patric, James H.** Harvest trees, reap water. Journal of Soil and Water Conservation 38: 390-392; 1983.

The relationship of timber harvesting to water yield is discussed by the authors. They trace the development of

current knowledge that clearcutting increases water yield from the earlier idea that an intact forest maximizes water yield. Experimental results from eastern and western watersheds are presented, along with implications for timber management as a tool for manipulating water yield.

77. **Farmers Federation News.** The Coweeta story. Farmers Federation News 31(12): 9, 44-45, 48; 1951.

Reasons for establishment of the Coweeta Hydrologic Laboratory are given, the research area is described, and studies concerning the effects of mountain farming, woodland grazing, and cutting of vegetation on streamflow are discussed.

78. **Fitzgerald, J. W.; Ash, J. T.; Strickland, T. C.; Swank, W. T.** Formation of organic sulfur in forest soils: a biologically mediated process. Canadian Journal of Forest Research 13: 1077-1082; 1983.

The ability of forest soils to incorporate sulfur from added inorganic sulfate into salt-extractable and non salt-extractable forms was investigated. At least 65 percent of the added sulfate was adsorbed while 8 to 27 percent of the sulfate added was recovered only after treatment of salt-extracted samples with acid and base. The incorporation of sulfur into this latter fraction was incubation time, temperature and depth dependent, and exhibited both spatial as well as seasonal variation in samples taken along a transect of one of the watersheds. Sulfur incorporation was inhibited by sodium azide, erythromycin and candicidin, suggesting that the incorporation of sulfur into the non salt-extractable fraction is mediated by bacteria and fungi.

79. **Fitzgerald, J. W.; Johnson, D. W.** Transformations of sulphate in forested and agricultural lands. In: More, A. I., ed. Proceedings of the conference: sulphur '82 international conference; 1982 November 14-17; London. London: British Sulphur Corp. Ltd.; vol. 1: 414-426; 1982.

The physiochemical and biological fates of exogenous inorganic sulphate in agricultural and forest soils were considered. Emphasis was given to the capacities of these soils to adsorb sulphate and to convert the sulphur of the remaining non-adsorbed anion into soil organic sulphur. While agricultural and forest systems can differ substantially in capacity for sulphate adsorption, both systems can incorporate sulphate as ester sulphate into organic matter. Ester-linked sulphur may also represent the form of soil organic sulphur which is reconverted to inorganic sulphate

in response to plant growth. Existing evidence suggests that the formation of soil organic sulphur is regulated by energy availability, whereas the reconversion process may be dictated by levels of available inorganic sulphate.

80. Fitzgerald, J. W.; Strickland, T. C.; Swank, W. T. Metabolic fate of inorganic sulfate in soil samples from undisturbed and managed forest ecosystems. Soil Biology and Biochemistry 14: 529-536; 1982.

Surface soils from four watersheds located at the Coweeta Hydrologic Laboratory were found to rapidly convert exogenous $^{35}SO_4^{2-}$ into nonextractable ester sulphate and carbon bonded-sulphur. A substantial proportion of the added $^{35}SO_4^{2-}$ remained adsorbed in all samples but was completely released after sequential leaching with 1M Na_2SO_4, NaH_2PO_4 and LiCl. This extraction procedure also released a number of ^{35}S-labeled metabolites and some of these have been identified on the basis of co-electrophoresis and co-chromatography with authentic standards. Recoveries of ^{35}S suggest that all samples were capable of volatilizing some of the added SO_4^{2-} but only after prolonged incubation. The results support the possibility that S accumulation in these watersheds is related to SO_4^{2-} adsorption. However, the results also indicate that incorporation of S into non-extractable organic forms is a possibility which must be addressed in future attempts to fully explain this phenomenon.

81. Flavell, T. H.; Lambert, H. L. The fall cankerworm: an evaluation of an epidemic population adjacent to the Coweeta Hydrologic Laboratory, North Carolina. Rep. 70-1-45. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry, Division of Forest Pest Control; 1970. 7 p.

The fall cankerworm is epidemic over an 800-acre area on the Standing Indian Wildlife Refuge near Franklin, N.C. The infestation has now spread slightly onto the research watersheds of the Coweeta Hydrologic Laboratory. Defoliation is expected to be moderate to heavy in the infested area, but the area of defoliation on the research watershed is not expected to exceed the Laboratory's tolerance level. Direct control measures are not deemed necessary at this time.

82. Forest Farmer. We learn about little waters of Coweeta. Forest Farmer 16(2): 20-21; 1956.

Experiments at Coweeta are pictorially described.

83. **Fox, T. R.; Burger, J. A.; Kreh, R. E.; Douglass, J. E.** An overview of watershed and nutrient cycling research at the Reynolds Homestead Research Center. In: Jones, Earle P., Jr., ed. Proceedings of the second biennial southern silvicultural research conference; 1982 November 2-4; Atlanta, GA. Gen. Tech. Rep. SE-24. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1983: 468-476.

Preliminary results of a study of changes brought about by clearcut harvesting and site preparation in the Virginia Piedmont are described. Three watersheds were commercially clearcut during 1981 and a fourth remained undisturbed as a control. Site treatments were: chop and burn; sheardisk (1 pass); and shear, rake-pile, disk (3-pass), representing three levels of site preparation intensity.

84. **Gentry, John B.; Odum, Eugene P.; Mason, Marc; Nabholz, Vince; Marshall, Samuel; McGinnis, John T.** Effect of altitude and forest manipulation on relative abundance of small mammals. Journal of Mammalogy 49(3): 539-541; 1968.

Twenty-seven trapping lines were run over a 2,500-foot altitude gradient on disturbed and undisturbed watersheds at Coweeta to test the hypothesis that the frequency of small mammals increases with increasing altitude. The results confirmed the hypothesis. There were no significant differences between disturbed and undisturbed watersheds, but differences in the varieties of species were noted.

85. **Georgian, Theodore J.; Wallace, J. Bruce.** A model of seston capture by net-spinning caddisflies. Oikos 36: 147-157; 1981.

Six species of net-spinning caddisflies (Trichoptera) coexist in the headwater region of the Tallulah River, feeding on suspended organic matter (seston) captured by their nets. Data on net mesh sizes, microhabitat preferences, etc., were incorporated into a model of seston capture. Results indicate that these coexisting caddisflies do not reduce competition by partitioning available food by particle size. The model predicts annual seston capture far exceeding (1000 X) annual production by the six species. It is suggested that availability of high-quality food items (primarily drifting animals) is limiting to these filter-feeders, rather than overall seston supply.

86. **Gist, C. S.; Crossley, D. A., Jr.** Feeding rates of some cryptozoa as determined by isotopic half-life studies. Environmental Entomology 4: 625-631; 1975.

Rates of ingestion were measured for nine groups of invertebrate cryptozoans, utilizing radioactive tracer turnover rate measurements. These groups were Diplopoda, Cryptostigmata, Pulmonata, Mesostigmata, Collembola, Orthoptera, Coleoptera, and two groups of Araneida. The radioisotopes ^{134}Cs and ^{85}Sr were considered as the metabolic analogs of potassium and calcium, respectively. Feeding rates were calculated as the ingestion necessary to maintain body pools of these elements. Values obtained were somewhat lower than results reported by others, possibly due to inflated estimates of assimilation for the radioisotopes.

87. **Gist, C. S.; Crossley, D. A., Jr.** A model of mineral-element cycling for an invertebrate food web in a southeastern hardwood forest litter community. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems: Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 84-106.

A 10-compartment model of the movement of calcium and potassium through a selected cryptozoan food web was constructed. The fluxes of potassium and calcium between the compartments were estimated using radioactive tracers. Results indicated that the models based on the summer states of the systems overemphasized the contribution of mesofauna to litter decomposition. On the basis of the annual nutrient models, Cryptostigmata and Collembola were the most important saprovores and small Araneida and Mesostigmata were the most important predators. The biomass model based on calcium fluxes showed that saprovores accounted for 20 percent of the total annual input; this agrees with the literature.

88. **Gist, Clayton S.; Crossley, D. A., Jr.** The litter arthropod community in a Southern Appalachian hardwood forest: numbers, biomass and mineral element content. American Midland Naturalist 93: 107-122; 1975.

The biomass, numbers of individuals and mineral content of the arthropod fauna in the litter of a mixed hardwood forest were examined. The biomass values of the litter arthropods were generally higher than in other forests. Possible reasons for higher biomass values are discussed. Potassium and calcium standing crops are compared to those of a *Liriodendron* forest in Tennessee. With few exceptions the potassium values are comparable. However, there appear to be great differences in the calcium values.

89. **Gist, Clayton S.; Swank, Wayne T.** An optical planimeter for leaf area determination. American Midland Naturalist 92: 213-217; 1974.

An optical planimeter for determining leaf area is presented. The system proposed is simple and easily used, compact and somewhat portable, accurate and species-independent with respect to estimates of leaf area. Calibration and tests have shown the system exhibits a linear response to changes in leaf area.

90. **Golladay, S. W.; Webster, J. R.; Benfield, E. F.** Factors affecting food utilization by a leaf shredding aquatic insect: leaf species and conditioning time. Holarctic Ecology 6: 157-162; 1983.

Gravimetric feeding studies were used to examine the feeding strategy of *Pteronarcys proteus* (Plecoptera) using unconditioned, 1-month conditioned, and 2-month conditioned deciduous leaves of four species. Assimilation efficiencies of *Pteronarcys* nymphs feeding on unconditioned and conditioned leaf material ranged from 13.4 to 21.9 percent AFDW of leaf material, indicating that *Pteronarcys* was able to digest and assimilate leaf material. Assimilation efficiences did not change as leaf material conditioned, which suggests that assimilation efficiency does not accurately reflect changes in detrital food quality. However, as leaves conditioned, the ingestion rate of *Pteronarcys* nymphs accelerated. Assimilation rates of *Pteronarcys* nymphs varied in a pattern similar to ingestion rates. This reflects the importance of ingestion rate in the feeding response of *Pteronarcys*.

91. **Greene, G. E.** Land use and trout streams. Journal of Soil and Water Conservation 5: 125-126; 1950.

Maximum stream temperatures rose appreciably when a forested watershed at Coweeta was converted to a mountain farm. Because absence of shade can increase stream temperatures, riparian vegetation should be carefully manipulated to maintain optimum temperatures for growth and development of trout and aquatic organisms.

92. **Grzenda, A. R.; Nicholson, H. P.; Teasley, J. I.; Patric, J. H.** DDT residues in mountain stream water as influenced by treatment practices. Journal of Economic Entomology 57: 615-618; 1964.

DDT residues in Coweeta streams after spraying for elm spanworm by airplane in 1961 and by helicopter in 1962 are compared. DDT contamination of Coweeta Creek was negligible after precise application by helicopter in upslope and ridge areas.

93. **Gurtz, Martin E.; Webster, Jackson R.; Wallace, J. Bruce.** Seston dynamics in southern Appalachian streams: effects of clear-cutting. Canadian Journal of Fisheries and Aquatic Sciences 37: 624-631; 1980.

Suspended particulate matter was studied from July 1977 to July 1978 in two second-order streams in the southern Appalachian Mountains. In the first stream, which drains an undisturbed hardwood forest watershed, seston concentrations fluctuated with season and with storm flows. Most organic and inorganic particles were smaller than 105 µm diameter. The second stream drains a watershed that was clear-cut in early 1977. Increased levels of both organic and inorganic seston were found in the latter stream, especially beginning 1 year after clear-cutting. Particles larger than 234 µm in diameter accounted for most of the increases in inorganic seston. We hypothesize that eventual recovery of the stream will be limited by the rate of recovery of the surrounding terrestrial ecosystem.

94. **Haefner, John D.; Wallace, J. Bruce.** Production and potential seston utilization by *Parapsyche cardis* and *Diplectrona modesta* (Trichoptera. Hydropsychidae) in two streams draining contrasting southern Appalachian watersheds. Environmental Entomology 10: 433-441; 1981.

Production of *Parapsyche cardis* Ross and *Diplectrona modesta* Banks was estimated in two first-order southern Appalachian streams. One stream drains a natural undisturbed hardwood watershed and the other a watershed subjected to several disturbances. Since 1968 the latter has been allowed to undergo natural succession. Both hydropsychid species were univoltine in each stream. Production estimates were higher for both species in the stream draining the disturbed watershed, attributable to: (1) more suitable habitat, (2) higher densities of prey species, and (3) potentially enhanced food quality resulting from a 200-fold greater NO_3-N concentration. Estimates of animal tissue consumption are several times higher than the invertebrate drift from each watershed, suggesting that the major impact of these net spinners is on the animal fraction of the seston.

95. **Haefner, John D.; Wallace, J. Bruce.** Shifts in aquatic insect populations in a first-order southern Appalachian stream following a decade of old field succession. Canadian Journal of Fisheries and Aquatic Science 38: 353-359; 1981.

Aquatic insect populations were sampled on two first-order southern Appalachian streams. Grady Branch, the control stream, drains an undisturbed hardwood watershed. Sawmill Branch has undergone natural succession since 1968, from artificially maintained grassland to hardwood coppice dominated by black locust. Aquatic insect densities on Sawmill Branch were about twice those on Grady Branch, a reversal of results obtained by a similar study in 1968. It is suggested that changes in watershed vegetation influence long-term changes in aquatic insect populations, including a shift toward an allochthonous energy base.

96. **Haines, B. L.; Best, G. R.** *Glomus mosseae*, endomycorrhizal with *Liquidambar styraciflua* L. seedlings retard NO_3 and NH_4 nitrogen loss from a temperate forest soil. Plant and Soil 45: 257-261; 1976.

The influence of a mycorrhizal fungus on downward movement of NH_4, NO_2, and NO_3 nitrogen in forest soil was determined by establishing combinations of soil, fungus and seedlings in plastic pipes and monitoring the nitrogen content of water percolating to two depths. Compared with controls of soil alone and of soil + seedling alone, treatments containing the mycorrhizae showed a significant reduction of NH_4-N loss from 5- and 25-cm depths and significant reduction of NO_3-N loss from the 5-cm depth. No significant effect was observed on nitrite loss.

97. **Haines, B. L.; Waide, J. B.; Todd, R. L.** Soil solution nutrient concentrations sampled with tension and zero-tension lysimeters: report of discrepancies. Soil Science Society of America Journal 46: 658-661; 1982.

Four lysimeters were installed at each of 16 randomly designated locations. At each location, first at the litter-soil interface and again 30 cm beneath the litter-soil interface, one tension and one zero-tension lysimeter were installed side by side. Samples for 13 time intervals over a 15-month period were analyzed for water volume, H^+, NH_4^+, K^+, Na^+, Ca^{2-}, Mg^{2+}, NO_3^-, Cl^-, SO_4^{2-}, H_2PO_4, and dissolved silica. Estimates of soil solution composition and water flow differed according to lysimeter type and sampling depth. A testable hypothesis is advanced to account for these observed discrepancies.

98. **Haines, Bruce.** Forest ecosystems SO_4-S input-output discrepancies and acid rain: Are they related? Oikos 41: 139-143; 1983.

The SO_4-S inputs exceed SO_4-S outputs in rain forests at San Carlos de Rio Negro, Amazonas, Venezuela and at La Selva, Costa Rica. Hypothesis to explain excess of inputs over outputs include (1) accumulation of S in biomass, (2) accumulation of S in soil, (3) conversion of SO_4-S to organic S compounds which leave the system in drainage water, (4) conversion of SO_4-S to volatile S compounds which leave as gases, and (5) estimation errors. Acid rain occurs at both sites. If the S were volatilized out of the forests, oxidized in the atmosphere to SO_4, (4 above) then washed out of the atmosphere by rain, the resulting quantity of H_2SO_4 would be sufficient to account for the rainfall acidity observed in the field in Costa Rica.

99. **Haines, Bruce; Best, George Ronnie.** The influence of an endomycorrhizal symbiosis on nitrogen movement through soil columns under regimes of artificial throughfall and acid rain. In: Dochinger, L. S.; Seliga, T. A., eds. Proceedings, first international symposium on acid rain and the forested ecosystem; 1975 May 12-15; Columbus, OH. Gen. Tech. Rep. NE-23; Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1976: 951-961.

The effect of artificial acid rain on nitrogen uptake by a fungus (*Glomus mosseae* (Nicol. & Gerd.) Gerd. & Trappe) endomycorrhizal with roots of sweetgum tree seedlings (*Liquidambar styraciflua* L.) was investigated by applying three kinds of test solutions to the surface of soil profiles planted with five combinations of sweetgum seedlings and fungus. When artificial Eastern United States acid rainfall was used to acidify the top 5 cm of soil to a soil solution pH of 2.0, NO_3-N concentrations were unaffected by soil-treefungus treatments while ammonia appeared to be excluded from soil exchange sites, apparently by H^+ ions. Ammonia uptake by mycorrhizal roots was not detectable, thus acid rain may promote leaching from NH_4-N from soil profiles.

100. **Haines, Bruce; Stefani, Marcia; Hendrix, Floyd.** Acid rain: threshold of leaf damage in eight plant species from a southern Appalachian forest succession. Water, Air and Soil Pollution 14: 403-407; 1980.

Eight plant species were subjected to artificial acid rains of pH 2.5, 2.0, 1.5, 1.0, and 0.5 in order to determine the

threshold for and symptoms of damage. The plants were *Erechtites, Robinia, Pinus, Quercus, Carya, Liriodendron, Acer* and *Cornus* from the Coweeta Hydrologic Laboratory. Droplets of pH 2.0 produced brown/necrotic spots on all species except *Pinus*, while droplets of pH 1.0 produced necroses on leaves of all species examined. The size of necrotic spots increased with increasing acidity. Results of this study suggest that a tenfold increase in acidity from pH 3.2 to 2.2 in a single spring or summer storm could bring damage or death to mature leaves of dominant flowering plants in the Southern Appalachians.

101. **Haines, Bruce; Waide, Jack B.** Predicting potential impacts of acid rain on elemental cycling in a southern Appalachian deciduous forest at Coweeta. In: Hutchinson, T. C.; Havas, M., eds. Effects of acid precipitation in terrestrial ecosystems: Proceedings of the symposium; 1978 May 21-27; Toronto. New York: Plenum Publications; North Atlantic Treaty Organization, Scientific Affairs Division; 1980: 335-340.

Experimental efforts to characterize the responses of plant leaves, plant roots and soils to different regimes of acid rain are described. The goal is to integrate response data into ecosystem models in order to make predictive simulations of potential long-term responses of southeastern forests to acid rain regimes differing in intensity and in duration as well as ecosystem recovery following cessation of low pH rainfall.

102. **Hairston, Nelson G.** Ecology, selection and systematics. Cambridge, MA: Museum of Comparative Zoology; 1973; Breviora 414. 21 p.

Three different kinds of ecological relationships between newly separated species are examined, with the aim of establishing their expected effects on the systematic differences between the species involved. In cases of slight difference between the habitats of two products of recent speciation, selection can be expected to favor specific competitive mechanisms, but taxonomic differences would be expected to be slight, and examples of hybrid superiority would be common. Where the habitats of the two species are markedly different, as along a steep ecological gradient, adaptation to the different places will result in species that become broadly overlapping in habitat, and taxonomically different in many clearly adaptive characters. Although this latter process leads to species with somewhat different food habits, it would not lead to food specialization.

103. **Hairston, Nelson G.** Species packing in the salamander genus *Desmognathus*: what are the interspecific interactions involved? The American Naturalist 115(3): 354-366; 1980.

The present paper presents evidence that questions previous interpretations and indicates that predation in and near streams has been more important than competition as the significant force in determining the evolution of the genus and the present structure of the community. The evidence consists of the size relationships, which are the reverse of what would be expected if competition had required increasing efficiency, the relative abundance of salamander predators in aquatic and terrestrial environments, and the failure of a majority of predictions about habitat shifts and size relationships when the predictions are based on the assumption of interspecific competition.

104. **Harris, W. F.; Santantonio, Dan; McGinty, D.** The dynamic belowground ecosystem. In: Waring, Richard H., ed. Forests: fresh perspectives from ecosystem analysis: proceedings of the 40th annual biology colloquium; 1979 April 27-28; Corvallis, OR. Corvallis, OR: Oregon State Press; 1980: 119-129.

The belowground ecosystem, especially the autotrophic root component, plays an important role in the structure and function of forest ecosystems. This paper discusses the seasonal accumulation and turnover of root organic matter, the significance of root dynamics to element inputs to soil and element cycling, and the significance of root sloughing to the forest energy balance.

105. **Harshbarger, T. J.** Effects of changed structural habitat on trout and invertebrate populations. In: Proceedings of the trout stream habitat improvement workshop; 1980 November 3-6; Asheville, NC. Atlanta, GA: U.S. Department of Agriculture, Forest Service; 1980: 123-126.

Channel constructions and over-logs placed in a three-order stream in North Carolina increased depth and velocity but decreased surface area of water. The number of cover units increased, but their size decreased. The net effect was a significant reduction in standing crop of wild brown and rainbow trout. Streamside debris supported high invertebrate biomass (fish food), and carrying capacity of streams might benefit from installing devices to trap and hold organic debris.

106. **Harshbarger, T. J.; Bhattacharyya, H.** An application of factor analysis in an aquatic habitat study. In: Capen, D. E., ed. The use of multivariate statistics in studies of wildlife habitat. Gen. Tech. Rep. RM-87. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest Experiment Station; 1981: 180-184.

In five small, high-gradient trout streams in western North Carolina, 18 cover variables were related to standing crop biomass of wild brook trout (*Salvelinus fontinalis*), rainbow trout (*Salmo gairdneri*) and brown trout (*Salmo trutta*). Factor analysis showed that only a few factors or variables were needed to explain relations between variables in the observed set. Key cover factors were area in debris, turbulent water, vegetation in and over stream, and overhanging banks. Resolutions obtained were used to explore relationships between standing crop of trout and age of fish.

107. **Harshbarger, T. J.; Perkins, C. J.; Martin, R. E.** Legume response unrelated to fuel moisture at time of burning. Journal of Range Management 28: 70-71; 1975.

The response of sensitive partridgepea and other legumes was unrelated to moisture content of fuels at the time a slash pine stand was burned.

108. **Harshbarger, T. J.; Porter, P. E.** Embryo survival and fry emergence from artificially planted trout eggs: two techniques compared. North American Journal of Fisheries Management 2: 84-89; 1982.

Survival of larval trout through the swim-up stage was determined for eyed eggs of brown trout (*Salmo trutta*) planted both in the streambed and in Whitlock Vibert boxes. Direct plants produced 2 times more sac fry than box plants and 3.5 times more swim-up fry. Sediment deposition was approximately 100 percent greater in first- and second-order streams than in third-order streams, and sediments accumulated disproportionately in box plants. This seemed to account for survival differences between planting techniques and among stream orders.

109. **Harshbarger, Thomas J.** Factors affecting regional trout stream productivity. In: Proceedings of the southeastern trout resource: ecology and management symposium; 1975 October 24-25; Blacksburg, VA. Blacksburg, VA: Virginia Polytechnic Institute and State University; 1978: 11-27.

This paper reviews effects of abiotic factors such as temperature, stream velocity, discharge, and dissolved ions on distribution and abundance of trout independent of population density. Some factors, such as temperature and dissolved ions, act in a fairly constant manner but others, such as discharge, are erratic in occurrence and cause major fluctuations in production levels. More information is needed to fully assess the effects of climate and physical environment on wild trout.

110. **Harshbarger, Thomas J.** Research in aquatic habitats at Southeastern Station. In: Symposium on trout habitat research and management: Proceedings; 1974 September 5-6; Cullowhee, NC; Boone, NC: Appalachian Consortium Press; 1975: 102-106.

Research is urgently needed to restore, maintain, or improve approximately 20,000 miles of trout stream in the southern Appalachian Mountains. Studies conducted at the Coweeta Hydrologic Laboratory in western North Carolina have shown that land management practices change the quantity, quality, and stability of water flowing from forest land and the stream biota. This paper describes research approaches, current studies, and plans for future work in aquatic habitat research by the Southeastern Forest Experiment Station.

111. **Harshbarger, Thomas J.** Scraping improves silver nitrate brands on trout. Progressive Fish-Culturist 41: 209; 1979.

A device for scraping mucosal material and scales from fish prior to branding with silver nitrate is described. Improved brands are obtained using this technique.

112. **Harshbarger, Thomas J.; Porter, Pamela E.** Effects of a dam and sewage outflow on a small oligotrophic stream in the Southern Appalachians. Res. Note SE-308. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1982. 10 p.

Treated sewage added to a Southern Appalachian trout stream increased bacterial production by 476 percent, periphyton production by 191 percent, and the number of benthic macroinvertebrates by 441 percent; biomass of fish decreased 56 percent. Downstream 300 m from the sewage outflow, fish biomass was significantly greater than in upstream sections. The dam influenced fish distribution and upstream migration and the abundance of filter-feeding caddisflies and midges.

113. **Harshbarger, Thomas J.; Porter, Pamela E.** Survival of brown trout eggs: two planting techniques compared. Progressive Fish-Culturist 41: 206-209; 1979.

This paper compares survival of eggs, embryos, and swim-up fry of brown trout (*Salmo trutta*) in direct intragravel plants and in Vibert boxes. Egg mortality increased disproportionately in Vibert boxes after 4 weeks until time of hatching. Direct intragravel plants yielded the highest survival to the swim-up stage.

114. **Hassler, W. W.; Tebo, L. B., Jr.** Fish management investigations on trout streams. Proj. Completion Rep. Proj. F-4-R. Raleigh, NC: North Carolina Wildlife Resources Commission, Fish Division; 1958. 118 p.

This is a report of the cooperative Dingell-Johnson investigation at Coweeta Hydrologic Laboratory. The report includes an extensive description of bottom fauna and describes the effects of erosion debris and riparian cuttings upon fish life.

115. **Hatcher, Robert D., Jr.** The Coweeta Group and Coweeta syncline: major features of the North Carolina - Georgia Blue Ridge. Southeastern Geology 21(1): 17-29; 1979.

The name Coweeta Group is proposed for a group of metasedimentary and possible metaigneous rocks which occur in the east-central Blue Ridge of North Carolina and Georgia and overlie the rocks of the Tallulah Falls Formation. The group is composed of three formations. The oldest is the Persimmon Creek Gneiss. This is overlain by the Coleman River Formation, then the Ridgepole Mountain Formation. The age of the Coweeta Group is uncertain. The Coweeta syncline results from a history of polyphase deformation. It appears to be overturned toward the east, and the west limb is cut off by the Shope Fork fault.

116. **Helvey, J. D.** Interception by eastern white pine. Water Resources Research 3: 723-729; 1967.

Measurements taken in a 10-, a 35-, and a 60-year-old stand of eastern white pine in the southern Appalachians of western North Carolina were used to derive regression equations for estimating throughfall, stemflow, and the sum of throughfall and stemflow from measurements of gross rainfall. Equations for total interception loss were derived and used to predict total seasonal interception loss (I) from measurements of total seasonal rainfall (ΣP) and number of storms

(N). For the 10-year-old stand, I = 0.05(N) + 0.08 (ΣP); for the 35-year-old stand, I = 0.05(N) + 0.12 (ΣP); and for the 60-year-old stand, I = 0.06(N) + 0.18(ΣP). Total interception loss in white pine increased with stand age, and total loss from all pine stands studied exceeded losses calculated for mature hardwoods.

117. **Helvey, J. D.** Interception of rain. In: Toebes, C.; Ouryvaev, V., eds. Representative and experimental basins; an international guide for research and practice. Haarlem: Henkes-Holland, UNESCO; 1970; 4: 89-93.

Some guidelines are presented for designing studies of rainfall interception in forest vegetation. Methods are presented for sampling gross rainfall, throughfall, stemflow, and litter interception loss. The necessary information is presented for determining a first approximation of the sampling intensity needed to achieve a desired level of accuracy.

118. **Helvey, J. D.** Reply to Editor Langbein in answer to Professor Miller's comments on "Interception by Eastern White Pine." Water Resources Research 4: 455-456; 1968.

This is a rebuttal to comments by Professor Miller on the article "Interception by Eastern White Pine."

119. **Helvey, J. D.** A summary of rainfall interception by certain conifers of North America. In: Monke, E. J., ed. Biological effects in the hydrological cycle-terrestrial phase: proceedings of the third international seminar for hydrology professors; 1971 July 18-30; West Lafayette, IN. West Lafayette, IN: Purdue University, Department of Agricultural Engineering, Agricultural Experiment Station; 1971: 103-113.

Conifer interception data were compiled from many sources and generalized equations derived for canopy interception, throughfall, and stemflow. Equations for six conifers are compared with an earlier derived one for mixed deciduous forest. Surface area index correlates with differences in interception loss between dense-canopy species such as spruce, fir, and hemlock, and more-open canopies of the pines.

120. **Helvey, J. D.; Hewlett, J. D.** The annual range of soil moisture under high rainfall in the Southern Appalachians. Journal of Forestry 60: 485-486; 1962.

Observations of soil moisture at Coweeta suggest that forest vegetation at this Laboratory rarely, if ever, suffers true drought. Seasonal changes in soil moisture were strongly correlated with changes in streamflow.

121. **Helvey, J. D.; Hewlett, J. D.; Douglass, J. E.** Predicting soil moisture in the Southern Appalachians. Proceedings, Soil Science Society of America 36: 954-959; 1972.

Soil moisture was measured for 3.5 years on forested slopes in the mountains of western North Carolina to develop equations for predicting soil moisture. Predictors were precipitation, sand content, moisture, retention at 1-bar suction, position on slope, and season. Moisture changes in surface layers were correlated best with rainfall on days immediately preceding. Changes in deeper layers were better correlated with rainfall during previous weeks. Equations developed account for about 88 percent of the variation in soil moisture.

122. **Helvey, J. D.; Patric, J. H.** Canopy and litter interception of rainfall by hardwoods of eastern United States. Water Resources Research 1: 193-206; 1965.

Results from all available studies of rainfall interception by hardwoods of the Eastern United States vary over a small range. Data from past studies were used to develop regression equations describing the relation between gross rainfall, throughfall, and stemflow for eastern hardwood forests during the growing and dormant seasons.

123. **Helvey, J. D.; Patric, J. H.** Design criteria for interception studies. In: Design of hydrological networks: symposium. International Association of Scientific Hydrology; 1965 June 15-22; Quebec, Canada. Bulletin 67. Washington, DC: International Association of Scientific Hydrology; 1966: 131-137.

This report, gleaned from over 50 studies, defines variability of interception parameters and provides sampling designs for obtaining estimates to selected levels of probability for each parameter mean. A new method for estimating stemflow is outlined which greatly reduces variability inherent in the traditional single-tree method. These sampling and analytical methods will help ensure that results of different studes are comparable.

124. **Helvey, Junior D.** Rainfall interception by hardwood forest litter in the southern Appalachians. Res. Pap. SE-8. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1964; 9 p.

Moisture interception by hardwood litter was measured during 1961 and 1962. The maximum field water content--water retained against drainage--averaged 215 percent of ovendry

weight. About 1 inch of throughfall was required to wet the litter to this maximum. The amount of water evaporated per month from litter was greater during the dormant season. Interception loss during 1962 was about 2.2 inches and the longterm average is estimated to be about 3 inches.

125. **Henderson, G. S.; Swank, W. T.; Waide, J. B.; Grier, C. C.** Nutrient budgets of Appalachian and Cascade region watersheds: a comparison. Forest Science 24: 385-397; 1978.

Precipitation inputs and streamflow outputs of nitrogen, calcium, potassium, magnesium, and sodium were compared for two deciduous forest watersheds and a coniferous forest watershed. While nitrogen inputs varied by nearly tenfold among the watersheds, ammonium and nitrate discharge in streamflow was uniformly small, resulting in net accumulation within all three ecosystems. In contrast, cation discharge was more variable among the watersheds than cation input and was strongly related to the bedrock of each watershed. The internal distribution and cycling of nitrogen, potassium, and calcium within each of the three watershed ecosystems were also compared. There were interpretable differences between nutrient cycling patterns in the coniferous and deciduous forests. Overall, however, all three ecosystems were effectively retaining and recycling these nutrients.

126. **Henderson, Gray S.; Swank, Wayne T.; Hornbeck, James W.** Impacts of sulfur deposition on the quality of water from forested watersheds. In: Shriner, D. S.; Richmond, C. R.; Lindberg, S. E., eds. Potential environmental and health consequences of atmospheric sulfur deposition: proceedings of the second life science symposium; 1979 October 14-18; Gatlinburg, TN. Ann Arbor, MI: Ann Arbor Science Publications, Incorporated; 1980: 431-441.

Observed stream discharge of nitrate nitrogen was used to calculate H^+ production due to accelerated nitrification in response to forest harvest for five experimental watersheds. The value for H^+ production was combined with observed cation discharge, which had been corrected for release from organic matter decomposition, to estimate cation release ratios from the soil exchange complex, due to H^+. These ratios were then used to estimate potential increases in watershed discharge of cations if precipitation acidity were to change from pH 4.3 to pH 4.0, 3.5, or 3.0. The potential increases in annual Ca, Mg, K, and Na discharge were calculated to be less than 0.5 kg/ha at pH 4.0 and less than 2.5 kg/ha at pH 3.5, increases which would be difficult to detect

among natural variations in stream water chemistry. Calculations for precipitation at pH 3.0 suggest a potential increase in cation discharge which could be as great as 8.5 kg/ha for individual elements, a change which would be more easily detected.

127. **Hermann, H. R.; Mullen, M.; Wallace, J. B.** Suction disc in *Blepharia separata* Alexander. Journal of the Georgia Entomological Society 10: 145-150; 1975.

Suction discs on blepharocerid larvae occur on six segments of the head, thorax and abdomen. All of the structures associated with each disc are below the ventral longitudinal muscle of the body and hence belong to the sternal region. Each disc can be broken down into a zone of membranous cushion, a zone of inverted filaments, a zone of tactile setae and a zone of support. Each zone has a specific function and every zone is important in the suction mechanism. A sternal gland secretes a substance that flows into the zone of inverted filaments. Strong dilator muscle groups are responsible for indefinite suction and release mechanisms.

128. **Hershfield, David M.** On spacing of raingages. In: Design of hydrological networks: symposium, 1965 June 15-22; Quebec, Canada. Publication 67. Gentbrugge, Belgium: International Association of Scientific Hydrology; 1965: 72-81.

Rainfall data for 15 storms from each of 15 watersheds with a total of 400 raingages were used to obtain relationships fundamental to the spacing of raingages for hydrologic investigations. The product-moment correlation coefficient (r) was computed for each combination of two raingages in a watershed. Isocorrelation lines around a key gage in each watershed generally exhibit a non-isotrophic pattern. The size and shape of area enveloped by the r = 0.9 isoline around different key gages in the same watershed suggests that each gage represents a different size rainfall area.

A relationship is presented for obtaining the distance between raingages for an arbitrary standard (r = 0.9) as a function of two readily available climatic parameters.

129. **Hertzler, R. A.** Determination of a formula for the 120° V-notch weir. Civil Engineering 8: 756-757; 1938.

Design of a 120° V-notch sharp-crested weir for accurate measurement of flows up to 26 second-feet is described. For a 2-foot head, the 120° notch has 1.73 times the capacity of a 90° notch and slightly greater capacity than the 2.6-foot

rectangular weir. Weir blades were constructed of 3½- by 3½-inch structural angle iron. The discharge formula was $Q = 4.43\ H^{2.449}$, where Q = discharge in second-feet and H = observed head on weir.

130. **Hertzler, R. A.** Engineering aspects of the influence of forests on mountain streams. Civil Engineering 9: 487-489; 1939.

This article discusses the objectives of the hydrologic research program at Coweeta, Bent Creek and Cooper Basin, the weir instrumentation used, and typical early analyses and applications. The application of Horton's infiltration theory to forest lands which have high infiltration rates is questioned. Unit graph analyses of runoff showed that peak percentages of runoff were inversely related to basin area, that basal lengths of the distribution graphs were directly related to drainage area, and that the effects of vegetative cover were reflected in both peak percentages and width of the distribution graphs. A quantitative ranking of peak discharge from four cover types is presented.

131. **Hewlett, J. D.** Letter to editor on article "Groundwater: Definition" by H. E. Thomas and L. B. Leopold. Science 144(3625): 1407-1408; 1964.

This letter questions the definition of groundwater used in the article.

132. **Hewlett, J. D.; Cunningham, G. B.; Troendle, C. A.** Predicting stormflow and peakflow from small basins in humid areas by the R-index method. Water Resources Research 13: 231-253; 1977.

A nonlinear equation was fitted to 468 stormflows on 11 forested basins from New Hampshire to South Carolina, providing an equation for use on forest and wild lands in humid regions. Stormflow (Q) is a function of R, P and I, where R, the average storage capacity index, is the mean value of Q/P. P is storm rainfall, and I is the initial flow rate. S.E. is 0.3 inch of stormflow. Peakflow was similarly estimated (S.E. 26 $ft^3/sec/mi^2$). The R-index method is proposed as a practical tool in wild land management. When tested against the runoff curve method on four independent basins, predictions by the R-index method were considerably more accurate.

133. **Hewlett, J. D.; Fortson, J. C.; Cunningham, G. B.** The effect of rainfall intensity on storm flow and peak discharge from forest land. Water Resources Research 13: 259-265; 1977.

Analysis of a 30-year record of rainfall and storm flow (545 events) from a forested watershed in the southern Appalachians was made to determine whether rainfall intensity influences storm flow volume or peak discharge. For all practical purposes, rainfall intensities during storms had no effect on storm flow volumes. Storm rainfall, antecedent flow, season, and duration of the rainstorm accounted for 86.4 percent of total variation in the log of storm flow. Addition of maximum 60-, 30-, 15-, and 5-minute intensities raised this to 86.7 percent. Only 4.7 percent of the total variation in the log of peak flow was attributable to intensity.

134. **Hewlett, John D.** Coweeta Hydrologic Laboratory. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1957. 8 p.

This booklet describes research conducted at Coweeta to develop practical methods of managing forest land for maximum timber production, while providing for flood control and maintaining the quality and quantity of water needed for industrial, municipal, and agricultural uses. Results of watershed clearings, mountain farming, woodland grazing, and proper logging procedures are illustrated.

135. **Hewlett, John D.** Pine and hardwood forest yield. Journal of Soil and Water Conservation 13: 106-109; 1958.

This paper discusses the theoretical concepts and experimental results which indicate that conifers use more water than hardwoods. Two catchment studies of the effect on water yield of converting hardwoods to white pine are described.

136. **Hewlett, John D.** Research in hydrology of forested headwaters of the Coweeta Hydrologic Laboratory. In: Transactions, Twenty-ninth North American wildlife and natural resources conference; 1964 March 9-11; Las Vegas, NV. Washington, DC: Wildlife Management Institute; 1964: 103-112.

The author provides background and review of research in forest hydrology at Coweeta and plans for future staffing and research at the Laboratory.

137. **Hewlett, John D.** Response of fescue to natural moisture gradient on an artificial slope. Asheville, NC: Res. Notes 152. U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1961. 2 p.

Minor changes in soil moisture stress on well-watered natural slopes may, in part, account for observed reductions in form and vigor of plants with increasing elevation.

138. **Hewlett, John D.** Soil moisture as a source of base flow from steep mountain watersheds. Stn. Pap. 132. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1961. 11 p.

Model studies of unsaturated flow in sloping soil columns show that unsaturated flow of water is an important source of base flow in mountain streams.

139. **Hewlett, John D.** Water or forest - can we have all we need of both? Frontiers of Plant Science 17: 2-3; 1964.

The author outlines an experiment with a transpiration inhibitor and cites benefits possible if this or related tests succeed.

140. **Hewlett, John D.** Will water demand dominate forest management in the East? In: Proceedings of the Society of American Foresters meeting; 1966 September 12-15; Seattle, WA. Washington, DC: Society of American Foresters; 1966: 154-158.

The author discusses results of watershed management studies at Wagon Wheel Gap and Coweeta. He raises questions about forest management solely for the purpose of water regulation and points to an alternative of intensive management for water, timber, wildlife, and recreation, using Coweeta's watershed 28 as a successful example.

141. **Hewlett, John D.; Douglass, James E.** Blending forest uses. Res. Pap. SE-37. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1968. 15 p.

Compatibility of forest management practices on a 360-acre southern Appalachian watershed, along with conflicts among uses, is examined in this unique experiment to determine the feasibility of intensive management for wood, water, wildlife, and recreation. An efficient and stable access system is stressed, and the effect of various woods practices on the four basic resources is rated. Increases are shown in water yield, game forage, quality timber growth, and general use of the area, and some unresolved conflicts among uses of the forest are revealed.

142. **Hewlett, John D.; Douglass, James E.** A method for calculating error of soil moisture volumes in gravimetric sampling. Forest Science 7: 265-272; 1961.

A method for calculating error of soil moisture volumes in gravimetric sampling is presented. Limitations in sampling soil density and percentage of moisture to determine inches of water render the gravimetric method a poor tool for hydrologic research.

143. **Hewlett, John D.; Douglass, James E.; Clutter, Jerome L.** Instrumental and soil moisture variance using the neutron-scattering method. Soil Science 97: 19-24; 1964.

The variance in estimates of soil moisture as determined by the neutron-scattering method is examined and related to field data from two research areas. Instrument and timing errors are shown to contribute insignificantly to the standard error of estimate. Furthermore, their contribution to estimates of moisture change with time is negligible as long as the timing interval used at each observation exceeds 30 seconds.

144. **Hewlett, John D.; Helvey, J. D.** Effects of forest clear-felling on the storm hydrograph. Water Resoures Research 6: 768-782; 1970.

A statistical analysis of all major storm hydrographs before and after clear-felling a mature hardwood forest on a 108-acre calibrated catchment revealed that, after felling, stormflow volume was significantly (0.001 level) increased 11 percent overall, or 0.23 inch at the mean stormflow volume of 2.1 inches. Peak discharge increased slightly after felling (about 6 c.f.s.m. or 7 percent at the mean peak flow of 92 c.f.s.m.). Time to peak, recession time, and duration of stormflow were tested to an accuracy within 10 percent of their respective mean values (0.05 level), but no treatment effect was detected. Increases in stormflow as a result of felling ranged from 0 in small floods to 1.9 inches during a record 7-day flood sequence.

145. **Hewlett, John D.; Hibbert, A. R.** Increases in water yield after several types of forest cutting. International Association Scientific Hydrology Bulletin 6(3): 5-17; 1961.

Effects of timber and brush removal on water yields from small watersheds are examined in the light of 25 years of hydrologic research at Coweeta.

146. **Hewlett, John D.; Hibbert, Alden R.** Factors affecting the response of small watersheds to precipitation in humid areas. In: Proceedings of a National Science Foundation advanced science seminar, international symposium of forest hydrology;

1965 August 29 - September 10; University Park, PA. Oxford; New York: Pergamon Press; 1966: 275-290.

A numerical rating system, the response factor, was developed from precipitation and streamflow records for use in classifying the hydrologic response of small watersheds in humid areas. Long-term hydrograph records from 15 forested watersheds in the Eastern United States were separated into quick and delayed flow by computer and ranked according to mean precipitation, quick flow, and the response factors quick flow/precipitation and quick flow/total water yield.

147. **Hewlett, John D.; Hibbert, Alden R.** Moisture and energy conditions within a sloping soil mass during drainage. Journal of Geophysical Research 68: 1081-1087; 1963.

A model of a sloping soil profile is used to show that slow, unsaturated flow of soil moisture above the water table furnishes much of the sustained streamflow between storms in mountain land.

148. **Hewlett, John D.; Kramer, P. J.** The measurement of water deficits in broadleaf plants. Protoplasma 57: 381-391; 1963.

A comparison of the disk technique with Stocker's whole leaf method for determining water deficit of some hardwood trees reveals confusion in existing terms and methods. The water relations of leaf disks cut from broadleaf trees cannot be assumed to be the same as whole leaves, because more water per unit weight is usually required to saturate excised disks. Stocker's term *wasser defizit* (WD) and the whole leaf method, when modified to allow shorter equilibration schedules, remain the best way to express and measure water deficits in forest trees.

149. **Hewlett, John D.; Metz, L. J.** Watershed management research in the Southeast. Journal of Forestry 58: 269-271; 1960.

This article is a review of research on watershed management at the Coweeta Hydrologic Laboratory and Union Research Center.

150. **Hewlett, John D.; Nutter, Wade L.** The varying source area of streamflow from upland basins. In: Interdisciplinary aspects of watershed management: Proceedings of the symposium; 1970 August 3-6; Bozeman, MT. New York: American Society of Agricultural Engineers; 1970: 65-83.

The variable source area concept of upland streamflow may soon become a working model to account for the various sources, pathways, and timing delays which underlie the dynamics of discharge from headwater areas. The variable source area concept is substantially different from the traditional view of storm or flood flow as a hydrograph of surface runoff. By ignoring infiltration, which has not been connected quantitatively to the hydrograph, the model has the freedom to accommodate the more important dynamic aspects of the stream-flow production process.

151. **Hewlett, John D.; Patric, J. H.** An example of multiple use on a small mountain watershed. In: Proceedings, seventh annual meeting, Soil Conservation Society of America, Georgia Chapter; 1963 May 24-25; Eatonton, GA. Eatonton, GA: Soil Conservation Society of America, Georgia Chapter; 1963; 3: 12-26.

An example of multiple use on a 356-acre watershed at Coweeta Hydrologic Laboratory is presented. This report discusses the concept of forest access as being the key to management. Plans for management of the area for water, timber, wildlife, and recreational values are presented.

152. **Hewlett, John D.; Patric, James H.** A pilot test of multiple use on a small mountain watershed. In: Proceedings, 42nd annual meeting, Society of American Foresters, Appalachian section; 1963 February 8-9; Greenville, SC. Charlottesville, VA: Society of American Foresters; 1963: 11-18.

A pilot test of the multiple-use concept on a 356-acre watershed at Coweeta Hydrologic Laboratory is presented. This report discusses that concept in terms of management of the area for water, timber, wildlife, and recreational values. A proper access system is cited as the key to effective resource management.

153. **Hibbert, A. R.** Water yield changes after converting a forested catchment to grass. Water Resources Research 5: 634-640; 1969.

After a forested catchment was converted to grass, the amount of evapotranspiration was closely related to the amount of grass produced. During years when grass production was high, water yield from the catchment was about the same as or less than the expected yield from the original forest. As grass productivity declined, water yield gradually increased until it exceeded the predicted yield from the forest by over 5 inches annually. The grass appeared to evaporate more water

early in the spring and less water late in the summer than the original forest cover.

154. **Hibbert, Alden R.** Forest treatment effects on water yield. In: Proceedings of a National Science Foundation advanced science seminar, international symposium on forest hydrology; 1965 August 29 - September 10, University Park, PA. Oxford, New York: Pergamon Press; 1966: 527-543.

Results are reported for 39 studies of the effect of altering forest cover on water yield. Taken collectively, these studies reveal that forest reduction increases water yield and that reforestation decreases water yield.

155. **Hibbert, Alden R.; Cunningham, G. B.** Streamflow data processing opportunities and application. In: Proceedings of a National Science Foundation advanced science seminar, international symposium of forest hydrology; 1965 August 29 - September 10; University Park, PA. Oxford, New York: Pergamon Press; 1966: 725-736.

The techniques used at the Coweeta Hydrologic Laboratory for processing streamflow records from recorder charts and analog-to-digital recorder tape to final integration of discharge are discussed in detail.

156. **Hilmon, Junior B.; Douglass, James E.** Potential impact of forest fertilization on range, wildlife, and watershed management. In: Forest fertilization theory and practice symposium; 1967 April 18-27; Gainesville, FL. Muscle Shoals, AL: Tennessee Valley Authority; 1968: 197-202.

This paper reviews the impacts of forest fertilization on forage, wildlife, and water resources.

157. **Hogg, D. C.** Millimeter-wave communication through the atmosphere. Science 159(3810): 39-46; 1968.

Millimeter-length radio wave bands are not utilized for communication because water vapor in the atmosphere absorbs energy at these frequencies and limits distance of transmission. Rain is one of several causes of radio wave attenuation discussed in this review. Data collected for the Illinois State water survey by a raindrop camera at Coweeta Hydrologic Laboratory are used with data from other sites to estimate the degree of radio interference and develop design guidelines for communications systems.

158. **Hoover, M. D.** Careless skidding reduces benefits of forest cover for watershed protection. Journal of Forestry 43: 765-766; 1945.

Careless skidding creates channels which concentrate runoff from road surfaces and cause erosion which is unnecessary if roads are carefully located and constructed. Techniques which minimize erosion from skid roads are presented.

159. **Hoover, M. D.** Effect of removal of forest vegetation upon water yields. Transactions, American Geophysical Union. Part 6: 969-977; 1944.

A clearcutting experiment on Coweeta Watershed 17 is described, and effects of the cutting and subsequent treatment on increasing water yield are presented. Peak discharges were not significantly increased by the cutting, and surface runoff did not occur after treatment. Data indicate that a forest stand annually transpires 17 to 22 inches of water.

160. **Hoover, M. D.** Water and timber management. Journal of Soil and Water Conservation 7: 75-78; 1952.

As demand for water increases, management of forested headwaters assumes greater importance. Compatibility of objectives in the management of timber and water is demonstrated, and management practices which protect the values of each resource are stressed.

161. **Hoover, M. D.; Hursh, C. R.** Influence of topography and soil depth on runoff from forest land. Transactions, American Geophysical Union, Part 2: 693-698; 1943.

Data are presented on rainfall and discharge for seven watersheds at Coweeta during a storm on December 27-29, 1942. The difference in peak discharges is assigned in part to higher rainfall at higher elevations, but peaks were also related to soil depth, topography, and hydrologic characteristics associated with different elevations.

162. **Hoover, M. D.; Hursh, C. R.** Installation of shallow observation wells. Tech. Note 56. Asheville, NC: U.S. Department of Agriculture, Forest Service, Appalachian Forest Experiment Station. 1943. 5 p.

The location, installation, and operation of shallow groundwater observation wells are described. This Note is of value to field personnel involved in well installation and in the analysis of observations taken from wells constructed by the methods described.

163. **Hoover, M. D.; Lunt, H. A.** A key for the classification of forest humus types. Proceedings, Soil Science Society of America 16(4): 368-370; 1952.

A key is presented for classifying major organic layers into Mull, Duff Mull, and Mor. It is applicable for well- and moderately well-drained soils. Basic criteria in the classification are (1) presence or absence of an H layer; (2) the degree of incorporation of organic matter into the upper mineral soil; and (3) the structure, thickness, and organic content of the H layer and the A horizon.

164. **Hornick, L. E.; Webster, J. R.; Benfield, E. F.** Periphyton production in an Appalachian mountain trout stream. American Midland Naturalist 106: 22-36; 1981.

Periphyton primary production was investigated in a second-order Appalachian Mountain stream and two of its tributaries. Using ^{14}C fixation in recirculating chambers, estimates averaged 2.27 mg C m^{-2} h^{-1} in the mainstream and 1.65 and 1.37 mg C m^{-2} h^{-1} in the two tributaries. Abiotic factors most influential on primary production rates were light, streamflow and inorganic carbon. Based on annual budgets, the estimated stream energy input attributable to autochthonous primary production was about 3 percent of allochthonous inputs. However, because of high nutritive value and timing, autochthony may be more important than indicated by annual budgets.

165. **Huff, D. D.; Begovich, C. L.** An evaluation of two hydrograph separation methods of potential use in regional water quality assessment. Springfield, VA: National Technical Information Service, U.S. Department of Commerce; 1976 March; Oak Ridge National Laboratory/TM 5258. 112 p.

Streamflow data are more useful for evaluating hydrologic model results and studying water quality once baseflow and storm runoff have been separated by an appropriate technique. The Snyder and Curlin and the Coweeta methods were evaluated as to conceptual basis, ease of application, cost of data processing, and acceptability of results. The quick flow hydrograph separation method, in use at the Coweeta Hydrologic Laboratory, was selected for use because it gives acceptable results and is easy and inexpensive to use. The Coweeta program should be useful in developing regional quantitative relationships between changes in land use and changes in runoff and water quality.

166. **Huff, D. D.; Swank, W. T.; Troendle, C. A.; Henderson, G. S.; Waide, J. B.; Haynes, T.** Element cycles and water budget analysis applied to forest management in the Eastern United States. In: Proceedings, Society of American Foresters; 1978 October 23; St. Louis, MO. Washington, DC: Society of American Foresters; 1978: 77-89.

Ecosystem science has made significant advances in the past several years that can provide information useful in the evaluation of environmental and resource management issues. Examination of nutrient budgets has shown that concentrations of all dissolved nutrients in stream discharge from watersheds altered by cutting, species conversions, and changes in land use remained low after manipulations. None of the treatments produced long-term elevated nutrient levels that would adversely affect water use. However, simulations suggest that elevated losses of NO_3-N associated with harvesting may cause a significant decline in the nitrogen pool of the forest ecosystem. Furthermore, nitrogen depletion may increase with increasing time of management, and complete-tree harvest probably results in the greatest nitrogen depletions of any cutting alternative.

167. **Hursh, C. R.** Abandoned mountain farms an erosion menace but a forestry opportunity. Farmers Federation News 11(12): 3, 5; 1931.

The author describes agricultural practices which leave mountain soils exposed to erosion and recommends that slopes unsuitable for agriculture not be cleared and that abandoned land be converted to pasture or forest cover to prevent erosion.

168. **Hursh, C. R.** Appendix B--report of sub-committee on subsurface-flow. Transactions, American Geophysical Union, Part 5: 743-746; 1945.

Literature on subsurface flow is reviewed, and the lack of records from suitable experimental watersheds is cited as a handicap in interpreting the nature of subsurface stormflow.

169. **Hursh, C. R.** Climatic factors controlling roadside design and development. National Research Council Magazine; 1949: 9-19.

Factors which influence the revegetation of roadbanks--drying by wind, soil temperatures, frost action, mulching, and road design--are discussed.

170. **Hursh, C. R.** Control of exposed soil on road banks. Tech. Note 12. Asheville, NC: U.S. Department of Agriculture, Forest Service, Appalachian Forest Experiment Station; 1935. 4 p.

Increased erosion, siltation, and road maintenance can be largely eliminated by covering road banks with litter or revegetating banks at the time of road construction. The simplest and most practical measures include planting, seeding, and use of stake and brush wattles. Selection of suitable plant species is discussed.

171. **Hursh, C. R.** Discussion of paper entitled "Determination of the Effects of Watershed-Management on Mountain Streams" by C. L. Wicht. Transactions, American Geophysical Union; 1943: 606-608.

Elimination of the effects of climatic variability and factors such as size, shape, and soil-depth of watersheds through various statistical methods is questioned. Statistical methods are recognized as valuable research tools, but in order to develop practical watershed management techniques, the very factors to be eliminated in the experimental design must be evaluated. The concept of watershed standardization over a period of years is discussed as a procedure which eliminates comparison of the physical characteristics of one watershed with those of another.

172. **Hursh, C. R.** The eastern forester and his watersheds. Journal of Forestry 44: 1037-1040; 1946.

The author pointedly questions whether the average forester is trained to manage water resources of the forest. Basic concepts of geophysical science (soils, climatology, and the origin and distribution of water on the earth's surface) are discussed in relation to the water resource and its management.

173. **Hursh, C. R.** Forest management in East Africa in relation to local climate, water and soil resources. East Africa Agricultural Organization Annual Report 1952: 26-35.

As a Fulbright Research Scholar, the author presents his views on East Africa's need for expansion of farm forestry, improvement of damaged local climate, management of grazed areas, and catchment management and research.

174. **Hursh, C. R.** Frog makes record. Bull. 21(16). Washington, DC: U.S. Department of Agriculture, Forest Service; 1937. 6 p.

The recording of the journeys of a small frog on the float of a water-level recording instrument in a ground-water observation well is described.

175. **Hursh, C. R.** The geomorphic aspects of mudflows as a type of accelerated erosion in the Southern Appalachians. Transactions, American Geophysical Union, Part 2: 253-254; 1941.

Under certain conditions, high infiltration rates and deep soils give rise to conditions which cause mudflows. After prolonged rainfall, the soil mass is surcharged with water; a major surface break, such as uprooting of large trees, may start mass movement. The nature of movement of the soil mass depends on the slope of the contact zone with stable material.

176. **Hursh, C. R.** Litter keeps forest soil productive. Southern Lumberman 133(1734): 219-221; 1928.

Forest soils are, for the most part, self-fertilized by organic material derived from litter. Litter has a beneficial effect on the ability of soil to absorb and retain moisture, on chemical characteristics, and on biological activity. The effects of fire and aspect on litter production are discussed.

177. **Hursh, C. R.** Local climate in the Copper Basin of Tennessee as modified by the removal of vegetation. Circ. 774. Washington, DC: U.S. Department of Agriculture; 1948. 38 p.

Meteorological records were collected from three contiguous land areas that once supported a uniform hardwood forest but are now characterized by three distinct vegetative conditions: forest, grass, and bare soil. Differences in air and soil temperatures, wind, evaporation, moisture saturation deficit of the air, and rainfall indicate that each vegetative zone possesses a distinctive local climate.

178. **Hursh, C. R.** Mulching for road bank fixation. Tech. Note 31. Asheville, NC: U.S. Department of Agriculture, Forest Service, Appalachian Forest Experiment Station; 1938. 4 p.

Road bank fixation on dry, infertile sites is particularly troublesome, and the use of mulches on dry and infertile banks at the time banks are planted is the most successful and inexpensive method of stabilization. Transplanting of woody shrubs offers no particular problem. Two general methods of mulch application are (1) staked weed mulches and (2) staked brush and litter mulches. The author lists materials, equipment, labor requirements, and procedures for mulch application.

179. **Hursh, C. R.** The naturalization of roadbanks. Roads and Bridges (Can.) 80(7): 22-26, 131-137; 1942.

Naturalization and stabilization of roadbanks by vegetation are discussed as part of road construction. Experiments begun in 1934 at the Appalachian Forest Experiment Station indicate that seeding, planting, fertilizing, and mulching are methods of stabilizing banks.

180. **Hursh, C. R.** The naturalization of roadbanks. Tech. Note 51. Asheville, NC: U.S. Department of Agriculture, Forest Service, Appalachian Forest Experiment Station; 1942. 36 p.

The problems involved in natural stabilization of roadbanks, including the factors limiting plant growth and the origin and causes of soil stability, are discussed. Suggestions are given for stabilization of banks with different slopes and with moist, fertile soil and dry, infertile soil. Establishment of vegetation with commercial fertilizers, seeding, planting, and mulches is discussed.

181. **Hursh, C. R.** Now is the time. Farmers Federation News 32(7): 12; 1952.

Owners of idle land are urged to initiate conservation measures. The value of trees for protection against erosion, stream sedimentation, and local floods is emphasized.

182. **Hursh, C. R.** Outline for compiling precipitation and runoff data from small drainage areas. Tech. Note 34. Asheville, NC: U.S. Department of Agriculture, Forest Service, Appalachian Forest Experiment Station; 1940. 59 p.

This is the original description of procedures used by the Station for the systematic compilation of continuous records of precipitation and stream discharges.

183. **Hursh, C. R.** Plants, shrubs, trees in slope stabilization. Contractors and Engineers Monthly 42(6): 26-27; 1945.

Natural vegetation is the most efficient and esthetically pleasing means of roadbank stabilization. Deep-rooted legumes such as perennial lespedeza and Scotch broom together with native woody shrubs are advised. In the Eastern States, rainfall and site conditions favor a plant succession toward a forest cover, but the possibility of trees being uprooted or interfering with viewing distance should be taken into account.

184. **Hursh, C. R.** Research in forest-streamflow relations. Unasylva 5: 2-9; 1951.

The objectives of the research program at the Coweeta Hydrologic Laboratory are defined, and current watershed studies are described. The practical significance of research findings in the management of watershed resources is discussed.

185. **Hursh, C. R.** Roadbank stabilization at low cost. Tech. Note 38. Asheville, NC: U.S. Department of Agriculture, Forest Service, Appalachian Forest Experiment Station; 1939. 20 p.

Low-cost methods of establishing vegetation on cut-and-fill slopes of roadbanks are described. Planting and seeding without preliminary stabilization are too expensive for extensive use. Two types of mulch application--staked weed mulches and staked brush and litter mulches--are outlined. Requirements for labor and equipment are listed, and procedures for mulch application are discussed.

186. **Hursh, C. R.** Water from the family spring. Living Wilderness 16(39): 11-12; 1952.

The part a spring plays in rural family life is described.

187. **Hursh, C. R.** Water resource management. North Carolina Engineer 3(2): 9-12, 40; 1947.

This article is a general summary on the research facilities, program, and findings at the Coweeta Hydrologic Laboratory.

188. **Hursh, C. R.** Water storage limitations in forest soil profiles. Proceedings, Soil Science Society of America 8: 412-414; 1944.

At Coweeta, measurements of macro-pore space were used to estimate differences in water storage between natural forest soil and soil from pine stands on eroded old-field land.

189. **Hursh, C. R.** Watershed aspects of the New York water supply problems. Journal of Forestry 49: 442-444; 1951.

Watershed aspects of New York's problems with water supply from the Croton and Catskill systems are discussed. Past practices in forest conservation have contributed to the development and protection of these systems. However, complete closure is not synonymous with watershed management; vegetative management is often a direct means of improving soil and increasing water resource values. Watershed problems which merit further consideration are listed by priority.

190. **Hursh, C. R.** Watershed experiments conducted in giant outdoor laboratory. Timber Topics 10(4): 2-4, 9; 1947.

The author reviews the objective of watershed research at the Coweeta Hydrologic Laboratory and discusses the effects on water yield of clearing and cultivating steep forest lands, of complete removal of forest trees, of woodland grazing, and of logging and burning watersheds.

191. **Hursh, C. R.** Watershed management: 1931-1946. Anniv. Rep. 1921-1946. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1946: 43-50.

This is a progress report of the activities at Coweeta Hydrologic Laboratory and Copper Basin from 1931 to 1946.

192. **Hursh, C. R.** Where little waters write big stories. American Forests 52: 574-577, 603; 1946.

The author describes watershed experiments underway at the Coweeta Hydrologic Laboratory and discusses what has been learned about water yield and erosion from studies of complete removal of forests, of clearing and cultivating steep forest lands, and of woodland grazing.

193. **Hursh, C. R.; Brater, E. F.** Separating storm-hydrographs from small drainage-areas into surface- and subsurface-flow. Transactions, American Geophysical Union, Part 3: 863-871; 1941.

This classic study of hydrographs from streams and groundwater wells demonstrates that hydrographs from forested catchments at Coweeta are comprised of channel precipitation and various subsurface flow components rather than overland flow. In accounting for the stormflow volume, the authors describe five sources of stormwater. They also describe the process which became known 20 years later as the concept of variable source area.

194. **Hursh, C. R.; Connaughton, C. A.** Effects of forests upon local climate. Journal of Forestry 36: 864-866; 1938.

Early studies of the effects of forests on climate as authorized in the United States under the McSweeney-McNary Forest Research Act of 1928 are described. Indications are that forests exert little influence on climate of large areas but

have a marked effect on local or environmental climate. Observations were made at Copper Basin, a 7,000-acre area completely denuded by smelter fumes, and in the adjacent hardwood forest. The information obtained on microclimate has application in studies of fire, shelter-belts, forest management, and watershed management.

195. **Hursh, C. R.; Craddock, G. W.** Review on book "Hydrology" by C. O. Wisler and E. F. Brater. Journal of Forestry 47: 844-845; 1949.

As the citation indicates.

196. **Hursh, C. R.; Crafton, W. M.** Plant indicators of soil conditions on recently abandoned fields. Tech. Note 17. Asheville, NC: U.S. Department of Agriculture, Forest Service, Appalachian Forest Experiment Station; 1935. 3 p.

Growing conditions on abandoned farm fields to be reforested are indicated by the species of plants present. Plant indicators which serve as guides in the selection of tree species and planting methods are given for four grades of sites, as determined by the amounts of soil moisture and nutrients present. Plant succession on each of these sites is discussed.

197. **Hursh, C. R.; Fletcher, P. W.** The soil profile as a natural reservoir. Proceedings, Soil Science Society of America 7: 480-486; 1943.

A 7-acre watershed was intensively instrumented with groundwater wells to test the concept that the soil profile has a measurable storage capacity and a regulating effect on ground-water discharge. Well elevations were correlated with measured discharge so that aquifer dimensions and porosity required for detention storage could be estimated. Three types of reservoir functions of the soil profile were recognized.

198. **Hursh, C. R.; Haasis, F. W.** Effects of 1925 summer drought on Southern Appalachian hardwoods. Ecology 12: 380-386; 1931.

Total rainfall recorded at Asheville, N.C., from May to August 1925 was 5.11 inches, whereas the normal is 15.97 inches. Trees on ridges and upper slopes between 2,100 and 2,600 feet elevation became wholly or partially brown during August and September, and some species (chiefly oaks and shortleaf and pitch pines) experienced premature leaf fall. Leaf browning and early fall were more pronounced on younger trees and were particularly severe on dogwood, sourwood, and

chestnut. Chestnut oaks and pine survived on areas where black oaks were completely killed.

199. **Hursh, C. R.; Hoover, M. D.** Naturalized roadbanks. Better Roads 12(6): 13-15, 24-25; 12(7): 17-20; 1942.

Naturalization and stabilization of roadbanks by vegetation are discussed as part of road construction. Experiments begun in 1934 at the Appalachian Forest Experiment Station indicate that seeding, planting, fertilizing, and mulching are practical methods of stabilizing banks.

200. **Hursh, C. R.; Hoover, M. D.** Soil profile characteristics pertinent to hydrologic studies in the southern Appalachians. Proceedings, Soil Science Society of America 6: 414-422; 1942.

The two most essential profile characteristics in hydrologic studies--retention and detention storage--are functions of soil porosity, water-storage opportunity, and transmission rate of water. Detention storage is measured as noncapillary porosity. Retention storage is measured in terms of additional water of specific retention needed to satisfy capillary requirements. The characteristics of pore space in the soil mass can be easily determined by utilizing the principle of water displacement of air from undisturbed volume samples.

201. **Hursh, C. R.; Hoover, M. D.; Fletcher, P. W.** Studies in the balanced water-economy of experimental drainage-areas. Transactions, American Geophysical Union. Part 2: 509-517; 1942.

In this intensive study of the water balance, estimates of precipitation, ground-water and surface-water flow, and evapotranspiration are the factors used to account for water circulating through a watershed system.

202. **Hursh, C. R.; Lieberman, J. A.** Watershed management in the Southeastern States. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1946. 7 p.

Knowledge gained at Coweeta from cutting forest stands, unrestricted logging, mountain farming, and woodland grazing is related to good watershed management in the Southeast.

203. **Hursh, C. R.; Pereira, H. C.** Field moisture balance in the Shimba Hills, Kenya. East Africa Agricultural Journal 18(4): 1-7; 1953.

This article draws on limited observations and field measurements to reconstruct and compare the moisture balance of the grass-covered and depleted Shimba Hills of Kenya with that under a natural forest. The natural forest, which once occupied the Shimba Hills, is a more desirable cover than grass for maximum-sustained water yield because water additions from mist and dew are greater from the forest.

204. **Hursh, Charles R.; Barrett, Leonard I.** Forests of Georgia highlands; their importance for watershed protection, recreation and wood production. Bull. 15. Georgia Forest Service, 1931. 32 p. U.S. Forest Service, Georgia Forest Service, and Georgia Agricultural Experiment Station Cooperating.

The results of an early investigation of the value of Georgia's mountain forests with respect to timber production, watershed protection, and recreation use are presented.

205. **Johnson, Dale W.; Hornbeck, J. W.; Kelly, J. M.; Swank, W. T.; Todd, D. E.** Regional analysis of soil sulfate accumulation: relevance to ecosystem sulfur budgets. In: Shriner, D. S.; Richmond, C. R.; Lindberg, S. E., eds. Potential environmental and health consequences of atmospheric sulfur deposition: proceedings of the second life science symposium; 1979 October 14-18; Gatlinburg, TN. Ann Arbor, MI: Ann Arbor Science Publications, Incorporated; 1980: 507-520.

Analyses of soils from Walker Branch, Camp Branch, and Cross Creek, Tenn.; Coweeta, N.C.; and Hubbard Brook, N.H., support the hypothesis that watershed sulfur accumulation is due to inorganic sulfate adsorption in soils. Analyses of soils from lysimeter study sites at La Selva, Costa Rica, and Thompson site, Wash., produced similar results. In laboratory adsorption studies, only soils from Coweeta retained substantial (50 to 100 percent) additional amounts of sulfate in insoluble forms.

Soil-adsorbed sulfate content and sulfate-adsorption capacity were positively correlated with free iron content but negatively correlated with organic matter content. Organic matter apparently blocks adsorption sites, preventing sulfate adsorption in iron-rich A horizons and Spodosol B2ir horizons. This blockage may account for the accumulation of adsorbed sulfate in B horizons in temperate and tropical soils and the susceptibility of New England Spodosols to leaching by H_2SO_4.

206. **Johnson, E. A.** Effect of farm woodland grazing on watershed values in the southern Appalachian Mountains. Journal of Forestry 50: 109-113; 1952.

The effects of 11 years of grazing cattle on a forested Appalachian watershed are reported. The experiment is described; the effects of grazing on vegetation, soil, and water are presented; and practical implications of grazing mountain watersheds are discussed.

207. **Johnson, E. A.** Watershed studies producing valuable information. Outdoor News Bulletin 3(11): 4; 1949.

Research at Coweeta to determine the influence of management practices on streamflow is briefly discussed.

208. **Johnson, E. A.; Kovner, J. L.** Increasing water yield by cutting forest vegetation. Georgia Mineral Newsletter 7(4): 145-148; 1954.

The authors report on changes in water yield at Coweeta after several different forest treatments.

209. **Johnson, E. A.; Meginnis, H. G.** Effect of altering forest vegetation on low flows of small streams. In: 12th general assembly International Union of Geodesy and Geophysics, International Association of Scientific Hydrology; 1960 July 25 - August 6; Helsinki, Finland. Publication 51. Washington, DC: International Association of Scientific Hydrology 1960: 257-266.

Large increases in low flows were recorded after mountain hardwood stands were cut on controlled watersheds in North Carolina, and appreciable decreases in flow were recorded after pines were planted on a small Ohio watershed.

210. **Johnson, Edward A.; Dils, Robert E.** Outline for compiling precipitation, runoff, and ground water data from small watersheds. Stn. Pap. 68. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1956. 40 p.

Procedures used at the Coweeta Hydrologic Laboratory for systematic compilation of data for continuous records of precipitation and stream discharges are described.

211. **Johnson, Edward A.; Kovner, Jacob L.** Effect on streamflow of cutting a forest understory. Forest Science 2: 82-91; 1956.

On Coweeta Watershed 19, the laurel and rhododendron understory (22 percent of total basal area) was cut between December 1948 and March 1949. A 4-inch increase in water yield was achieved the first year after treatment, and the yield

increase declined during the next 6 years. This increase was almost evenly divided between the growing and dormant seasons.

212. **Johnson, Philip L.; Swank, Wayne T.** Studies on cation budgets in the southern Appalachians on four experimental watersheds with contrasting vegetation. Ecology 54: 70-80; 1973.

Concentrations and flux of cations moving through a hardwood forest stand, a weed to forest succession, a hardwood coppice stand, and an eastern white pine stand on steep mountain topography are compared. Although concentrations for Ca^{++}, Mg^{++}, K^{+} and Na^{+} combined were usually less than 3.5 p/m, over 98 percent of the loss of each cation was in dissolved form on all four watersheds. Regression analysis showed that 50 to 60 percent of the variation in monthly weighted average concentration was accounted for by monthly discharge amounts. Annual losses of the four cations from the mature hardwood stand were in the amounts of approximately 7, 3, 5, and 10 kg/ha, respectively, for the Ca^{++}, Mg^{++}, K^{+}, and Na^{+}. Annual budgets showed net changes to be -0.8, -1.8, -2.0, and -4.3 kg/ha, respectively, for this mature hardwood ecosystem. In contrast, the weed stand lost significantly greater amounts, and the young pine and hardwood coppice watersheds showed a net gain in Ca^{++} and significantly lower losses than the mature ecosystem for the other three ions. These budgets show that major alterations to these forest ecosystems are not now producing a substantial out-flux for these cations.

213. **Kirby, J. M.; Webster, J. R.; Benfield, E. F.** The role of shredders in detrital dynamics of permanent and temporary streams. In: Fontaine, Thomas D., III; Bartell, Steven M. Dynamics of lotic ecosystems. Ann Arbor, MI: Ann Arbor Science Publishers; 1983: 425-435.

It has been suggested that leaf-shredding insects have an important role in breakdown of leaf detritus and the production of particulate organic matter (POM) in streams. This role was evaluated by comparing detrital dynamics in three permanent and three temporary tributaries of Guys Run, Rockbridge County, Virginia. In general, the streams with fastest leaf breakdown, highest low-flow POM concentrations, and largest average POM particle sizes were found to have the greatest shredder and total insect densities. It was concluded that this is further evidence for the importance of shredders in woodland streams.

214. **Knipling, Edward B.** Effect of leaf aging on water deficit-water potential relationships of dogwood leaves growing in two environments. Physiologia Plantarum 20: 65-72; 1967.

The relationships between water deficit and water potential were not the same for dogwood leaves of different ages or for leaves of the same age but growing in different environments. With leaf aging, particularly under high light intensity and dry environmental conditions, the relationships shifted to progessively lower water potentials for a given water deficit, increased dry weight, decreased cell-wall elasticity, and decreased osmotic potentials. The lack of constancy in the relationships reduces the usefulness of water deficit or relative turgidity as an estimator of water potential.

215. **Knipling, Edward B.** Measurement of leaf water potential by the dye method. Ecology 48: 1038-1041; 1967.

The dye method for measuring leaf water potential is simple, inexpensive, and suitable for both laboratory and field work. Leaves are immersed in a graded series of solutions, and the solution which neither gains nor loses water is assumed to have a water potential equal to that of the leaf.

216. **Knipling, Edward B.; Kramer, Paul J.** Comparison of the dye method with the thermocouple psychrometer for measuring leaf water potentials. Plant Physiology 42: 1315-1320; 1967.

The dye method for measuring water potential was compared with the thermocouple psychrometer method and found to be useful for measuring leaf water potentials of forest trees and common laboratory plants.

217. **Kovner, J. L.** Evapotranspiration in forest stands of the southern Appalachian Mountains. Bulletin of the Georgia Academy of Science 15(3): 80-85; 1957.

The author presents a method of estimating evapotranspiration by the water balance equation P - Ro = Ev, where P = precipitation, Ro = streamflow, and Ev = evapotranspiration, and discusses the relationship between estimated evapotranspiration and elevation.

218. **Kovner, Jacob L.** Evapotranspiration and water yields following forest cutting and natural regrowth. Proceedings, Society of American Foresters; 1956; Memphis, TN. Washington, DC: Society of American Foresters; 1957: 106-110.

The effects on stream regimen of cutting and later regrowth of a hardwood forest in the southern Appalachians are reported. Changes in stand density are compared with changes in streamflow and P - RO (precipitation minus runoff).

219. **Kovner, Jacob L.; Evans, Thomas C.** A method for determining the minimum duration of watershed experiments. Transactions, American Geophysical Union 35: 608-612; 1954.

A simple graphic solution is described for approximating the length of time required to detect significant differences between treatments on experimental watersheds.

220. **Larson, N. M.; Reeves, M.** Analytical analysis of soil-moisture and trace-contaminant transport. Springfield, VA: National Technical Information Service, U.S. Department of Commerce; 1976 March; Oak Ridge National Laboratory/National Science Foundation/Ecology and Analysis of Trace Contaminants Program - 12. 180 p.

The Darcy conservation equation was formulated for solution of moisture movement through soil. Development of formulation and FORTRAN implementation are given. Computed outflow - versus time curve was compared with experimental data from Coweeta Soil Model III and previous simulation by finite element technique.

221. **Lewis, Clifford E.; Harshbarger, Thomas J.** Shrub and herbaceous vegetation after 20 years of prescribed burning in the South Carolina Coastal Plain. Journal of Range Management 29: 13-18; 1976.

Twenty years of prescribed burning at different seasons and different frequencies altered the condition of shrub and herbaceous vegetation in the South Carolina Lower Coastal Plain. The six treatments were annual winter, annual summer, periodic winter, periodic summer, and biennial summer burning, and a no-burn control. Ground cover increased with most burning treatments, and herbage yields increased with all treatments. Annual summer burning eliminated most shrubs but periodic summer, annual, and periodic winter treatments did not. The number and density of herbaceous species increased with burning, especially on the annual and biennial summer treatments. Most of these changes appear beneficial for wildlife or grazing.

222. **Lieberman, J. A.; Fletcher, P. W.** Further studies of the balanced water cycle on experimental watersheds. Transactions, American Geophysical Union 28: 421-424; 1947.

Maintaining a chronological account or balance of the components of the water resource on a watershed is frequently valuable in hydrology studies. In this paper, a time period for studying this balance is described: the period between

the times of maximum watershed storage at the end of each dormant season. Changes in ground-water storage are thus taken into account, and, by choosing the beginning and ending points of the year at times of field capacity, changes in water storage in the soil mass are minimized.

223. **Lieberman, J. A.; Hoover, M. D.** The effect of uncontrolled logging on stream turbidity. Water and Sewage Works 95(7): 255-258; 1948.

The effects of the unrestricted logging of Watershed 1U at Coweeta on soil erosion and stream turbidity are reported. The authors stress the need for improvements in the design, location, and maintenance of roads and in logging methods.

224. **Lieberman, J. A.; Hoover, M. D.** Protecting quality of stream flow by better logging. Southern Lumberman 177(2225): 236-240; 1948.

The authors report on the results of unrestricted logging on Watershed 10 at Coweeta and present suggestions for road location and maintenance and logging practices which will protect the soil and water resource.

225. **Lieberman, J. A.; Hoover, M. D.** Stream-flow frequency changes on Coweeta experimental watersheds. Transactions, American Geophysical Union 32: 73-76; 1951.

Frequency distribution curves of mean daily discharge from treated and control watersheds at Coweeta are compared for the prior- and post-treatment periods. Conclusions are drawn about the effect of the treatments on the regimen of daily streamflow and about the practicability of using frequency distribution curves to show streamflow changes brought about by experimental land use treatments.

226. **Lieberman, Joseph A.** Water resource and watershed management research in the Southeast. American Waterworks Association Journal 39(5): 443-454; 1947.

The facilities, research program, and research findings at Coweeta Hydrologic Laboratory are reviewed.

227. **Lindberg, E.; Turner, R.; Lovett, M.** Mechanisms of the flux of acidic compounds and heavy metals onto receptors in the environment. In: Acid precipitation - origins and effects: VDI - Berichte 500; 1983 June 7-9; Lindau, West Germany. Dusseldorf, West Germany: Verlag des Vereins Deutscher Ingenieure; 1983: 165-171.

The authors report results of investigations of dry and wet atmospheric deposition of H, Cd, Mn, Pb, and Zn to several forested areas in the Eastern United States including Coweeta. The dry deposition of soluble metals on leaf surfaces was found to be significant. Their interaction with precipitation increases concentrations, which may augment their physiological effects, particularly during periods of light precipitation.

228. **Lindberg, S. E.; Turner, R. R.** Trace metals in rain at forested sites in the Eastern United States. In: Proceedings of the international conference on heavy metals in the environment; 1983 September 6-9; Heidelberg, West Germany. Edinburgh, Scotland: CEP Consultants, Ltd., 1983: 107-114.

Precipitation was collected intermittently between 1975 and 1982 as wetfall-only at four forested sites in the Southeastern United States and analyzed for Cd, Mn, Pb, and Zn. Mean concentrations at these rural sites were low. Significant temporal and spatial trends were observed: all metal concentrations were higher during warm weather periods; concentrations of Cd and Pb decreased from 1976-1977 to 1980-1982; and for this later period Cd and Pb also exhibited significant differences in concentration among sites. Manganese exhibited no significant trends. Metal concentrations in rain are negatively correlated with rainfall amount. We estimate that in-cloud aerosol scavenging dominates the long-term total wet deposition of these elements, but it is more important for Pb than for Cd and Mn.

229. **McMinn, Jane W.; Hewlett, John D.** First-year yield increase after forest cutting: an alternative model. Journal of Forestry 73(10): 654-655; 1975.

Analysis of the biologic and hydrologic processes suggests a more logical and general nonlinear model than the simple linear one previously used. Predictions of water yield increase based on the alternative model agree with those of the earlier model for heavy reductions in stand density, but are also forced to be non-negative for light reductions in stand density.

230. **McSwain, Michael R.** Baseline levels and seasonal variations of enteric bacteria in oligotrophic streams. In: Correll, David L., ed. Watershed research in eastern North America: a workshop to compare results; 1977 February 28 - March 3; Edgewater, MD. Edgewater, MD: Smithsonian Institution; 1977: 555-578.

Naturally occurring populations of enteric bacteria fluctuated seasonally and diurnally in mountain streams. Measurements of enteric bacteria were correlated with stream turbidities and stream temperatures. Data suggested that seasonal cycles were caused by multiplication of enteric bacteria in bottom sediments and that multiplication was regulated by stream temperatures. Elevated levels of total and fecal coliforms during storms appeared more related to bottom sediment disturbances than to streambank flushing. In contrast, increases in fecal streptococcus counts during storms appeared more related to the washing of overhanging stream vegetation and streambank flushing.

231. **McSwain, Michael R.; Swank, Wayne T.** Fluctuations in naturally occurring populations of enteric bacteria in oligotrophic streams of western North Carolina. Res. Note SE-158. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1977. 12 p.

In mountain streams of western North Carolina, naturally occurring populations of enteric bacteria fluctuated seasonally and diurnally. Seasonal fluctuations in total coliforms and fecal coliforms were apparently regulated by water temperature. Diurnal fluctuations in total coliforms were inversely related to daily cycles in streamflow. Total and fecal coliforms and fecal streptococci peaked during stormflows. These fluctuations complicate the assessment of water quality and should be considered in designs for stream sampling.

232. **McSwain, Michael R.; Watrous, Russel J.; Douglass, James E.** Improved methylthymol blue procedure for automated sulfate determination. Analytical Chemistry 46: 1329-1331; 1974.

Describes a methylthymol blue procedure which increases the sensitivity of sulfate determinations using automated equipment.

233. **Malas, Diane M.; Wallace, J. Bruce.** Strategies for coexistence in three species of net-spinning caddisflies (Trichoptera) in second order southern Appalachian streams. Canadian Journal of Zoology 55: 1829-1840; 1977.

Three species of net-spinning caddisflies, *Parapsyche cardis*, *Diplectrona modesta*, and *Dolophilodes distinctus* were studied. Larvae of *Dolophilodes* are found at the lowest current velocities followed by *Diplectrona*, then *Parapsyche*, which prefer the higher velocities. *Parapsyche* larvae are most abundant

on upper surfaces of stones while *Diplectrona* and *Dolophilodes* are found primarily on undersides of stones. These distribution patterns are probably related to capture net mesh dimensions which differ greatly for the three species, *Parapsyche* having the largest and *Dolophilodes* the smallest meshes. There are large differences between mesh opening sizes of last-instar *Dolophilodes* and first- and second-instar *Diplectrona* larvae. However, based on mean particle size measurements of foregut contents, there is no corresponding gap in the spectrum of particle sizes used for food. Dietary composition also varied between species. *Parapsyche* consumed primarily animal material. Fine particulate detritus composed over 95 percent of *Dolophilodes* gut contents and *Diplectrona* consumed mostly vascular plant and detritus fragments in late instars and fine particulate detritus in early instars.

234. **March, William J.; Wallace, James R.; Swift, Lloyd W., Jr.** An investigation into the effect of storm type on precipitation in a small mountain watershed. Water Resources Research 15: 298-304; 1979.

A set of regression equations relating storm rainfall depth to watershed topography and storm type was derived for the high-density precipitation network at Coweeta Hydrologic Laboratory. The most general equation predicted storm amounts for an independent test group of gages with an average error of 0.38 cm (0.15 inches). Predictions for the air-mass or thunderstorm type had the greatest errors. The dependent variable was the ratio of rainfall at each gage site to rainfall at a base gage. Predictive variables were topographic slope, aspect, ground elevation at the gage site, and smoothed elevation.

235. **Mayack, David T.; Bush, Parshall, B.; Neary, Daniel G.; Douglass, James E.** Impact of hexazinone on invertebrates after application to forested watersheds. Archives of Environmental Contamination and Toxicology 11: 209-217; 1982.

The impact of the herbicide, hexazinone, was assessed on aquatic macrophytes, aquatic and terrestrial invertebrate communities within forested watersheds in the Georgia Piedmont. Four watersheds were treated and subsequently monitored for 8 months. Residue levels in terrestrial invertebrates were a maximum of two orders of magnitude greater than comparable levels (0.01 to 0.18 p/m) found in forest floor material. Aquatic organisms in a second-order perennial stream were exposed to intermittent concentrations of hexazinone (6 to 44 p/b). Hexazinone residues were generally not detected (<0.1 p/m) in aquatic invertebrates and macrophytes. No

major alterations in species composition or diversity were detected in the aquatic macroinvertebrate community.

236. **Meginnis, H. G.** Increasing water yields by cutting forest vegetation. In: Woodlands and water-lysimeters: Symposium, International Union of Geodesy and Geophysics. International Association of Scientific Hydrology; 1959 September 8-13; Hannoversch-Munden, Germany. Publication 48. Gerdbrugge, Belgium: International Association of Scientific Hydrology; 1959: 59-68.

The author discusses volume and timing of yield increases produced by clearcutting with annual cutting of regrowth, clearcutting with coppice regrowth allowed, and clearcutting of understory vegetation. Despite indications afforded by these experiments, a more complete knowledge of water requirements of cover and of plant-soil-climatic factors which govern evapotranspiration is required before yield increases caused by cover manipulations can be predicted accurately.

237. **Meginnis, H. G.** Watershed management research--challenging career for young scientists. Ames Forester 47: 20-24; 1960.

The author outlines present knowledge in the field of watershed management, needs for further research, and opportunities for specialists in many disciplines who might wish to enter this field.

238. **Merrick, Elliot T.; Johnson, E. A.** Mountain water. American Forests 58(10): 30-32, 38; 1952.

Objectives of the research program at Coweeta and studies of stream temperature and interception are briefly discussed.

239. **Merritt, Richard W.; Wallace, J. Bruce.** Filter-feeding insects. Scientific American 244(4): 132-136, 141-142, 144; 1981.

This article discusses the variety of mechanisms that filter-feeding insect larvae employ to capture and ingest their food. These larvae utilize organic material which would otherwise be transported downstream, playing an important role in the processing and storage of organic material in stream ecosystems.

240. **Meyer, Judy L.; Johnson, Carol.** The influence of elevated nitrate concentration on rate of leaf decomposition in a stream. Freshwater Biology 13: 177-183; 1983.

Leaf decomposition was compared in two Coweeta streams, one draining an undisturbed hardwood watershed (18) and one draining a successional watershed (6) subject to an insect outbreak. The successional watershed had elevated nitrate concentrations in the streamwater. Both black locust (*Robinia pseudo-acacia*) and sweet birch (*Betula lenta*) leaf litter decomposed 2.8 times more rapidly in the stream with high nitrate concentrations. The more rapid decay rates appeared to be partly due to accelerated microbial processing in response to nitrate enrichment, because microbial biomass (as ATP) was higher in the nitrate-enriched stream. Nitrogen and phosphorus content of the litter at the same state of decay was the same in the two streams.

241. **Meyer, Judy L.; O'Hop, Joe.** Leaf-shredding insects as a source of dissolved organic carbon in a headwater stream. American Midland Naturalist 109: 175-183; 1983.

We investigated the importance of leaf-shredding insects as generators of dissolved organic carbon (DOC) in a headwater stream. We fed three common shredders (*Peltoperla maria, Pteronarcys scotti,* and *Tipula* spp.) naturally conditioned leaves and measured the rates at which they generated DOC. Rates ranged from 0.2 to 160 μg C·mg AFDW^{-1}·d^{-1}, and 62 percent of this variation could be explained by organism weight. Less than 10 percent of DOC generated was produced by mechanical breakup of the leaves. DOC generated was predominantly of high (>10000 daltons) molecular weight. DOC released by shredders is a potentially significant source of DOC in headwater streams during low flow. Shredder feeding is potentially as important a source of DOC in small streams as leaching of leaf litter.

242. **Meyer, Judy L.; Tate, Cathy M.** The effects of watershed disturbance on dissolved organic carbon dynamics of a stream. Ecology 64: 33-44; 1983.

The response of a stream ecosystem to watershed disturbance was investigated by comparing budgets of DOC for a stream draining an undisturbed watershed with a stream draining a watershed clearcut 2 years previously. Both streams had elevated DOC concentration during storms. In the undisturbed stream, DOC concentration increased from seep to weir during the growing season. DOC concentration and annual export from the clearcut watershed was less (9.8 - 11.5 kg/ha) than from the reference (14.6 - 15.1 kg/ha). Lower export was partly due to reduced DOC inputs from throughfall and leaching litter, but most importantly to lower DOC inputs in subsurface water and less in-stream generation of DOC. The rate

of recovery of this stream from disturbance is dependent on the rate at which the terrestrial system recovers.

243. **Mitchell, John E.; Waide, Jack B.; Todd, Robert L.** A preliminary compartment model of the nitrogen cycle in a deciduous forest ecosystem. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems: Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 41-52.

A compartment model of nitrogen storage and transfer in a mature hardwood forest at Coweeta Hydrologic Laboratory is described and discussed. Most of the nitrogen in this ecosystem is localized in large storage compartments that turn over slowly. Over 80 percent of the total nitrogen is in soil organic matter, with about 11 percent in vegetation, 3 percent in litter, 4 percent in microbes, and 2 percent in free soil pools. Uptake of nitrogen is estimated to be 141.6 kg ha^{-1} $year^{-1}$, of which about 10 percent is retained within the vegetation. A quantitatively large pool of nitrogen is shown to recycle annually within plants. Calculations suggest that litter inputs to soil organic pools are dominated by belowground material, especially small roots and mycorrhizae. In the soil available nitrogen seems to be rapidly immobilized by soil biota or taken up by the root--mycorrhizae complex, with very little nitrogen being lost from the system in stream water or via denitrification. The picture that emerges from this study is that of a dynamic cycle in which nitrogen is efficiently retained and recycled within the ecosystem.

244. **Monk, Carl D.** Nutrient losses in particulate form as weir pond sediments from four unit watersheds in the southern Appalachians. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems: Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 862-867.

Weir-pond sediments were collected at 3-month intervals for a period of 2 years from four watersheds with contrasting vegetation. Annual sediment losses for the four watersheds were 283 kg/ha from the coppice hardwoods, 176 kg/ha from the old field, 76 kg/ha from the pine plantation, and 30 kg/ha from the mature hardwoods. Greater losses occurred during the winter season. The composition of the sediments from the old field, coppice hardwoods, and pine plantations

were similar. Nutrient concentrations varied from watershed to watershed and in some instances seasonally. Nutrient loss as weir-pond sediments accounts for no more than 1 percent of the total loss.

245. **Monk, Carl D.** Species and area relationships in the eastern deciduous forest. Journal of the Elisha Mitchell Science Society 87: 227-230; 1971.

The species curve derived from data within the Eastern Deciduous Forest is a three-component curve.

Species and area are linearly related to areas between 10^2 to 10^6 sq. km with a slope of approximately 0.25. The model that gives the best fit is a simple log-log regression equation. In large contiguous continental sites, area is a better estimator of the number of species than maximum elevation or elevation range. Since elevation and area are highly correlated, including both in multiple regression models does not improve the prediction of number of species.

246. **Monk, C. D.; Crossley, D. A., Jr.; Todd, R. L.; Swank, W. T.; Waide, J. B.; Webster, J. R.** An overview of nutrient cycling research at Coweeta Hydrologic Laboratory. In: Correll, David L., ed. Watershed research in eastern North America: a workshop to compare results; 1977 February 28 - March 3; Edgewater, MD. Edgewater, MD: Smithsonian Institution; 1977: 35-50.

A research program at the Coweeta Hydrologic Laboratory, North Carolina, is investigating effects of manipulations on nutrient cycling and productivity of forested watersheds. The experimental approach is to explain whole ecosystem behavior, as revealed by watershed nutrient and water budgets, by reference to internal ecosystem processes. This report describes the general scope of the research at process levels, and relates dynamics of internal processes to ecosystem level response. The research is organized around a general theory of ecosystem relative stability, based on the complementary aspects of resistance to disturbance and resilience following disturbance.

247. **Moore, Allen; Swank, Wayne T.** A model of water content and evaporation for hardwood leaf litter. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems: ERDA Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 58-69.

A predictive model of water content and evaporative losses in the litter of a mixed deciduous forest is presented. The model uses readily obtainable data on total daily incoming solar radiation, rainfall, mean daytime temperature, and mean daytime relative humidity. The model also requires data on site latitude, slope and aspect; initial litter accumulation; annual quantity and timing of leaf fall; and transmission of solar radiation through the canopy. The model incorporates throughfall and litter decay functions. Model performance was tested against independent data collected over 8- to 11-day periods in summer and winter seasons and agreed within 13 percent of estimated evaporation. Daily values of litter water content were usually within the error limits of experimental data. Predicted evaporation and litter water content over an 80-day period also showed good agreement with experimental data.

248. **Mueller, E. A.; Sims, A. L.** Raindrop distibutions at Franklin, North Carolina. Tech. Rep. ECOM-02071-RR3. Fort Monmouth, NJ: U.S. Army Electronic Command, Atmospheric Sciences Laboratory; 1967. 165 p.

Raindrop-size distributions are presented in a tabular form for 4,742 samples of one cubic meter each. These were obtained from a drop camera near Franklin, N.C., during the period of December 21, 1960, through March 25, 1962. For each of the samples, certain parameters calculated from the distribution are reported. These include rainfall rate, radar reflectivity, liquid water content, attenuation cross-section, median volume diameter, and the total number of drops. Average distributions for various rainfall rates and radar reflectivities are also reported.

249. **Mueller, E. A.; Sims, A. L.; Cataneo, R.** Investigation of the quantitative determination of precipitation by radar. Interim Report 1. Fort Monmouth, NJ: U.S. Army Electronics Command; 1967. 58 p.

Rainfall drop-size distributions measured by Illinois State Water Survey drop camera at Coweeta Hydrologic Laboratory and four other sites in Eastern and Western United States were analyzed to define attenuation of weather radar at the 75-mile range. Drop-size distributions from Coweeta and New Jersey were similar, but both were different from Arizona data.

250. **Munns, Edward N.** Forest hydrology in the Appalachians. Journal of Soil and Water Conservation 2: 71-76; 1947.

The author discusses the beneficial effects of the forest on regulating streamflow, as opposed to other forms of land management, and also gives a general discussion of watershed experiments at the Coweeta Hydrologic Laboratory.

251. **Munns, Edward N.** Our forests and watersheds. Scientific Monthly 67(5): 347-354; 1948.

The research facilities, program, and findings at Coweeta Hydrologic Laboratory are summarized.

252. **Murphy, Charles E., Jr.; Knoerr, Kenneth R.** The evaporation of intercepted rainfall from a forest stand: an analysis by simulation. Water Resources Research 11(2): 273-280; 1975.

A model of the energy exchange between the atmosphere and a vegetated surface has been developed and used to investigate the sources of energy available for evaporation of precipitation intercepted by a forest canopy. Simulations with this model have demonstrated that a forest canopy wetted by rainfall will partition more of the absorbed radiant energy into latent heat exchange than an unwetted canopy in the same environment. This energy diversion creates a decrease in sensible heat transfer from the canopy to the atmosphere and a smaller decrease in a long-wave radiation emitted by the canopy.

253. **Neary, D. G.; Bush, P. B.; Douglass, J. E.** 2, 4, and 14-month efficacy of hexazinone for site preparation. In: Proceedings, Southern Weed Science Society; 1981 January 20-22; Dallas, TX. Champaign, IL: Southern Weed Science Society; 1981; 34: 181-191.

Hexazinone pellets were applied at 1.68 kg ai/ha to kill hardwoods in 60- to 80-year-old mixed hardwood-pine stand in the upper Piedmont of Georgia. Herbicidal effects on vegetation were observed within 2 weeks of the first rain, and defoliation of the hardwood canopy started 1 month later. Two months after the hexazinone application most oaks were severely affected. Four months after treatment, 63 to 91 percent of the oaks were completely defoliated. After 14 months, 83 to 96 percent of all oaks were killed, and most other hardwoods suffered heavy mortality. Mortality among residual pine stems were affected to some degree (5 to 15 percent).

254. **Neary, D. G.; Douglass, J. E.; Fox, Walter.** Low picloram concentrations in streamflow resulting from application of Tordon 10K. In: Proceedings, Southern Weed Science Society; 1979 January 23-25; Atlanta, GA. Auburn, AL: Auburn University Printing Service; 1979; 32: 182-197.

Picloram pellets were applied to Watershed 19 at the Coweeta Hydrologic Laboratory to prepare a low-quality hardwood stand for planting eastern white pine. The herbicide was applied in May 1978 at a rate of 50 kg ai/ha. Despite dry weather, 76 percent of the overstory plants and 95 percent of the rhododendron and laurel in the understory were initially affected. During the first 5 months after application, soil solution at 30 cm contained less than 10 p/b picloram until heavy rains in August; then, a peak of 174 p/b was measured. At 60 cm, picloram peaked at 179 p/b. At 120 cm, picloram never exceeded 3 p/b. Picloram was detected only twice in streamflow (maximum concentration 8 p/b).

255. **Neary, Daniel G.** Monitoring herbicide residues in springflow after an operational application of hexazinone. Southern Journal of Applied Forestry 7(4): 217-223; 1983.

Parts of two forested watersheds (440 ac and 482 ac) in central Tennessee were aerially treated with 15 pounds per acre of hexazinone pellets (10 percent active ingredient) to remove hardwood competition prior to establishing loblolly pine (*Pinus taeda* L.). Both treated watersheds and a control were monitored to determine if hexazinone residues were entering ground water and appearing in springflow. Seven months of monitoring included two intensively sampled periods during application and the first storm. No detectable residues of hexazinone or its two primary metabolites were measured in samples from a watershed in which hexazinone was applied up to 66 feet from the monitoring point. Springflow samples from a watershed treated a year earlier (in 1980) were also clear of herbicide residues.

256. **Neary, Daniel G.; Bush, Parshall B.; Douglass, James E.** Off-site movement of hexazinone in stormflow and baseflow from forest watersheds. Weed Science 31: 543-551; 1983.

Four forest watersheds in the upper Piedmont of Georgia were treated with hexazinone pellets at a rate of 1.68 kg ai/ha. Twenty-six storms were monitored to determine movement of hexazinone and two of its metabolites in runoff. Residues peaked in the first storm after application (442 $\pm$ 53 p/bw), and declined with subsequent storms in a power curve function. Loss of hexazinone averaged 0.53 percent of the applied herbicide, with two storms accounting for 59.3 percent of the chemical exported. Subsurface movement of hexazinone appeared in streamflow 3 to 4 months after application and produced an additional loss of 0.05 percent.

257. **Neary, Daniel G.; Currier, John B.** Impact of wildfire and watershed restoration on water quality in South Carolina's Blue Ridge Mountains. Southern Journal of Applied Forestry 6: 81-90; 1982.

Streams in the Blue Ridge Mountains of South Carolina were monitored after the 1978 Jumping Branch Wildfire. Differences in NO_3-N, NH_4-N, PO_4-P, Na, K, Ca, and Mg concentrations were attributed to the fire or watershed restoration. Concentrations of NO_3-N increased the most (peak of 0.394 mg/l), primarily as a result of fertilizer application during restoration operations. Ammonium nitrogen, NO_3-N, and PO_4-P levels were elevated on burned and fertilized watersheds mainly during storm events. Cation concentrations were 12 to 82 percent above background levels during the monitoring. Suspended solids showed no relationship to watershed condition. Changes in water quality did not reduce the value of the streams as a source of drinking water or affect aquatic ecosystem stability.

258. **Nelson, Thomas C.** Chestnut replacement in the southern highlands. Ecology 36: 352-353; 1955.

Seventeen 1/5-acre plots were established in 1934 prior to the onset of chestnut blight and were resurveyed in 1941 and 1953. Chestnut decreased from 41 to 1 percent of total basal area from 1934 to 1953. Basal area of yellow-poplar, black oak, and scarlet oak increased while other species remained approximately the same or decreased. Invasion of openings was primarily by sourwood, cucumber magnolia, sweet birch, and eastern hemlock.

259. **Nelson, Thomas C.; Johnson, Edward A.** Applying unit area control to watershed management. Journal of Forestry 52: 130; 1954.

The authors outline the potential application of unit area control to a watershed for integrated management of timber and water resources.

260. **Neves, Richard J.; Pardue, Garland B.** Abundance and production of fishes in a small Appalachian stream. Transactions of the American Fisheries Society 112: 21-26; 1983.

Fish production was evaluated at three sites in Guys Run, Virginia, an 8-km, second-order Appalachian stream, from August 1979 through July 1980. Mean standing stock ranged from 21.4 $kg \cdot hectare^{-1}$ upstream to 47.4 $kg \cdot hectare^{-1}$ downstream. Annual production by the fish taxocene was estimated at 28.4, 31.6, and 39.6 $kg \cdot hectare^{-1} \cdot year^{-1}$ in the

upper, middle, and lower sections, respectively. Brook trout *Salvelinus fontinalis*, mottled sculpin *Cottus bairdi*, blacknose dace *Rhinichthys atratulus*, and bluehead chub *Nocomis leptocephalus* were the dominant species, accounting for 87 to 99 percent of total fish production in the stream. Annual production: biomass (P/B) ratios ranged from 0.6 to 1.6 and were consistent with previously determined values for the same or similar species in other small streams.

261. **Nicholson, S. A.; Monk, C. D.** Plant species diversity in old-field succession on the Georgia Piedmont. Ecology 55: 1075-1085; 1974.

Species diversity of vascular plants was determined in 51 seral communities ranging from 0.2-200+ years old. Species richness, information content, redundancy, and evenness were calculated for numbers of individuals in four strata (ground layer, shrub, understory, and canopy). Richness (S) in the strata and major growth forms (herbs, woody vines, shrubs, and trees) increased rapidly following their establishment, then at a decreasing rate throughout the remainder of succession. Equitability, on the other hand, increased to near maximum levels immediately after establishment but changed little thereafter. Contrasts in seral richness and equitability trends suggest differing regulatory mechanisms--equitability being regulated primarily by short-term factors and richness by long-term factors.

262. **Nicholson, Stuart A.; Monk, Carl D.** Changes in several community characteristics associated with forest formation in secondary succession. American Midland Naturalist 93: 302-310; 1975.

Density, biomass, diversity, and niche structure of 51 successionally related plant communities from the Georgia Piedmont were examined. These characteristics displayed large stand-to-stand variation early in succession (0-30 years) but little thereafter. The time during succession at which these began to stabilize (about 30 years) coincided with the formation of a closed forest. Relative species importance values approximate a geometric series early in the sere. This reflects low species richness and dominance by a few species in accordance with a niche preemption hypothesis. In later stages, relative species importance value curves flatten, with some suggestion of the log-normal distribution.

263. **Nutter, Wade L.** Moisture and energy conditions in a draining soil mass. Athens, GA: University of Georgia, School of Forest Resources; 1975 June; Technical Completion Report, ERC 0875. 77 p.

A 6.1-m-long, 1.2-m-deep and 0.3-m-wide soil model was packed with a mixed subsurface horizon soil and saturated. Three slopes (25, 15 and 5 degrees) were drained at three depths (120, 80, and 40 cm). Equipotential lines of hydraulic head approach a position normal to the surface during the drainage sequence. The degree of divergence from normal increases with decrease in slope angle. Water content gradients suggest that a zone of active water movement migrates downslope during drainage and may identify the limits of source areas during stormflow. Slope angle exerted the greatest influence on the nature of drainage from a soil mass. Response of a moderately steep and moderately deep slope will be similar to that of a steep and deep slope.

264. **Nutter, Wade L.** The role of soil water in the hydrologic behavior of upland basins. In: Field soil science regime; 1971 August 15-20; New York. Madison, WI: Soil Science Society of America; 1973: 181-193.

Except during the most extreme storms, all the precipitation falling on well-vegetated slopes infiltrates and while some reappears in the channel as stormflow, a major portion remains in the basin as dynamic storage. During a storm, the stormflow source area expands out from the stream channel as slopes contribute subsurface flow and the channel system lengthens. After the storm, source areas may continue to expand as subsurface flow feeds the lower slopes near the channel, often leading to a second hydrograph peak. Physical models of hillslope segments have provided some insight into the flow pathways and source areas of subsurface flow.

265. **Nutter, Wade L.; Douglass, James E.** Consequences of harvesting and site preparation in the Piedmont. In: Tippin, T., ed. Proceedings: a symposium on principles of maintaining productivity on prepared sites; 1978 March 21-22; Starkville, MS. New Orleans, LA: U.S. Department of Agriculture; Southern Forest Experiment Station; 1978: 65-72.

Piedmont soils suffered years of abuse under agriculture. Now stabilized under forest, these sites are subject to change by harvesting and site preparation. Increased erosion and lowered water quality may occur as a result. These changes can be controlled if the manager specifies conservation practices and the amount of mineral soil that can be exposed during harvest and regeneration. Methods of site preparation applied in the Piedmont need to be reexamined in light of specific silvicultural objectives and disturbance created by various methods.

266. O'Hop, **Joe; Wallace, J. Bruce.** Invertebrate drift, discharge and sediment relations in a southern Appalachian headwater stream. Hydrobiologia 98: 71-84; 1983.

Drifting invertebrates and suspended sediments were collected at monthly intervals from June 1977 to May 1978. The numbers and biomass of drifting organisms reflected the seasonal cycles of aquatic insects. Some aquatic organisms showed behavioral drift either during a sample day or during some portion of their life cycle. *Parapsyche cardis* Ross and *Diplectrona modesta* Banks (Trichoptera: Hydropsychidae) dispersed as first instar larvae; few later instars of these two net-spinning caddisflies drifted. The drift of nymphal *Peltoperla maria* Needham et Smith (Plecoptera: Peltoperlidae) was apparently related more to detritus transport than to benthic densities or discharge alone. The general level of stream invertebrate drift appears to be related to detritus transport, and drift during storms is also related to detritus transport. During storms, terrestrial invertebrate drift was related to rainfall intensity, canopy washing, and channel expansion.

267. O'**Reilly, Patrick J.** Clock-hour/instantaneous rainfall rate relationships applicable to the Eastern United States. Tech. Note 71-12. Washington, DC: U.S. Air Force Environmental Technical Applications Center; 1971. 19 p.

Rainfall drop-size distributions measured by Illinois State Water Survey drop camera at Coweeta Hydrologic Laboratory and two other sites were used to derive climatological estimates of the frequencies of instantaneous rainfall rates at a point and along a surface horizontal path length as a function of the clock-hour rate. These relationships are intended primarily for use over the Eastern United States but may find application for other areas.

268. **Parker, G. R.; Swank, W. T.** Tree species response to clearcutting a Southern Appalachian watershed. American Midland Naturalist 108: 304-310; 1982.

A 16.1-ha watershed was experimentally clearcut in 1939 and again in 1962. All material over 1 cm in diameter was cut and left in place, thereby minimizing soil disturbance. Density data collected on permanent quadrats, before cutting, 13 years after the first cut and 15 years following the second cut, indicate vegetation response varies by species and physiographic position. There was also a difference in response between the two clearcuts. There was little change in number of tree species found per unit area following the two

clearcuts. However, certain species such as *Liriodendron tulipfera* became much more abundant while others decreased in abundance, especially on lower slope to cove and mid-to-upper N and E physiographic positions following the second cut.

269. **Patric, J. H.** Harvesting effects on soil and water in the eastern hardwood forest. Southern Journal of Applied Forestry 2(3): 66-73; 1978.

For the Eastern United States, there is overwhelming evidence that neither the productivity of forest soil nor the quality of forest water are substantially lessened during or after responsibly managed harvest of wood products. Carelessness, however, damages both resources. The key is forest roads; they cause little adverse effect on soil or water given proper location, drainage, traffic control, and maintenance. The public must better understand that it bears much of the cost for these measures.

270. **Patric, James H.** Forest experiment demonstration area on trail. Appalachian Trailway News 24(2): 21; 1963.

A new experiment in multiple use management at Coweeta is visible to hikers on the Appalachian Trail.

271. **Patric, James H.; Douglass, James E.; Hewlett, John D.** Soil water absorption by mountain and piedmont forests. Proceedings, Soil Science Society of America 29: 303-308; 1965.

In the southern Appalachians and the South Carolina Piedmont, absorption of soil water by tree roots in the top 20 feet of soil was determined from moisture and matric potential measurements under 50- by 50-foot, plastic-covered plots. The data indicate that, where soil matric potential is kept low by frequent rainfall, most transpired water comes from densely rooted surface soil, whereas soil water well beyond rooting depths returns to the surface during long periods without rain.

272. **Penman, H. L.** Estimating evaporation. Transactions, American Geophysical Union 37(1): 43-50; 1956.

Penman's classic energy balance combination equation for estimating evaporation was applied to climatic data from Wagon Wheel Gap and Coweeta Hydrologic Laboratory. Computed totals of evaporation were compared to estimates derived from hydrologic data. Discrepancies between energy balance

and hydrologic estimates for Coweeta Watershed 17 were assumed to be due to errors in precipitation and/or runoff measurements, bringing the author to conclude that the results of the clearcutting experiment should be reexamined. Discussions by Blaney, Wilm, and Penman reflect differences between the biological and purely physical views of the evapotranspiration process.

273. **Peterson, Ronald H.** Notes on Cantharelloid fungi - two: some new taxa, and notes on Pseudocraterellus. Persoonia 5(3): 211-223; 1969.

A new species of *Craterellus, C. carolinensis*, is described. Descriptions are given for the type specimens of *Thelephora subundulata* and *Stereum calyculus* and for representative specimens of *Craterellus sinuosus, C. crispus,* and *Cantharellus lutescens* sensu Fr. 1821. Comments on the relative taxonomic relevance of accepting *Pseudocraterellus* at generic rank are made. Two North American varieties of *Cantharellus cibarius* thought to have wide distribution are informally described.

274. **Phillips, N. A.; Rowe, R.; Todd, R. L.** The role of nitrification in nutrient cycling of forested ecosystems. In: Correll, David L., ed. Watershed research in eastern North America: a workshop to compare results; 1977 February 28 - March 3; Edgewater, MD. Edgewater, MD: Smithsonian Institution; 1977: 579-590.

In this review nitrate-nitrogen levels in streamflow are compared for a number of manipulated forested watersheds. The microbial mediated conversion of ammonium-nitrogen to nitrate-nitrogen (nitrification) is discussed as it relates to nitrate-nitrogen content in runoff water. Finally, hypotheses for system control of the nitrification process are reviewed.

275. **Progressive Farmer.** Woods grazing may be bad. Progressive Farmer, Georgia-Alabama-Florida Edition; 1953 January: 111.

Cattle gains, vegetative growth, and soil relations on a forested Appalachian watershed after 11 years of cattle grazing are reviewed.

276. **Reeves, M.; Duguid, J. O.** Water movement through saturated-unsaturated porous media: a finite-element Galerkin model. Oak Ridge, TN: Oak Ridge National Laboratory; 1975; Oak Ridge National Laboratory-4927. 236 p.

A two-dimensional transient model for flow through saturated-unsaturated porous media is given with complete FORTRAN code. This model numerically solves the partial differential equations which are highly nonlinear. The Galerkin finite-element method is superior to the finite-difference method used by previous investigators. Infiltration into or seepage from the surface may be simulated. Different material properties may be assigned to allow simulation of layered geologic formations. The computer model gives good results in a simulation of experimental data obtained from an inclined soil slab at Coweeta Hydrologic Laboratory. Here a comparison with finite-difference model developed by R. A. Freeze is made. By exploiting the flexibility of the finite-element geometrical discretization, the user may easily reduce computer running time by a factor of two.

277. **Robinson, Vernon L.; Fisher, Edward L.** High-lead yarding costs in the Southern Appalachians. Southern Journal of Applied Forestry 6: 172-176; 1982.

An analysis was made of the time devoted to the various work-and-delay elements of high-lead cable logging. A comparison of the resulting per unit volume with those of a conventional logging system shows that in spite of inefficiencies, the cable system is competitive, with a difference of only $2.85 per Mbm (Doyle rule) between the two systems. With better preplanning of sets, better crew organization and more experience with the equipment, the cable yarding costs should decline, making it a viable alternative to conventional logging in the Southern Appalachians.

278. **Robinson, Vernon L.; Fisher, Edward L.** A model of turn-time requirements in a highlead yarding system. Forest Science 29(3): 641-652; 1983.

A theoretical model is developed for specifying regression equations for the time requirements of four yarding elements in the highlead yarding system. The equations are estimated from sample data taken from a commercial logging operation in the Southern Appalachians. The hook and unhook equations proved to be the most difficult to specify and estimate. The outhaul and inhaul times were found to be a function of the operating gear, the slope distance to the log, and the work done on the cable and log.

279. **Ross, Douglas H.; Wallace, J. Bruce.** Factors influencing the longitudinal distribution of larval Hydropsychidae (Trichoptera) in a Southern Appalachian stream system. Hydrobiologia 96: 185-199; 1982.

The influence of physical habitat variables and suspended particulate organic matter (seston) on the distribution and production of eight species of larval Hydropsychidae was studied along a 6.4-km section of a Southern Appalachian stream. Samples were collected at six stations encompassing stream orders 1-4 and an elevation range of 610 m. Multivariate analysis of covariance (using time as the covariable) and discriminant function analysis were used to examine habitat differences between the sampling stations due to the following variables: current velocity; coarse benthic detritus; substrate composition (by particle size); substrate heterogeneity; degree-days; and diel temperature fluctuation. Hydropsychid species distribution along the stream system followed subfamily lines, i.e., Arctopsychinae and Diplectroninae were more abundant and productive in the upper 4.5 km of the stream, while Hydropsychinae were dominant in the lower 1.9 km. Diel temperature fluctuation was the habitat variable most highly correlated with patterns of hydropsychid abundance and production.

280. **Ross, Douglas H.; Wallace, J. Bruce.** Longitudinal patterns of production, food consumption, and seston utilization by net-spinning caddisflies (Trichoptera) in a Southern Appalachian stream. Holarctic Ecology 6: 270-284; 1983.

Larval production of 10 species of Hydropsychidae and Philipotamidae was studied at six stations along 6.4 km of a southern Appalachian stream, encompassing stream orders 1-4 and a 600-m elevation change. Species-specific production estimates ranged from 23 to 983 mg AFDM m^{-2} yr^{-1}. These low values are attributed to the paucity of nutrients in these undisturbed headwater streams which reduces detrital food quality, algal growth, and production of smaller invertebrates eaten by hydropsychids. Animal food supported the majority of hydropsychid production (72 percent); philopotamids relied primarily on fine detritus (80 percent) and diatoms (15 percent). Net-spinning caddisflies had a minor impact on seston quantity, consuming only 0.0003 percent - 0.005 percent of the total seston (including invertebrate drift) passing over a m^2 of substrate annually.

281. **Ross, Douglas; Wallace, J. Bruce.** Production of *Brachycentrus spinae* Ross (Trichoptera: Brachycentridae) and its role in seston dynamics of a southern Appalachian stream. Environmental Entomology 10: 240-248; 1981.

Annual production and turnover ratios for *Brachycentrus spinae* (Trichoptera) were estimated and production attributable to five food types were calculated. Annual food accounted

for 62 percent of the *B. spinae* production. While larvae ingested only 0.00007 percent m^{-2} of total available summer seston, they selectively captured animal material, consuming 3.5 times the amount entering the study section. These data suggested that the animal component of the seston must be replaced every 400 m to support Brachycentrus feeding alone. While this species exerted a minor influence on seston quantity, its selective capture of high-quality animal food could significantly alter seston quality.

282. **Rowe, R.; Todd, R. L.; Waide, J. B.** A microtechnique for MPN analysis. Applied Environmental Microbiology 33: 675-680; 1977.

A microtechnique based on the most-probable-number (MPN) method has been developed for the enumeration of the ammonium-oxidizing population in soil samples. An MPN table for a research design ([8 by 12] i.e., 12 dilutions, 8 replicates per dilution) is presented. A correlation of 0.68 was found between MPNs determined by the microtechnique and the standard tube technique. Higher MPNs were obtained with the microtechnique with increased accuracy in endpoint determinations being a possible cause. Considerable savings of time, space, equipment, and reagents are observed using this method. The microtechnique described may be adapted to other microbial populations using various types of media and endpoint determinations.

283. **Santee, William R.; Monk, Carl D.** Stem diameter and dry weight relationships in *Tsuga canadensis* (L.) Carr. Bulletin of the Torrey Botanical Club 108: 320-323; 1981.

Stem diameters and dry weight for bole, branches, bark and needles are given for 20 hemlock trees from the southern Appalachians. Simple allometric equations relating dry weight to d.b.h. are also presented. Nutrient concentrations for 15 elements are included.

284. **Schmid, Marvin.** Managing a watershed. The Conservationist 29(2): 25; 1974.

An article discussing changes in attitudes toward forest management on municipal watersheds.

285. **Scholl, David G.; Hibbert, Alden R.** Unsaturated flow properties used to predict outflow and evaporation from a sloping lysimeter. Water Resources Research 9(6): 1645-1655; 1973.

Soil moisture content and pressure potential measurements were used to determine the moisture flux, hydraulic gradients, and dynamic conductivity of a 200-foot sloping soil lysimeter. A vertical unsaturated Darcian analysis was used to evaluate conductivity when evapotranspiration was eliminated by sealing the model surface with plastic. The moisture flux term in the Darcy equation was determined by evaluating moisture content change in depth and time and agreed with measured outflow. Conductivities were solved from flux and hydraulic gradients, and corresponding water contents were assigned. Evapotranspiration was solved after grass was established by using a water balance based on moisture content and potential, rainfall, and conductivity. Results at the deepest level in the profile agreed well with those based on actual outflow.

286. **Schowalter, T. D.; Webb, J. Warren; Crossley, D. A., Jr.** Community structure and nutrient content of canopy arthropods in clearcut and uncut forest ecosystems. Ecology 62: 1010-1019; 1981.

Differences in canopy arthropod community structure, major cation content, and calculated nutrient consumption between clearcut and undisturbed hardwood forest watersheds at Coweeta were observed during the first two growing seasons following cutting. Although canopy arthropod biomass was about 0.08 percent of foliage biomass on both watersheds, aphid mass increased 23-fold and ant mass increased 6-fold per unit following cutting. These groups in general had lower nutrient concentrations than did chewing herbivores and predators. Arthropod K concentrations were 33 percent lower on the clearcut; Na, K, and Mg concentrations were 20 to 50 percent higher in 1978 than in 1977. Arthropod Mg and Ca concentrations, but not Na and K, were reduced significantly more by the greater effect of drought on the clearcut watershed. Consumption estimates based in part on consumption rates reported by others indicated increased nutrient translocation from foliage via arthropods following cutting. These data indicated that canopy arthropod responses to changes in nutrient availability following disturbance could have increased nutrient cycling rates and contributed to nutrient retention by the recovering ecosystem.

287. **Schowalter, Timothy D.** Insect herbivore relationship to the state of the host plant: biotic regulation of ecosystem nutrient cycling through ecological succession. Oikos 37: 126-130; 1981.

This paper provides a conceptual framework for increasing our understanding of the relationships between plant resistance to insect herbivores and insect herbivore influences on ecosystem nutrient cycling and succession. For a given plant species, adequate nutrient/light availability favors establishment and productivity; small insect herbivore populations regulated by plant biochemistry stimulate primary productivity and short-term nutrient cycling. As biomass and competition for nutrients and light increase during succession, plants become stressed as they approach their tolerance limits. Earlier successional plant species initially dominating the plant community have higher nutrient/light requirements and become stressed sooner than later successional plant species. Abundance and stress make the earlier plant species more apparent and susceptible, than later plant species, to insect herbivores.

288. **Schreuder, H. T.; Swank, W. T.** A comparison of several statistical models in forest biomass and surface area estimation. In: Forest biomass studies, 15th meeting of the International Union of Forest Research Organizations; 1971 March 15-20; Gainesville, FL. Misc. Publ. 132. Orono, ME: University of Maine, Life Sciences and Agriculture Experiment Station; 1971: 123-136.

The squared correlation and log likelihood techniques are discussed and used to evaluate statistical estimation models for eastern white pine biomass and surface area data. Three *a priori* linear models are considered: (1) an unweighted untransformed model, (2) a weighted untransformed model, and (3) a log-log transformation model.

289. **Schreuder, H. T.; Swank, W. T.** Statistical considerations in sampling biomass and surface area over time for a *Pinus strobus* L. forest. In: IUFRO biomass studies, working party on the mensuration of the forest biomass, S4.01 Mensuration growth and yield; 1973 June 25-29; Nancy, France; 1973 August 20-24; Vancouver, Canada. Orono, ME: University of Maine, College of Life Sciences and Agriculture; 1973: 133-141.

A 16.1-ha white pine plantation was sampled at ages 10, 12, and 15 years for biomass and surface area of aboveground tree components. A weighted regression technique is recommended for estimating leaf, branch and stem biomass, and surface area with tree basal area as the independent variable. The double log and double square root models are alternate estimation models deserving serious consideration.

For any of these models, data from different years can sometimes be combined to reduce the number of trees that need to be felled.

290. **Schreuder, Hans T.; Swank, Wayne T.** Coniferous stands characterized with the Weibull distribution. Canadian Journal of Forestry Research 4: 518-523; 1974.

The Weibull distribution, $F(x) = 1 - e^{-(x/\alpha)^c}$, summarized diameter, basal area, surface area, biomass, and crown profile distribution data well for several different ages of white and loblolly pine plantations. The data for diameter, basal area, surface area, and biomass were easily summarized by this one distribution in a theoretically consistent fashion. This is not possible with the normal and the gamma distributions, and the lognormal gives less satisfactory results. The distribution function should prove useful in modeling tree stands since only the parameter values need to be changed over time for the above variables. The change in these parameters may be a good way to characterize and interpret changes in stands over time.

291. **Seastedt, T. R.; Crossley, D. A., Jr.** Effects of microarthropods on the seasonal dynamics of forest litter. Soil Biology and Biochemistry 12: 337-342; 1980.

The amounts of Ca, K, Mg and P were measured in leaf litter contained in litter bags in a Southeastern United States deciduous forest. Half of the litter was treated with naphthalene, a chemical that reduced microarthropod densities to about 10 percent of those found in untreated litter. Phosphorus losses were significantly greater in untreated litter. After initial elemental losses, amounts of Ca, K, and Mg generally increased in 9- to 12-month-old untreated litter, while naphthalene-treated litter generally showed no seasonal dynamics. Seasonal amounts of nutrients in forest litter depend upon elemental mobility, inputs of nutrients in rainfall, throughfall and particulates, and nutrient retention by forest floor biota. Microarthropods increase nutrient loss from forest litter by comminution; however, microbial stimulation as a result of microarthropod feeding activities appears to increase the nutrient retention capacities of forest litter.

292. **Seastedt, T. R.; Crossley, D. A., Jr.** Further investigations of microarthropod populations using the Merchant-Crossley high-gradient extractor. Journal of the Georgia Entomological Society 13: 338-344; 1978.

Estimates of microarthropod populations from litter and soil at Coweeta vary considerably, depending upon extraction method and technique. Estimates from high-gradient extractions are superior to estimates from both Tullgren funnel extraction and counts from examination of gelatin-embedded litter and soil samples.

The high-gradient extractor designed by Merchant and Crossley is inefficient under conditions of high humidity. Microarthropods adhere to condensation on funnel walls. Funnels must be rinsed prior to removing sample vials. In spite of this problem, the design is superior to a similar apparatus employing canister collectors.

293. **Seastedt, T. R.; Crossley, D. A., Jr.** Microarthropod response following cable logging and clear-cutting in the Southern Appalachians. Ecology 62: 126-135; 1981.

Litter and soil microarthropod populations were monitored following cable logging and clear-cutting of a forested watershed (WS 7) at Coweeta. Annual mean densities of microarthropods in litter bags were reduced over 50 percent on the clear-cut watershed when compared with an adjacent forested watershed (WS 2), and averaged 8.4 individuals/g of litter on WS 7 vs. 20.4/g on WS 2 ($P < .01$). Density estimates obtained from 5-cm-deep sections of litter and soil indicated a 25 percent reduction in densities on WS 7, with a 17-month average of 98,900 microarthropods/m^2 on WS 7 vs. 133,500 microarthropods/m^2 on WS 2 ($P < .001$). In contrast, densities of microarthropods increased over 100 percent in deeper soil horizons (5-55 cm), averaging 89,800 microarthropods/m^2 on WS 7 vs. 43,700 microarthropods/m^2 on WS 2 ($P < .001$).

294. **Seastedt, T. R.; Crossley, D. A., Jr.** Nutrients in forest litter treated with naphthalene and simulated throughfall: a field microcosm study. Soil Biology and Biochemistry 15: 159-165; 1983.

The effects of naphthalene (arthropod exclusion) and simulated throughfall (N, P, K, Ca and Mg) additions on the decomposition and mineralization of dogwood (*Cornus florida* L.) litter were studied by using a field microcosm approach in a Southeastern United States deciduous forest. Treatments without microarthropods decayed more slowly than litter with microarthropods. Simulated throughfall additions alone had no effect on litter decay rates. Fauna, simulated throughfall, and fauna plus simulated throughfall treatments increased the nutrient concentrations of decomposing litter;

the treatment with both microarthropods and simulated throughfall generally exhibited the highest nutrient concentrations. Simulated throughfall also significantly increased microarthropod densities in litter. Litter immobilization of elements in throughfall was insignificant in litter with microarthropods; naphthalene-treated litter immobilized up to 8 percent of the elements contained in simulated throughfall.

295. **Seastedt, T. R.; Crossley, D. A., Jr.** Sodium dynamics in forest ecosystems and the animal starvation hypothesis. American Naturalist 117: 1029-1034; 1981.

Sodium may be a critical limiting element for certain vertebrate herbivore populations. It has been hypothesized that the relative exclusion of sodium from the tissues of most land plants may help them against grazing by making it difficult for the grazers to obtain as much of this ion as they need. Contrary to this "animal starvation hypothesis," we contend that forest trees do not exhibit any aboveground allocation strategy for this element and that sodium concentrations in forest trees are at least one to two orders of magnitude above those levels found in soil percolates. As a null hypothesis, we state that sodium levels in plants do not affect levels of herbivory; however, alternatives include not only the animal starvation hypothesis but also its antithesis, i.e., sodium levels observed in plants stimulate consumption.

296. **Seastedt, T. R.; Crossley, D. A., Jr.; Hargrove, W. W.** The effects of low-level consumption by canopy arthropods on the growth and nutrient dynamics of black locust and red maple trees in the Southern Appalachians. Ecology 64(5): 1040-1048; 1983.

The effects of low-level consumption by canopy arthropods on foliage nutrient content, canopy leachates (throughfall), and biomass of 4-year-old black locust (*Robinia pseudoacacia*) and red maple (*Acer rubrum*) were studied in the Southern Appalachians of North Carolina. A carbaryl insecticide was used to reduce foliage consumption from $\approx$10 to $\approx$2 percent in black locust and from $\approx$4 to $\approx$1 percent in red maple.

Total biomass production (net primary production per kilogram of preseason biomass) was unaffected by the low levels of herbivory observed here. Such nominal herbivory did not stimulate biomass and nutrient accretion by these tree species but did increase the cycling of K and perhaps other elements within these systems.

297. **Seastedt, T. R.; Crossley, D. A., Jr.; Meentemeyer, V.; Waide, J. B.** A two-year study of leaf litter decomposition as related to macroclimatic factors and microarthropod abundance in the southern Appalachians. Holarctic Ecology 6: 11-16; 1983.

Chestnut oak *Quercus prinus* L. litter in the Southern Appalachian Mountains of the United States decomposes slowly during winter and more rapidly in other seasons. This pattern differed from other studies of litter decomposition in more northern environments where decomposition rates were relatively constant throughout the year or more rapid beneath a winter snow cover. The pattern observed can be approximated by using monthly actual evapotranspiration estimates as a correction factor for the decomposition constant, k, in the commonly used negative exponential decomposition model.

Mean microarthropod densities increased from a seasonally weighted estimate of 18.2 ind. g^{-1} litter during the first year of decomposition to 73.6 ind. g^{-1} litter during the second year. In spite of this increase, no difference in the rate of weight loss of the litter was observed between the first and second year of the study.

298. **Seastedt, T. R.; Kothari, A.; Crossley, D. A., Jr.** A simplified gelatine embedding technique for sectioning litter and soil samples. Pedobiologia 20: 55-59; 1980.

The importance of determining structural and functional relationships of soil biota within a systematic framework has been recognized by a number of researchers. Inspection of in situ microflora and fauna is a useful preliminary step in evaluating the roles of various groups within the soil milieu.

In this report methods for both embedding and sectioning soils have been simplified. All equipment used is present or readily available to most laboratories. The sectioning device presented is suitable for sectioning gravelly soils. Soil sections prepared by these procedures are useful in both visual confirmation of quantitative analyses of soil flora and fauna as well as in formulating new hypotheses for biota-substrate interactions.

299. **Seastedt, T. R.; Tate, C. M.** Decomposition rates and nutrient contents of arthropod remains in forest litter. Ecology 62: 13-19; 1981.

Decomposition rates and amounts of calcium, magnesium, potassium, and phosphorus were measured for dead millipedes and crickets buried in forest litter in North Carolina and Georgia. An average of 30 percent of the original mass of millipedes and 14 percent of the original mass of crickets was recovered after 1 year in the litter. Elemental losses generally followed the pattern: K > P > Mg > Ca; however, elemental amounts occasionally stabilized and in one experiment calcium increased in amount over time.

Decomposition of arthropod carcasses was described by a two-component, negative exponential decay model. Decay coefficients were used with literature estimates of arthropod standing crops to estimate standing crops of mass and elements of arthropod remains in forest litter and soil. Estimates of standing crops of mass, calcium, and magnesium of arthropod remains were greater than those of living forest floor arthropods.

300. **Sihanonth, P.; Todd, R. L.** Transfer of nutrients from ectomycorrhizal fungi to plant roots. In: Lohm, U.; Persson, T., eds. Soil organisms as components of ecosystems. Proceedings of the sixth international soil zoology colloquium; 1976 June 21-25; Uppsala, Sweden. Ecological Bulletin 25. Uppsala, Sweden: Swedish Soil Science Society; 1977: 392-397.

The magnesium, phosphorus, sulfur, potassium and calcium composition of ectomycorrhizae formed by *Pisolithus tinctorius* and *Cenococcum graniforme* was compared with the elemental distribution within the cortex root cells of *Pinus taeda*. The values were obtained by a combination scanning electron microscopy-electron microbeam technique. Significant concentrations of the five elements were observed within the fungus mantle sheath and Hartig net of both ectomycorrhizal types. Elemental concentrations were higher in the ectomycorrhizal root cells than the nonmycorrhizal root cells. This accumulation and transport of nutrients by ectomycorrhizal fungi to root cells is proposed as the major factor in the stimulation of plant growth under low fertility conditions.

301. **Sims, A. L.; Mueller, G. E.; Stout, G. E.; Ackerman, William C.** Investigation of quantitative determination of point and areal precipitation by radar echo measurements. Urbana, IL: Illinois State Water Survey; 1964; Final Report. 202 p.

A raindrop camera was operated at Mooney Gap, Coweeta Hydrologic Laboratory, for 18 months in cooperation with the Illinois Water Survey and the Army Electronics Research and

Development Laboratory. Graphical presentations of raindrop size and number per cubic meter for this and four other study sites show drop size and count are consistent between storm events and directly related to rainfall rate.

302. **Singer, F. J.; Swank, W. T.; Clebsch, E. E. C.** Some ecosystem responses to European wild boar rooting in a deciduous forest. NPS-SER Research/Resources Mgt. Rep. 54. Atlanta, GA: U.S. Department of Interior, National Park Service; 1982. 31 p.

The influence of rooting by European wild boar (*Sus scrofa*) upon surface fauna, nutrients and biomass of forest litter and soil was investigated in the northern hardwood forest of Great Smoky Mountains National Park, 1979-1980. Two vertebrates that depend largely on leaf litter for habitat, the red backed vole (*Clethrionomys gapperi*), and short-tailed shrew (*Blarina brevicauda*), were nearly eliminated from intensely rooted stands. Rooting accelerated the leaching of Ca, P, Zn, Cu, and Mg from leaf litter and soil. Nitrate concentrations, however, were higher in soil, soil water, and stream water from the rooted stands, suggesting alterations in ecosystem nitrogen transformation processes.

303. **Sluder, Earl R.** Mountain farm woodland grazing doesn't pay. Res. Notes 119. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1958. 2 p.

The general results of the mountain farm experiment at Coweeta are presented.

304. **Smith, Jeffrey.** At Coweeta. Emory Magazine 59(1): 6-13; 1982.

A general article discussing aspects of Dr. Ragsdale's research at Coweeta.

305. **Snyder, John E.; Hursh, Charles R.** Low cost erosion control on highway slopes in Southeastern United States. In: Erosion control, Proceedings of the eighteenth annual meeting of the Highway Research Board; 1938 December; Part 1: 213-215; 1938.

Important factors in stabilizing exposed highway slopes are the stability, moisture, and fertility of the soil. Steepness and length of slope, alternation of freezing and thawing, and the physical nature of soil affect soil stability. Lack of moisture because of overdrainage and direct exposure to solar radiation is also a basic cause of failure in roadside naturalization. Many road cuts expose infertile subsoil

and parentsoil material which are difficult to vegetate. Use of mulches of local organic materials is a suitable means for ameliorating unfavorable site conditions.

306. **Southeastern Forest Experiment Station.** Improvements at Coweeta. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1964. 16 p.

This report covers improvements and research at Coweeta since October 1962, when the accelerated Public Works program began at the Laboratory. Improvements consisted of construction of a road and bridge in the administration area, a 20,000-gallon gravity water system, a three-bedroom dwelling for forest superintendents, a 40- by 60-foot metal warehouse for storage, a 40- by 100-foot wet lab, and an extension to the existing office building, as well as repairs made on 18 weirs and the reworking of 25 miles of neglected roads and trails. Research activities included installation of a 356-acre multiple use watershed and clearcutting of two forested watersheds to determine the effects of such cutting on water yield.

307. **Southeastern Forest Experiment Station.** Visitor's guide - Coweeta Hydrologic Laboratory. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. [In-Serv. leafl.] 1968.

This leaflet enables the reader to make a self-guided tour of the Coweeta Hydrologic Laboratory.

308. **Southeastern Forest Experiment Station.** Watershed management research--Coweeta Experimental Forest. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1948. 45 p.

This is the first guidebook to Coweeta and is designed to acquaint the reader with the laboratory, the research methods, program, findings, and future research plans.

309. **Stone, E. L.; Swank, W. T.; Hornbeck, J. W.** Impacts of timber harvest and regeneration systems on stream flow and soils in the eastern deciduous region. In: Forest soils and land use: Proceedings of the fifth North American forest soils conference; 1978 August; Fort Collins, CO. Fort Collins, CO: Colorado State University, Department of Forest and Wood Sciences; 1980: 516-535.

The review draws together the present understanding of how cutting in eastern deciduous forests for any of a variety of purposes affects soil and streamflow. Based on experimental

results, generalizations are provided on responses in annual water yield and recovery after cutting, low flow, peak flow, soil moisture, stream temperature, sedimentation, and nutrients.

310. **Stout, Glenn E.; Mueller, Eugene A.** Survey of relationships between rainfall rate and radar reflectivity in the measurement of precipitation. Journal of Applied Meteorology 7(3): 465-474; 1968.

Raindrop-size distributions measured at Coweeta and eight other locations were used to derive a relationship between rainfall intensity and radar reflectivity for the purpose of using radar to estimate rainfall amount. Between geographic locations, rainfall rate varied 500 percent for the same reflectivity. Differences of 150 percent were attributed to storm type. At each site, differences within a storm were minor. For a given storm type at a specific location, errors in measurement of radar reflectivity are greater than errors of estimating rainfall from reflectivity.

311. **Strickland, T. C.; Fitzgerald, J. W.** Mineralization of sulphur in sulphoquinovose by forest soils. Soil Biology and Biochemistry 15(3): 347-349; 1983.

Surface soils from four watersheds located in the Coweeta Basin near Franklin, N.C., were assayed for their capacity to mineralize sulphur in 6-sulphoquinovose. All soils rapidly converted S in this component of the plant sulpholipid to inorganic sulphate, a soluble (salt extractable) ester sulphate and an insoluble ester sulphate. Sulphur in this latter fraction was released by acid hydrolysis of soil residues at 121°C. Although maximum concentrations of S in each fraction varied with duration of incubation, rates of conversion of S into all fractions were highest during the first hour. Mineralization rates based upon sulphate release and total S released from sulphoquinovose are reported.

312. **Swank, W. T.** The influence of rainfall interception on streamflow. In: Proceedings, hydrologic water resource management conference; 1968 March 28-29; Clemson, SC. Rep. 4. Clemson, SC: Clemson University Water Resources Research Institute; 1968: 101-112.

The data presented provide evidence that interception loss is a major hydrologic process which reduces the quantity and alters the timing of streamflow from watersheds in the Southern Appalachians when cover types are changed from mature

mixed hardwoods to eastern white pine. Differences in interception loss between loblolly pine and mature hardwoods in the Piedmont of South Carolina are discussed.

313. **Swank, W. T.** Models in forest hydrology, an overview. In: Proceedings, IUFRO workshop on water and nutrient simulation models; 1979 August 27 - September 1; Birmensdorf, Switzerland; Zurich, Switzerland. Birmensdorf: Swiss Federal Institute of Forestry Research; 1981: 13-20.

This paper summarizes the development of forest hydrology models from programmatic and technical viewpoints.

314. **Swank, W. T.** Soils and water. In: Wade, Larkin, ed. Social and political influence in the managed forest: proceedings of the eleventh Auburn forestry forum; 1972 December; Auburn, AL. Auburn, AL: Cooperative Extension Service, Auburn University; 1972: 51-58.

This paper reviews the impacts of forest cutting on water yield, timing, water quality, and soil nutrients for some forest ecosystems in the Eastern United States.

315. **Swank, W. T.; Douglass, J. E.** Nutrient budgets for undisturbed and manipulated hardwood forest ecosystems in the mountains of North Carolina. In: Correll, David L., ed. Watershed research in eastern North America: a workshop to compare results; 1977 February 28 - March 3; Edgewater, MD. Edgewater, MD: Smithsonian Institution; 1977: 363-364.

Stream chemistry was monitored for 8 mature hardwood ecosystems and 16 altered forested systems. Net budgets of NO_3-N, NH_4-N, PO_4-P, Cl^-, K^+, Na^+, Ca^{++}, Mg^{++}, $SO_4^=$, and SiO_2 were estimated for 15 ecosystems. Nitrate-Nitrogen was most sensitive to disturbance. When forests were cut, NO_3-N discharge was elevated for at least 13 years. No changes in the discharge of NH_4-N and PO_4-P were observed for any of the watersheds; all ecosystems showed very large accumulations of $SO_4^=$. A grass-to-forest succession watershed that had been fertilized, limed, and herbicided showed large nutrient losses. Conversion of hardwoods to white pine reduced the loss of most nutrients.

316. **Swank, W. T.; Douglass, J. E.** Nutrient flux in undisturbed and manipulated forest ecosystems in the southern Appalachian Mountains. In: Proceedings of the Tokyo symposium on the hydrological characteristics of river basins and the effects on these characteristics of better water management; 1975 December; Tokyo, Japan. Washington, DC: International Association of Hydrological Science; 1975: 445-456.

Nutrient concentrations in stream water were studied on 8 mature hardwood ecosystems and 16 altered forested systems. The budget of NO_3-N, NH_4-N, PO_4-P, Cl^-, K^+, Na^+, Ca^{++}, Mg^{++}, and $SO_4^=$ was derived for 14 watersheds. Compared with undisturbed watersheds, a grass-to-forest succession watershed that had been fertilized, limed, and herbicided showed larger losses of ions except for PO_4-P. Elevated NO_3-N discharge was evident at least 10 years after cutting, but appeared to return to baseline levels 20 years after treatment. Conversion of hardwoods to white pine reduced the loss of most nutrients. No changes in the discharge of NH_4-N and PO_4-P were observed for any of the watersheds; all ecosystems showed very large accumulations of $SO_4^=$.

317. **Swank, W. T.; Douglass, J. E.; Cunningham, G. B.** Changes in water yield and storm hydrographs following commercial clearcutting on a Southern Appalachian catchment. In: Hydrological research basins and their use in water resource planning: proceedings of the international symposium; 1982 September 21-23; Berne, Switzerland. Berne, Switzerland: Landeshydrologie; 1982; 2: 583-594.

The first year after commercial clearcutting and cable logging in a mixed hardwood forest, annual streamflow from a 59-ha catchment increased 26 cm. The experimental response in flow was within 4 percent of the value predicted from a regional model. During the first 4 years of regrowth, the model prediction was within 15 percent of the 72-cm total change in water yield. The largest measured changes in monthly flow occurred during the lowest flow months. Storm hydrograph analysis showed that, on the average, initial flow rate and peakflow rate increased about 15 percent and stormflow increased 10 percent. The treatment effect was greatest for small storms and the alteration of storm hydrograph parameters was judged to be of minor importance in management planning.

318. **Swank, W. T.; Helvey, J. D.** Reduction of streamflow increases following regrowth of clearcut hardwood forests. In: Symposium on the results of research on representative and experimental basins; 1970 December; Wellington, New Zealand. Publication 96. Leuven, Belgium: United Nations Educational, Scientific and Cultural Organization - International Association of Scientific Hydrology; 1970: 346-360.

The mature hardwood forest on a 16-hectare catchment at the Coweeta Hydrologic Laboratory was initially clearcut in 1939. The first year following cutting, streamflow increased 360 mm. As the even-aged coppice stand regrew, annual streamflow

increases approached pretreatment levels as a linear function of the logarithm of time. The watershed was clearcut again in 1962, and streamflow response for the year following cutting was 380 mm. In striking contrast to the first cutting, streamflow increases have diminished at a much faster rate, and it appears that annual water yield will return to pretreatment levels after just 16 years of forest regrowth following the second cutting. The difference in the measured response is attributed primarily to a more rapid recovery of vegetation in the second treatment period.

319. **Swank, W. T.; Miner, N. H.** Coversion of hardwood-covered watersheds to white pine reduces water yield. Water Resources Research 4: 947-954; 1968.

Mixed mature hardwoods were cleared from two experimental watersheds in the Southern Appalachians, and the areas were planted with eastern white pine in 1956-57. Once the pine crowns began to close, streamflow steadily declined at a rate of 1 to 2 inches per year. By 1967, water yield from a 10-year-old pine stand on a south-facing watershed was 3.7 inches less than the expected water yield from the original hardwood forest. Most of the reduction in water yield occurred during the dormant season and was attributed mainly to greater interception loss from white pine than from hardwoods. Because interception differences increase as white pine matures, an even greater reduction in streamflow is expected.

320. **Swank, W. T.; Schreuder, H. T.** Temporal changes in biomass, surface area and net production for a *Pinus strobus* L. forest. In: International Union of Forest Research Organizations biomass studies, working party on the mensuration of forest biomass, S4.01 mensuration growth and yield; 1973 June 25-29; Nancy, France; 1973 August 20-24; Vancouver, Canada. Orono, ME: University of Maine, College of Life Science and Agriculture; 1973: 173-182.

Weighted, linear regression models were used to estimate biomass and surface area of foliage, branches, and stems from tree basal area for a planted white pine stand on a 16.1 hectare watershed. Estimates were made at stand ages 10, 12, and 15 years. During the 5-year period, the stand closure changed from partial to complete and model coefficients showed large changes, particularly for foliage. In February 1972, aboveground biomass for the population was 4,664, 22,825, and 42,110 kilograms per hectare for foliage, branches, and stems. The population of trees contained 9.9, 2.3, and 0.4 hectares of foliage, branches, and stems per

hectare of land surface. Net primary production was estimated to be 13,500 kilograms per hectare per year, and foliage development for the pine population culminated when the stand was only 12 years old.

321. **Swank, W. T.; Waide, J. B.** Interpretation of nutrient cycling research in a management context: evaluating potential effects of alternative management strategies on site productivity. In: Waring, Richard W., ed. Forests: fresh perspective from ecosystem analysis; 1979 April 27. Corvallis, OR: Oregon State University Press; 1980: 137-158.

This paper evaluates the effects of various harvesting practices and alternative levels of wood fiber utilization on the sustainable productivity of forests. The analysis includes three phases: (1) characterization of ecosystem nutrient budgets for several contrasting forest ecosystems in different physiographic regions of the United States; (2) examination of nutrient pools contained within ecosystem compartments, and annual transfer rates among compartments; and (3) elaboration of the conceptual model framework which has guided ecosystem research at Coweeta Hydrologic Laboratory, and illustration of how specific data sets can be used to determine important management needs.

322. **Swank, W. T.; Waide, J. B.; Crossley, D. A., Jr.; Todd, R. L.** Insect defoliation enhances nitrate export from forest ecosytems. Oecologia 51: 297-299; 1981.

Chronic defoliation by the fall cankerworm, *Alsophila pometaria* (Harris), accompanied substantial increases in the stream export of nitrate nitrogen (NO_3-N) from three mixed hardwood forests in the southern Appalachians. These integrated results clearly demonstrate a measurable effect of insect consumers on ecosystem processes, and provide support for the regulatory importance of insects on a landscape scale.

323. **Swank, Wayne T.** Ecosystem studies program. In: Environmental Biology. National Science Foundation Program Report (2)4. Washington, DC: National Science Foundation; 1978. 57 p.

This paper traces the development of the Ecosystem Studies Program at the National Science Foundation from its early development through 1978 with illustrations and examples of contributions to ecosystem science.

324. **Swank, Wayne T.** Review of biogeochemical cycling of mineral-forming elements: studies in environmental science; vol. 3. Quarterly Review of Biology 56: 91; 1981.

A book review.

325. **Swank, Wayne T.** Studi di ecologia e idrologia forestali. Padova, Italy: Universaita di Padova, Instituto di Ecologia e Selvicoltura; 1982. 103 p.

This document is a series of lectures presented at the Institute of Ecology and Silviculture of the University of Padova, Italy. The lectures are organized into four main topics: (1) biogeochemical cycling in forest ecosystems, (2) effects of forest management practices on quality and timing of streamflow, (3) water quality and management practices, and (4) impact of site preparation on soil and water characteristics.

326. **Swank, Wayne T.; Caskey, William H.** Nitrate depletion in a second-order mountain stream. Journal of Environmental Quality 11: 581-584; 1982.

The amount of NO_3-N exported in a second-order mountain stream draining a clearcut and logged mixed-hardwood forest was studied over a 4-year period. Calculations based on measurements of stream chemistry and discharge rates indicated a within-stream depletion of NO_3 from the upper reaches of the stream to the watershed outlet. Within-stream depletion the first year of treatment was 127 percent of total NO_3-N discharged from the watershed outlet and declined in succeeding years after treatment to 99, 42, and 5 percent. Assays of the quantities of denitrifying enzymes in stream sediment samples suggested 1.7 kg N $year^{-1}$ were lost via this pathway, compared with 3.9 kg N $year^{-1}$ calculated from within-stream depletion for the same time period. This study suggests sediment denitrification is a major pathway by which NO_3-N is lost.

327. **Swank, Wayne T.; Douglass, James E.** Streamflow greatly reduced by coverting deciduous hardwood stands to pine. Science 185: 857-859; 1974.

Fifteen years after two experimental watersheds in the southern Appalachians had been converted from a mature deciduous hardwood cover to white pine, annual streamflow was reduced about 20 centimeters (20 percent) below that expected for the hardwood cover. Streamflow was reduced during every month, with the largest monthly reductions (1.5 to 3.5 centimeters) occurring in the dormant and early growing seasons.

328. **Swank, Wayne T.; Fitzgerald, John W.; Ash, Jaru T.** Microbial transformation of sulfate in forest soils. Science 223: (4632)182-184; 1984.

Incubation of forest soils containing sulfate labeled with sulfur-35 showed rapid conversion of the added sulfate to organic sulfur forms by microbial populations. Activity rates were highest in the forest floor, but significant activity was observed throughout the soil profile. The annual potential sulfur incorporation for forest floor and soil combined is estimated to be 30 kilograms per hectare. The metabolism of inorganic sulfate to organic forms can be a major process in the sulfur cycle, influencing sulfate accumulation and mobility in forest ecosystems.

329. **Swank, Wayne T.; Goebel, Norbert B.; Helvey, Junior D.** Interception loss in loblolly pine stands of the South Carolina Piedmont. Journal of Soil and Water Conservation 27: 160-164; 1972.

Annual interception loss was measured in 5-, 10-, 20-, and 30-year-old loblolly pine stands and in a mature hardwood-pine forest in the Piedmont of South Carolina. Interception loss for the loblolly pine stands was estimated to be 14, 22, 18, and 18 percent of annual precipitation (54 inches). Annual interception loss from the hardwood-pine stand was similar to that of the pine stands. However, on the average, the loss of water intercepted annually by loblolly pine appeared to be about 4 inches greater than the loss estimated from a number of hardwood studies. Where extensive conversions of hardwood to loblolly pine occur, significant reductions in the amount of water available for streamflow or groundwater should be expected.

330. **Swank, Wayne T.; Henderson, Gray S.** Atmospheric input of some cations and anions to forest ecosystems in North Carolina and Tennessee. Water Resources Research 12: 541-546; 1976.

The atmospheric contributions of elements in precipitation and dry fallout to forest ecosystems were measured at two sites in the Southern Appalachians. At both sites, relative mean annual concentrations of cations in bulk precipitation were in the order Ca > Na > K > Mg. At the Coweeta Hydrologic Laboratory in North Carolina, average annual inputs of Ca^{++}, Na^{+}, K^{+}, Mg^{++}, and NH_4-N in 1970-1973 were 4.88, 3.52, 1.62, 1.01, and 0.52 kg/ha/yr, respectively. At Walker Branch, Tenn., the inputs of these elements during the same time period were 15.73, 3.89, 2.99, 2.94, and 2.37 kg/ha/yr. The

inputs of NO_3-N, PO_4-P, and Cl^- in 1972-1973 were 2.88, 0.19, and 8.53 kg/ha/yr at Coweeta. Inputs of NO_3-N and PO_4-P were 4.61 and 0.55 kg/ha at Walker Branch over the same period. One reason for differences in bulk precipitation chemistry was greater dry fallout for some cations at Walker Branch than at Coweeta. For both sites, dry fallout associated with local land use activities influenced seasonal concentrations of bulk precipitation except for Na^+, which appeared to be partly derived from marine sources. Total inputs of elements are considered to be minimum estimates for both forest ecosystems due to sampling and analytical methods.

331. **Swank, Wayne T.; Schreuder, Hans T.** Comparison of three methods of estimating surface area and biomass for a forest of young eastern white pine. Forest Science 20: 91-100; 1974.

Foliage, branch and stem surface area, and ovendry weight, with estimates of precision of these statistics are presented for a 10-year-old stand of eastern white pine on a 16-ha watershed at the Coweeta Hydrologic Laboratory. Three different methods were used to estimate the forest surface area and biomass: (1) stratified two-phase sampling, (2) two-phase sampling with a regression estimator, and (3) two-phase sampling with a ratio-of-means estimator. Stratified two-phase sampling was the most precise and appropriate method; the population was estimated to contain 5.3 ha foliage, 0.76 ha branches, and 0.13 ha stems per hectare of land surface. The estimated ovendry weight of tree components was estimated to be 2.71, 6.83, and 7.01 metric tons per hectare, respectively, for foliage, branches, and stems. The standard error of estimate for surface area and biomass ranged from 5 to 10 percent, depending upon the tree components of interest.

332. **Swift, Lloyd W., Jr.** Algorithm for solar radiation on mountain slopes. Water Resources Research 12: 108-112; 1976.

A generalized algorithm provides the daily total of potential solar radiation on any sloping surface at any latitude. The algorithm can be coded as subroutines of a computer model that requires solar radiation as a variable. The required inputs are Julian dates and the latitude, inclination, and aspect of the slope. In addition to computing potential solar radiation, the routine provides estimates of actual radiation on any slope on the basis of measured solar radiation for a nearby horizontal surface that has the same cloud cover.

333. **Swift, Lloyd W., Jr.** Duration of stream temperature increases following forest cutting in the Southern Appalachian mountains. In: Johnson, A. Ivan; Clark, Robert A., eds. Proceedings of the international symposium on hydrometeorology; 1982 June 13-17; Denver, CO. Bethesda, MD: American Water Resource Association; 1983: 273-275.

Cutting timber along small streams in the Southern Appalachian Mountains increases water temperature. Clearcutting all vegetation over 2.5 cm d.b.h. from a 59.6-ha south-facing watershed in western North Carolina allowed both the magnitude and duration of water temperature increases to be studied. About 958 m^2 of stream were exposed. Daily maximum temperatures at the downstream margin of the cutting were increased an average of 3.3° C the first two summers after cutting. The increases declined in the next three summers to 1.2° C. Daily minimums were increased about 1.3° C both winter and summer, but only in the first year. The daily range of water temperatures (maximum minus minimum) was increased during all five summers. A method for predicting water temperature changes was tested and found to overestimate the summer increases.

334. **Swift, Lloyd W., Jr.** Green sponge. The American Tree Farmer 2(5): 7; 1983.

Water yield should be a concern to the tree farmer. Choices in managing piedmont lands between pine or hardwood forests affect future streamflow amounts. As an example, average streamflow may be four area inches greater under hardwood management. However, the change in streamflow due to thinning and cutting previously unmanaged piedmont forest is greatest for pine stands.

335. **Swift, Lloyd W., Jr.** Visitor's guide--Coweeta Hydrologic Laboratory; Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1980. 11 p.

This illustrated folder, prepared for nontechnical visitors to the Laboratory, describes the objectives of Watershed Management research at Coweeta and gives highlights of results and directions to nine points of interest.

336. **Swift, Lloyd W., Jr.; Baker, Samuel E.** Lower water temperatures within a streamside buffer strip. Res. Note SE-193. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1973. 7 p.

The removal of streamside vegetation increases the water temperature in mountain streams. Clearcutting and farming have been found to raise temperatures beyond the tolerance level for trout (68° F.). Within the sale area of a commercial clearcut in the mountains of North Carolina, a narrow buffer strip of uncut trees and shrubs was left beside a stream. Although water temperatures within the sale area may have exceeded 68° F., the stream immediately below the sale area was never warmer than 62° F.

337. **Swift, Lloyd W., Jr.; Knoerr, Kenneth R.** Estimating solar radiation on mountain slopes. Agricultural Meteorology 12: 329-336; 1973.

The amount of solar irradiation on a mountain slope is an important parameter for describing the climatology of a sloping site, but measurements are not easily obtained. Daily totals of solar irradiation can be estimated from the daily total of global solar radiation measured on a horizontal surface at a site near enough to have the same cloud cover as the mountain slope. The adjusting function is a ratio of the value of potential solar irradiation for a slope to that for a horizontal surface. Valid estimates of solar radiation input were obtained for two opposite-facing slopes.

338. **Swift, Lloyd W., Jr.; Messer, James B.** Forest cuttings raise temperatures of small streams in the Southern Appalachians. Journal of Soil and Water Conservation 26: 111-116; 1971.

Stream temperatures were measured during six forest-cutting treatments imposed on 23- to 70-acre watersheds in the Southern Appalachian Mountains. Where forest trees and all understory vegetation were completely cut, maximum stream temperatures in summer were raised from the normal 66° F. up to 73° or more. Some extreme treatments raised temperatures over 12° above normal. Where streambank vegetation was uncut or had regrown, summer maximums were unchanged or reduced from levels found under uncut mature hardwoods. Increases in stream temperature were judged to degrade water quality and constitute thermal pollution because, after each clearcut, water temperatures exceeded optimum levels for trout habitat.

339. **Swift, Lloyd W., Jr.; Schreuder, Hans T.** Fitting daily precipitation amounts using the S_B distribution. Monthly Weather Review 109: 2535-2541; 1981.

The log-normal, gamma, Weibull, S_B and beta distributions were fit to daily precipitation amounts for each calendar

month for a 38-year period. Data are from the high precipitation zone of the southern Appalachian Mountains. The S_B distribution, a generalization of the log-normal, consistently fit the data best. The gamma distribution fit rainfall amounts accumulated for two and three consecutive wet days.

Higher-order Markov chains, up through the fifth order, described the data better than lower-order chains. The S_B distribution of precipitation amounts on all dates preceded by dry days is different from that for all dates preceded by precipitation.

340. **Swift, Lloyd W., Jr.; Swank, Wayne T.** Long term responses of streamflow following clearcutting and regrowth. Hydrological Sciences Bulletin 26: 245-256; 1981.

Long-term changes in streamflow following forest cutting for three experimental basins show that streamflow declines with the logarithm of time as the forest regrows. The decline is related to vegetation regrowth, but is not a consistent function of simple stand measurements. The mixed hardwood forest of one basin was clearcut twice in 40 years. During the second regrowth period, streamflow increases were about one-half those after the first treatment. Concurrently, two other basins were cut whose mid-elevations are 400 m higher. Both streamflow increases were less than on the lower basin. Similar variability of increases for the three concurrent treatments appears partly related to precipitation.

341. **Swift, Lloyd W., Jr.; Swank, Wayne T.; Mankin, J. B.; Luxmoore, R. J.; Goldstein, R. A.** Simulation of evapotranspiration and drainage from mature and clear-cut deciduous forests and young pine plantation. Water Resources Research 11(5): 667-673; 1975.

PROSPER, a model for water exchange between soil, plant, and atmosphere, was used to simulate evapotranspiration and annual streamflow for 2 years from a mature oak-hickory forest in the Southern Appalachian Mountains. For a year having unusually high precipitation, simulated streamflow agreed within 1.5 percent with measured streamflow. Additional simulations were made using the same climatic data, but vegetation parameters were changed to represent a regrowing coppice forest after clearcutting, and a young white pine plantation. The predicted changes in streamflow showed good agreement with measured changes determined from watershed experiments at Coweeta Hydrologic Laboratory.

342. **Tan, K. H.; Sihanonth, P.; Todd, R. L.** Formation of humic acid-like compounds by the ectotrophic mycorrhizal fungus *Pisolithus tinctorius*. Soil Science Society of America Journal 42: 906-908; 1978.

Formation of organic compounds by the ectomycorrhizal fungus, *Pisolithus tinctorius*, was studied to establish the relationship of these microbial products to humic and fulvic acids. The fungus was grown in a Melins-Norkrans liquid culture with either sucrose or a mixture of L-malic and L-succinic acid as the C and energy source. The biologically synthesized substances were characterized by chemical and infrared analyses.

343. **Tate, Cathy M.; Meyer, Judy L.** The influence of hydrologic conditions and successional state on dissolved organic carbon export from forested watersheds. Ecology 64: 25-32; 1983.

Concentration and export of DOC were compared in streams draining four watersheds with different treatment histories in 1969-70 and again in 1979-80. In 1969-70, the watersheds were: old field (yr. 1), hardwood coppice (yr. 7), white pine (yr. 13) and mature hardwood (undisturbed for 45 yr.). DOC concentrations were 3 to 4 times greater than in 1979-80 on all watersheds. Annual export was greatest from the hardwood and old-field watersheds and least from the pine and coppice during both years. Despite higher runoff during 1979-80, DOC export was less during that year on all watersheds. Although there appears to be a trend toward decreasing DOC concentration and export over the first 2 decades of secondary succession, differences caused by periodic variations in runoff are far more significant than any successional changes observed.

344. **Tebo, L. B., Jr.** Effects of siltation, resulting from improper logging, on the bottom fauna of a small trout stream in the southern Appalachians. Progressive Fish-Culterist 55: 64-70; 1955.

Siltation resulting from improper land-use practices is regarded as one of the most important factors contributing to a reduction in the acreage of desirable fishing waters. This report presents quantitative data regarding the effect of siltation on bottom fauna of trout streams in the southern Appalachians.

345. **Todd, R. L.; Cromack, K., Jr.; Knutson, R. M.** *In situ* observations of microbial biomass by scanning electron microscopy. In: Rosswall, Thomas, ed. Modern methods in the

study of microbial ecology. Proceedings of the symposium; 1972 June 19-23; Uppsala, Sweden. Bulletin of the Ecological Research Committee, 17. Stockholm, Sweden; National Science Research Council; 1973: 109-118.

Improved methods are needed for assessing the role of microflora in decomposition and nutrient cycling. This paper describes an assessment technique that enables microbiologists to examine microorganisms *in situ*.

346. **Todd, Robert L.; Cromack, Kermit; Stormer, John C.** Chemical exploration of microhabitat by electron probe microanalysis of decomposer organisms. Nature 243: 544-546; 1973.

A method for chemical analysis of decomposer biomass without destruction of the detrital matrix is discussed. The probe uses a high energy beam of electrons to excite atoms into releasing their particular x-radiation, allowing measurement of essential nutrients for small individual fractions of detritus.

347. **Todd, R. L.; Humphreys, W. J.; Odum, E. P.** The application of scanning electron microscopy to estuarine microbial research. In: Stevenson, L. Harold; Colwell, R. R., eds. Estuarine microbial ecology: Belle W. Baruch symposium in marine sciences; 1971; Columbia, SC. Columbia, SC: University of South Carolina Press; 1973: 115-125.

This report is a discussion of the sensitivity of the scanning electron microscope in the detection of microorganisms from the estuarine environment. The future application of this technique for research in this area would allow for *in situ* observation with the minimum distortion of organism and environment. Such an application of this procedure may prove superior to existing methods, such as bright-field, dark-field, or phase-contrast microscopy, for such observations.

348. **Todd, R. L.; Kerr, T.** Scanning electron microscopy of microbial cells on membrane filters. Applied Microbiology 23: 1160-1162; 1972.

Scanning electron micrographs of a *Pseudomonas* species, *Staphylococcus aureus*, and *Bacillus subtilis* on two membrane filtration systems are compared.

349. **Todd, R. L.; Meyer, R. D.; Waide, J. B.** Nitrogen fixation in a Southeastern United States deciduous forest. In: Granhall, U., ed. Environmental role of nitrogen-fixing blue-green algae and asymbiotic bacteria; Proceedings of the seventh international soil zoology colloquium; 1976 September 20-24;

Uppsala, Sweden. Ecological Bulletin 26. Stockholm, Sweden: Swedish Soil Science Society; 1978: 172-177.

Dinitrogen fixation was quantified in a mixed deciduous forest ecosystem at Coweeta. Rates and annual amounts of nitrogen fixation were measured for several components of a mature oak-hickory forest. Highest rates were observed in the soil (8.53 kg N fixed ha^{-1} yr^{-1}), followed by woody litter (1.66), bole (1.00), leaf litter (0.63), and phyllosphere (0.22). The total amount of nitrogen fixed was estimated as 12.04 kg N ha^{-1} yr^{-1}. Generally these fixation rates for a deciduous forest compare favorably with similar measurements in coniferous forests. These results show that the biological fixation of gaseous nitrogen is a major input of nitrogen to deciduous forest ecosystems.

350. **Todd, R. L.; Nuner, J. H.** Comparison of two techniques for assessing denitrification in terrestrial ecosystems. In: Rosswall, Thomas, ed. Modern methods in the study of microbial ecology: proceedings of the symposium; 1972 June 19-23; Uppsala. Bulletin Ecological Research Committee, 17. Stockholm, Sweden: National Science Research Council; 1973: 277-278.

In an effort to quantify denitrification in a terrestrial ecosystem we are using gas chromatography. The preliminary results presented here compare the rates of denitrification (as determined by the conversion of nitrous oxide to atmospheric nitrogen) to the standard most probable number (MPN) procedure. While the latter technique can provide only enumeration of denitrifying cells, the gas chromatographic procedure allows for the calculation of actual transfer rates.

351. **Todd, R. L.; Swank, W. T.; Douglass, J. E.; Kerr, P. C.; Brockway, D. L.; Monk, C. D.** The relationship between nitrate concentration in the Southern Appalachian mountain streams and terrestrial nitrifiers. Agro-Ecosystems 2: 127-132; 1975.

The nitrate content of stream water and the nitrifying bacterial population of the terrestrial horizon were measured in three Southern Appalachian watersheds over a 22-month period. The watersheds studied were a fescue grass catchment, a 15-year-old white pine plantation, and a mature undisturbed hardwood forest. Monthly averages of nitrate-nitrogen in stream water from the three watersheds were 730, 190, and 3 p/b respectively; the respective nitrifying populations averaged 16,000, 175 and 22 per gram of dry weight for each 40 cm soil profile. These populations were concentrated in the

upper 10 cm of the profile (grass = 98 percent, white pine = 90 percent, and hardwood = 88 percent). A correlation is evident between the number of nitrifying bacteria in the soil from gaged watersheds and the NO_3 content of the streams. Nitrifying activity appears to be dependent on vegetation type and successional stage.

352. **Todd, Robert L.; Sihanonth, Prakitsin; Crossley, D. A., Jr.; Cromack, Kermit, Jr.** Elemental analysis of terrestrial microflora and fauna using an electron microbeam technique. In: Adrino, D. C.; Brisbin, Lehr, Jr., eds. Environmental chemistry and cycling processes, Energy Research and Development Symposium Series (Conf - 760429); 1976 April 28 - May 1; Augusta, GA. Springfield, VA: National Technical Information Service; 1978: 119-129.

A nondestructive, fast, and accurate means of obtaining elemental information about a variety of biologically different samples located within a microhabitat is X-ray microanalysis. Combining an X-ray spectrometer and a scanning electron microscope makes it possible for the environmental chemist to visualize the sample and to determine elemental concentration and spatial localization. Elemental concentrations and their distribution can be measured if consideration is given to specimen preparation and proper interpretation of the X-ray data. Analytical procedures (specimen preparation and data interpretation) and the potential of this technique as an environmental research tool are discussed.

353. **Todd, Robert L.; Waide, Jack B.; Cornaby, Barney W.** Significance of biological nitrogen fixation and dentrification in a deciduous forest ecosystem. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems: Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 729-735.

Gaseous transformations of nitrogen were quantified in relation to other components of the nitrogen cycle of a mixed deciduous forest ecosystem at Coweeta. Rates and total annual amounts of nitrogen fixation and potential denitrification were measured for several components of the litter-soil subsystem of a mature oak-hickory forest. Highest rates of both processes were observed in leaf and woody litter, but highest totals occurred in the soil. Of the total nitrogen input, including that via bulk precipitation, biological fixation accounted for 75 percent. Potential denitrification losses exceeded stream-water losses by 200 times. Our results

show that consideration must be given to both levels of activity and total fluxes in any examination of the forest nitrogen cycle and that existing pools of nitrogen may not indicate the magnitude of gaseous transformations that are occurring.

354. **Tramer, Elliot J.** Bird species diversity: components of Shannon's formula. Ecology 50(5): 927-929; 1969.

Shannon's diversity index $\bar{H} = \Sigma Pi \log_z Pi$ was calculated for 267 breeding bird censuses. The index was resolved into its components, species richness and relative abundance, to determine which components played a larger role in the determination of diversity patterns. Changes in diversity were correlated closely with species richness, while the relative abundance component remained stable. Photoplankton differ from birds in that the relative abundance component is not stable from one collection to the next. This is attributed to differences in the environmental uncertainty encountered by the two groups. It is suggested that the regulation of diversity by either the species richness or relative abundance components represent alternative strategies which are suited to predictable/nonrigorous and unpredictable/rigorous environments, respectively. Therefore, differences similar to those observed between birds and phytoplankton might be expected in other groups of organisms.

355. **Troendle, Charles A.** Hydrologic impacts of silvicultural activities. Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers; vol. 105 (No. IR 1): 57-70; 1979.

Discusses the use of hydrologic models to develop a handbook for evaluating impact of silvicultural practices on the hydrologic cycle. Models were evaluated for usefulness in developing regional response relationships and site specific modifiers useful to planners. Empirical relationships which allow pre- and posttreatment evaluation of hydrologic responses were derived from simulations. Prior work on the PROSPER model and Coweeta's Watershed 28 were used in development and illustration of methodology.

356. **U.S. Department of Agriculture, Forest Service.** Waters of Coweeta. Agricultural Information Bulletin 117. Washington, DC: U.S. Department of Agriculture, Forest Service; 1953. 22 p.

The results of 20 years of streamflow studies at Coweeta are highlighted. Text and pictorial illustrations are borrowed from a documentary film with the same title.

357. **Ursic, Stanley J.; Douglass, James E.** The effects of forestry practices on water resources. In: Proceedings of the W. Kelly Mosley environmental forum; 1978 May; Auburn, AL. Auburn, AL: Auburn University Press; 1979: 33-49.

Reviews and discusses the effects of management of southern forests on annual water yield, distribution of yield both monthly and seasonally, storm runoff, sediment yield, and water quality.

358. **Van Lear, D. H.; Douglass, J. E.** Water in the loblolly pine ecosystem - Eastern region. In: Symposium on the loblolly pine ecosystems (East region); 1982 December 8-10; Raleigh, NC. Raleigh, NC: School of Forest Resources; 1982: 285-296.

The hydrologic cycle in the loblolly pine ecosystem east of the Mississippi River is discussed with special reference to the effects of silvicultural practices and species conversion on quality and quantity of water yield, storm, runoff, and erosion. The conclusion reached is that adverse impacts of forestry activities can be minimized through careful planning and supervision of operations.

359. **Van Lear, D. H.; Douglass, J. E.; Cox, S. K.; Augspurger, M. K.; Nodine, S. K.** Regeneration of loblolly pine plantations in the Piedmont by clearcutting with seed in place. In: Jones, Earle P., Jr., ed. Proceedings of the second biennial southern silvicultural research conference; 1982 November 2-4; Atlanta, GA. Gen. Tech. Rep. SE-24. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1983: 87-93.

Near-maturity plantations of loblolly pine in the Piedmont of South Carolina were successfully regenerated by clearcutting with seed in place. Three prescribed fires prepared the seedbed and adequately controlled hardwood competetion. Two growing seasons after harvest, average seedling density was 21,160 stems/acre. An economic comparison of natural and artificial regeneration, plus the success using natural regeneration demonstrates that clearcutting with seed in place is a viable low-cost alternative for regenerating pine plantations.

360. **Vimmerstedt, John P.** Site index curves for Southern Appalachian white pine plantations. Res. Note 131. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1959. 2 p.

Site quality is a determining factor in how well white pine will grow in the Southern Appalachians. Site index curves are a convenient indicator of site quality. This paper gives site index curves for the Southern Appalachians which can be used to predict tree growth.

361. **Vitousek, Peter M.; Gosz, James R.; Grier, Charles C.; Melillo, Jerry M.; Reiners, William A.; Todd, Robert L.** Nitrate losses from disturbed ecosystems. Science 204: 469-474; 1979.

A systematic examination of nitrogen cycling in disturbed forest ecosystems demonstrates that eight processes, operating at three stages in the nitrogen cycle, could delay or prevent solution losses of nitrate from disturbed forests. An experimental and comparative study of nitrate losses from trenched plots in 19 forest sites throughout the United States suggests that four of these processes (nitrogen uptake by regrowing vegetation, nitrogen immobilization, lags in nitrification, and a lack of water for nitrate transport) are the most important in practice. The net effect of all of these processes except uptake by regrowing vegetation is insufficient to prevent or delay losses from relatively fertile sites, and hence such sites have the potential for very high nitrate losses following disturbance.

362. **Waggoner, P. E.; Hewlett, J. D.** Test of a transpiration inhibitor on a forested watershed. Water Resources Research 1: 391-396; 1965.

The glyceryl half-ester of decenylsuccinic acid (GlOSA) closes tree stomata when sprayed directly upon the undersides of leaves. At Coweeta, a 12 percent reduction in transpiration might be detected as a significant increase in streamflow. Two sprays of 50 pounds of GlOSA in water applied to 30 acres of one watershed from a helicopter produced little deposit on the undersides of leaves and no clear evidence of stomatal closure. Observed increases in streamflow were statistically insignificant.

363. **Waide, Jack B.; Swank, Wayne T.** Nutrient recycling and the stability of ecosystems: implications for forest management in the Southeastern United States. In: America's renewable resource potential - 1975: the turning point: proceedings of the 1975 national convention Society of American Foresters; 1975 September 28 - October 2; Washington, DC. Washington, DC: Society of American Foresters; 1976: 404-424.

This paper outlines a conceptual framework that has guided research on elemental cycles on forested watersheds at Coweeta. The basis framework is then applied to analyses of the nitrogen cycle in two important southeastern forest ecosystem types.

364. **Waide, Jack B.; Swank, Wayne T.** Simulation of potential effects of forest utilization on the nitrogen cycle in different southeastern ecosystems. In: Correll, David L., ed. Watershed research in eastern North America: a workshop to compare results; 1977 February 28 - March 3; Edgewater, MD. Edgewater, MD: Smithsonian Institution; 1977: 767-789.

Forest harvesting methods may alter both quality of streamwater draining forested lands (the off-site response) and sustainable productivity of forests being managed (the on-site response). Results from Coweeta suggest that long-term changes in water quality are not likely to result from current management practices, but effects on sustainable yield are unknown. Simulation models of nitrogen cycling were used to assess potential effects of several management alternatives on sustainable productivity and elemental cycling. Responses of nitrogen dynamics in oak-hickory and loblolly pine forests to simulated merchantable-stem and complete-tree harvests with several rotation lengths were examined. Results suggest that some management practices may lead to long-term alterations of nitrogen cycling and productivity, and that conclusions from such simulation studies will depend on how elemental cycling models are conceptualized.

365. **Waide, Jack B.; Webster, Jackson R.** Engineering systems analysis: applicability to ecosystems. In: Patten, B. C., ed. Systems analysis and simulation in ecology. New York: Academic Press; 1976; vol. 4: 329-371.

Four general classes of systems analysis appear to have potential benefit in ecology. Time domain analysis involves investigation of the timing and magnitude characteristics of signals fluxing through systems. A second broad class of analysis, frequency domain analysis, concentrates on the ability of systems to attenuate (or amplify) and phase shift sinusoidal inputs. The third category, stability analysis, seems very relevant to ecosystem theory, though stability considerations in ecology have often been plagued by vague and nonequivalent definitions. Finally, techniques of sensitivity analysis are examined in detail. From these discussions we conclude that the objectives of systems analysis in ecology and engineering are very different. Engineers are interested in designing systems, whereas ecologists must

attempt to analyze existing systems. Thus, many systems engineering methodologies either may not be applicable to ecosystem analysis or may require modification before they can be applied.

366. **Wallace, J. B.; O'Hop, Joe.** Fine particle suspension feeding capabilities of *Isonychia* spp. (Ephemeroptera: Siphlonuridae). Annals of the Entomological Society of America 72: 353-357; 1979.

Stream-inhabiting mayflies belonging to the genus *Isonychia* possess a well-developed fringe of long setae on their forelegs which is used to filter particulate materials suspended in the water column. In this paper we report on a mechanism, composed of two different types of microtrichia, that latches the long filtering setae to adjacent setae. This coupling mechanism results in an effective pore size of 0.1-0.7 m for portions of the filtration device. Both ultrastructure of the filtering mechanism and foregut particle size analysis indicate that *Isonychia* are capable of feeding on much smaller particles than previously suspected.

367. **Wallace, J. B.; Woodall, W. R., Jr.; Sherberger, F. F.** Breakdown of leaves by feeding of *Peltoperla maria* nymphs (Plecoptera: Peltoperlidae). Annals of the Entomological Society of America 63: 562-567; 1970.

Nymphs of *Peltoperla maria* Needham & Smith were exposed to 15 species of autumn-shed leaves in the laboratory. The insects fed on the cuticle and mesophyll of the leaves, leaving most of the vascular system intact. The insects consumed leaves in amounts (by dry weight) in excess of their dry body weight in a 2-week period. Feeding studies revealed that *P. maria* has definite preferences for specific kinds of leaves. Higher tannic acid content of water from feeding containers was found, apparently a result of increased leaching from the finely ground leaf material in the fecal pellets.

368. **Wallace, J. Bruce.** *Arctopsyche*: the larval retreat and food of *Arctopsyche*; with phylogenetic notes on feeding adaptations in Hydropsychidae larvae (Trichoptera). Annals of the Entomological Society of America 68: 167-173; 1975.

Arctopsyche larvae generally construct somewhat cornucopia-shaped dwellings at the top and sides of large rocks in swift mountain streams and spin a capture net across a U-shaped frame at the anterior end of the larval abode. The individual meshes of mature larval capture nets are the largest found to date in the Hydropsychidae. The structure

of the nets and larval abodes supports the placement of the Arctopsychinae as primitive Hydropsychidae. In the evolution of hydropsychid larvae there is a tendency toward more complicated larval feeding structures and smaller capture net mesh sizes.

369. **Wallace, J. Bruce.** A new species of Psilotera from North Carolina (Trichoptera: Odontoceridae) Entomological News 81: 243-245; 1970.

A survey of the Trichoptera of the Coweeta Hydrological Laboratory in Macon County, N.C., has resulted in the discovery of a new species of *Psilotreta* Banks from the southern Appalachians. The following description is offered to give workers in aquatic biology, especially those concerned with rearing and use of the metamorphotype technique, a more accurate determination of species in this genus in the Eastern United States.

The author is pleased to name this species for H. H. Ross, who has contributed so much to our knowledge of the North American Trichoptera fauna.

370. **Wallace, J. Bruce.** Some aspects of net-spinning trichopteran diversity. In: Discovery processes and scientific productivity: symposium celebrating the 20th anniversary of the Department of Entomology at Virginia Polytechnic Institute and State University; 1979 June 29; Blacksburg, VA. Blacksburg, VA: College of Agriculture, Virginia Polytechnic Institute and State University; 1982: 45-64.

Nets spun by larvae of the Hydropsychoidea are used to capture drifting food materials in streams. Nets allow these filter feeders to exploit food materials which are produced in many diverse habitats and made available to them by the current. Both net area and mesh size differ among species and instars within species. This fundamental adaptation has important implications that relate to space, food and temporal variations in life cycles. Large meshed capture nets are located in higher current velocities than smaller meshed nets. Evidence is presented which suggests that faster velocities are associated with increased carnivorous feeding by larvae. Net-spinning caddisfly production is apparently food-limited in certain habitats while spatial limitations are imposed in other habitats. The possible significance of mesh size differences is discussed with respect to both food and spatial limitations.

371. **Wallace, J. Bruce; Malas, Diane.** The fine structure of capture nets of larval Philopotamidae (Trichoptera) with special emphasis on *Dolophilodae distinctus*. Canadian Journal of Zoology 54: 1788-1802; 1976.

Philopotamid larvae spin, in flowing waters, capture nets that have the smallest mesh-opening sizes recorded among trichopterans. Sac-like nets of final-instar *Dolophilodes distinctus* are up to 6 cm long and 8 to 15 cm in circumference. Both larval nets and mesh-opening sizes increase with instar, those of final instars being about 0.5 x 5.5 μm. Based on scanning electron microscope examination, a probable net construction sequence is proposed. Nets of a *Wormaldia* sp. examined consisted of several layers of elongate rectangular meshes. Larval nets of *Chimarra* spp. examined have both elongate rectangular mesh-opening shapes and nets apparently consisting of randomly arranged silk strands.

372. **Wallace, J. Bruce; Malas, Diane.** The significance of the elongate rectangular mesh found in capture nets of fine particulate filter feeding Trichoptera larvae. Archiv fuer Hydrobiologie 77: 205-212; 1976.

Striking similarities exist in capture net mesh shapes of fine particle feeding Trichoptera larvae, even among genera in families that are not closely related phylogenetically. The capture nets of these fine particle feeders have elongate rectangular mesh openings. There are several important consequences associated with this type of mesh design.

373. **Wallace, J. Bruce; Ross, Douglas H.; Meyer, Judy L.** Seston and dissolved organic carbon dynamics in a Southern Appalachian stream. Ecology 63: 824-838; 1982.

Suspended particulate matter (seston) and dissolved organic carbon (DOC) were studied along a 6.4-km section of a Southern Appalachian headwater stream from July 1978 to August 1979. Samples were collected at six sites encompassing stream orders 1-4 and a 635-m elevation change. No significant changes in seston concentration occurred from upstream to downstream sites, and only one site had concentrations significantly different from the others. DOC/particulate organic carbon (0.45 X POM) ratios average ≈1. DOC concentrations (mg/L) increased over the first 2 km of stream but remained relatively constant farther downstream. Seven size classes of seston were measured, and discriminant analysis was used to assess longitudinal changes in particle-size distribution. Although the mean particle size decreased

downstream, the ratio of coarse particulate organic matter (CPOM)/fine particulate organic matter (FPOM) increased downstream. We suggest that CPOM/FPOM ratios do not necessarily reflect downstream reductions in mean particle size. The ratio of benthic CPOM/suspended CPOM decreases downstream, which is apparently attributable to the lack of retention devices in higher order streams.

374. **Wallace, J. Bruce; Webster, Jackson R.; Cuffney, Thomas F.** Stream detritus dynamics: regulations by invertebrate consumers. Oecologia 53: 197-200; 1982.

Insecticide treatment of a small, Appalachian forest stream caused massive downstream insect drift and reduced aquatic insect densities to <10 percent of an adjacent untreated reference stream. Reduction in breakdown rates of leaf detritus was accompanied by differences in quantity and composition of benthic organic matter between the two streams. Following treatment, transport of particulate organic matter was significantly lower in the treated stream than in the reference stream whereas no significant differences existed prior to treatment. Our results indicate that macroinvertebrate consumers, primarily insects, are important in regulating rates of detritus processing and availability to downstream communities.

375. **Wallace, J. Bruce; Webster, Jackson R.; Woodall, W. Robert.** The role of filter feeders in flowing waters. Archiv fuer Hydrobiologie 79(4): 506-532; 1977.

Net-spinning trichopteran larvae are used as examples of filter-feeding stream insects to show that various species feed upon a range of particle sizes. Individual species have evolved to crop particular sizes of particles in stream seston. The evolutionary mechanisms are discussed. The evolutionary diversity of filter feeders has important consequences for stream ecosystems that transcend the individual species involved.

376. **Wallace, L. L.; Dunn, E. L.** Comparative photosynthesis of three gap phase successional tree species. Oecologia 45: 331-340; 1980.

Photosynthesis was measured in situ on trees growing in an open, gap-like site and under a closed canopy. Photosynthetic responses also were monitored on trees grown in the laboratory under either a high or low light regime or on those trees transferred from a low to a high light regime. All three species studied, *Liriodendron tulipifera, Acer rubrum*

and *Cornus florida*, were able to acclimate to a high light environment as evidenced by their higher photosynthetic rates. This acclimation was achieved by an increase in transfer conductance and was ultimately due to changes in leaf anatomy.

377. **Waring, R. H.; Rogers, James J.; Swank, W. T.** Water relations and hydrologic cycles. In: Reichle, D. E., ed. Dynamic properties of forest ecosystems. Malta: Cambridge University Press; 1980: 205-264.

This book chapter first describes the processes affecting water movement and storage in forests with a detailed discussion of the structure and function of a watershed hydrologic system. The second section demonstrates the general application of the hydrologic processes by assembling them into a detailed computer simulation model and applying this model to three different forested watersheds where streamflow data were available.

378. **Webb, D. P.** Regulation of deciduous forest litter decomposition by soil arthropod feces. In: Mattson, W. J., ed. The role of arthropods in forest ecosystems. New York; Heidelberg; Berlin: Springer Verlag; 1977: 56-69.

Soil invertebrates may consume 20 to 100 percent of annual litter input and in so doing produce an immense amount of excrement. Presumably, feces merely represent pulverized litter which offers greater surface area for leaching and microbial attack. Positive feedback between microflora and soil fauna is believed to produce a slow step-by-step humification of litter as soil, litter, feces and microflora are ingested and reingested. Such litter decomposes rapidly via physical processes and, therefore, exclusion of arthropods from it has failed to show any decrease in decomposition rates.

379. **Webster, J. R.; Gurtz, M. E.; Hains, J. J.; Meyer, J. L.; Swank, W. T.; Waide, J. B.; Wallace, J. B.** Stability of stream ecosystems. In: Barnes, James R.; Minshall, G. Wayne, eds. Stream ecology. New York: Plenum Publishing Corporation; 1983: 355-395.

The ability of ecosystems to recover from external disturbances (stability) is a fundamental property of these systems. Quantification of stability and understanding of the mechanisms behind recovery are current areas of major ecological research. We present an overview of the stability concept used in ecology and a more specific discussion of

the application to stream ecosystems. We use a case study where we have observed the stability of small streams disturbed by watershed logging and compare stream stability to stability of the adjacent disturbed forest ecosystem.

380. **Webster, Jackson R.** Hierarchy theory and ecosystem models. In: Halfon, E., ed. Theoretical systems ecology. New York: Academic Press; 1978: 119-129.

The relevance of the hierarchy concept in biology has been questioned, but it is nevertheless a useful way to organize our perception of nature. The hierarchical ordering of nature is both structural and dynamic, with the vertical separation of levels dependent on behavioral frequencies and the horizontal separation the result of the degree of interaction between systems. Within this hierarchy of natural systems, one can perceive both upward and downward causation. This perception provides a philosophical midground between holism and reductionism. At the ecological levels of organization, ecosystems are comprised of interacting organisms. Communities and populations are not natural systems and can best be recognized as subunits of ecosystems. Advances in ecosystem ecology must proceed from an understanding of ecosystem level behaviors and laws.

381. **Webster, Jackson R.** Large particulate organic matter processing in stream ecosystems. In: Correll, David L., ed. Watershed research in Eastern North America: a workshop to compare results; 1977 February 28 - March 3; Edgewater, MD. Edgewater, MD: Smithsonian Institution; 1977: 505-526.

The stream ecosystems of eastern deciduous forests are highly adapted to their riparian terrestrial surroundings. Particulate organic matter inputs from the riparian vegetation are processed by the combined action of microbes and invertebrates and the mechanical action of flowing water. In unperturbed Coweeta streams, processing efficiency is 95 to 99 percent. Processing efficiency is less in watersheds where the vegetation has been disturbed. Comparison of Coweeta data with other studies suggests a greater processing efficiency in southeastern than northeastern streams.

382. **Webster, Jackson R.** The role of benthic macroinvertebrates in detritus dynamics of streams: a computer simulation. Ecological Monographs 53(4): 383-404; 1983.

Detritus dynamics in Big Hurricane Branch, a second-order stream at Coweeta, were simulated with a computer model using data from a variety of Coweeta stream studies. The model was

used to evaluate the role of macroinvertebrates in the stream. Macroinvertebrates accounted for only a small portion of the respiration of detritus; their major role was conversion of benthic detritus into transported detritus.

Based on an annual budget, macroinvertebrates decrease the efficiency of detritus processing in low-order streams, because they increase transport loss. On a longer time scale, however, macroinvertebrates prevent accumulation of large amounts of detritus in the stream and major losses during infrequent large storms. By stabilizing long-term detritus export dynamics, they provide an important link between low-order and higher-order streams.

383. **Webster, Jackson R.; Crossley, D. A., Jr.** Evaluation of two models for predicting elemental accumulation by arthropods. Environmental Entomology 7(3): 411-417; 1978.

Two different models have been proposed for predicting elemental accumulation by arthropods. Parameters of both models can be quantified from radioisotope elimination experiments. Our analysis of the two models shows that both predict identical elemental accumulation for a whole organism, though differing in the accumulation in body and gut. We quantified both models with experimental data from ^{134}Cs and ^{85}Sr elimination by crickets. Computer simulations of radioisotope accumulation were then compared with actual accumulation experiments. Neither model showed exact fit to the experimental data, though both showed the general pattern of elemental accumulation.

384. **Webster, Jackson R.; Patten, Bernard C.** Effect of watershed perturbation on stream potassium and calcium dynamics. Ecological Monographs 49: 51-72; 1979.

Three small streams located at Coweeta, on an old field watershed, a pine plantation watershed, and a hardwood forest watershed, were investigated to determine effects of watershed perturbation on K and Ca dynamics in the stream ecosystems. Data collected included measurements of litterfall inputs, large particulate organic matter and benthic organism standing crops, large particulate organic matter and organism drift, and insect emergence. We used ^{85}Sr and ^{134}Cs to estimate detritivore ingestion and elimination rates of Ca and K, respectively.

Watershed perturbations had altered stream inputs and caused accompanying changes in the stream fauna. Results indicated

that the perturbed streams had less efficient physical processing of allochthonous inputs, but greater biological utilization of inputs. The streams exhibited high resilience to perturbation with complete recovery limited by the recovery rate of allochthonous inputs.

385. **Webster, Jackson R.; Waide, Jack B.** Effects of forest clearcutting on leaf breakdown in a Southern Appalachian stream. Freshwater Biology 12: 331-344; 1982.

Effects of forest clearcutting on rates of leaf breakdown were studied in Big Hurricane Branch, a second-order stream located at Coweeta. Breakdown rates of leaves of three tree species were measured in the stream before, during and after the catchment were clearcut. Breakdown rates of all three leaf species were slowed during clearcutting and accelerated later. Following logging the breakdown rate of dogwood leaves was equal to the pretreatment rate, and white oak and rhododendron leaves broke down faster than prior to treatment. We attribute the slow breakdown during treatment to burial of the leaf packs in sediment. Subsequent acceleration may have been due to a lack of alternative food sources for invertebrate detritivores.

386. **Webster, Jackson R.; Waide, Jack B.; Patten, Bernard C.** Nutrient recycling and the stability of ecosystems. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems: Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 1-27.

A theoretical perspective on ecosystems is elaborated which relates alternative strategies of stability to observable and measurable attributes of ecosystems. Arguments are presented for viewing nutrient cycling as positive feedback. Attention is focused on two aspects of relative stability: resistance and resilience. A linear ecosystem model that embodies these concepts is discussed, and four relative stability indexes are derived. Random matrices, subject to mass-conservation limitations, and hypothetical ecosystem models, constructed according to a characterization of alternative properties of nutrient cycles, are analyzed to examine relationships between the relative stability indexes and specific properties of nutrient cycles. The theory put forth in this paper is seen as a rigorous, operational approach to ecosystems which is testable by both observation and experimental analysis.

387. **Webster, Jackson R.; Wallace, J. Bruce.** Productivity of southeastern stream ecosystems. In: Symposium on trout habitat research and management: Proceedings; 1974 September 5-6; Cullowhee, NC. Boone, NC: Appalachian Consortium Press; 1975: 64-78.

Streams differ from terrestrial ecosystems in a number of characteristics. Most studies indicate the main source of energy to streams is in allochthonous inputs. A generalized Southeastern United States trout stream model is proposed and examples of organisms performing various functions are described.

388. **Wells, Martha J. M.** The effect of silanol masking on the recovery of picloram and other solutes from a hydrocarbanaceous pre-analysis extraction column. Journal of Liquid Chromatography 5(12): 2293-2309; 1982.

The recoveries of picloram, picloram-methylester, hexazinone, benzene, and acetophenone from aqueous samples were studied using a commercially available hydrocarbonaceous pre-analysis extraction cartridge, both with and without tetrabutylammonium hydrogen sulfate (TBAHS) in the eluent. Extraction efficiency was found to be dependent on sample loading volume. The results suggest a mixed mechanism of retention involving both "silanophilic" and "hydrophobic" interactions in the absence of tetrabutylammonium ion. The ability of TBAHS to mask surface silanol groups and/or ion-pair with counterionic solutes is invoked to explain the observations. Chromatograms of the solutes obtained on a C_{18} bonded analytical column in both the presence and absence of TBAHS are also presented.

389. **Whelan, D. E.** Effects of land use on streamflow. Journal of the Alabama Academy of Science 29(4): 55-60; 1957.

Present knowledge of the effects of land use and treatment on streamflow is summarized. The basic concepts of land use and ground-water hydrology are discussed in order to show how soil and vegetal cover influence the disposition of precipitation.

390. **Whitford, W. G.; Meentemeyer, V.; Seastedt, T. R.; Cromack, K., Jr.; Crossley, D. A., Jr.; Santos, P.; Todd, R. L.; Waide, J. B.** Exceptions to the AET model: deserts and clear-cut forest. Ecology 62: 275-277; 1981.

A model for decomposition of litter as a function of actual evapotranspiration (AET) and lignin content developed for

temperate and boreal forest sites was tested for other ecosystems. The correlation between AET and decomposition does not necessarily apply to all vegetation types nor to severely disturbed sites. Decomposition is higher than predicted by the AET model in deserts where AET is low, and lower than predicted for a mesic clear-cut forest where AET values are higher than in uncut forests.

391. **Woodall, W. R.; Wallace, J. B.** Mineral pathways in small Appalachian streams. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems: Energy Research and Development Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 408-422.

Nutrient contents of benthic organisms in streams draining four small watersheds were examined. The watersheds, which were located in the Southern Appalachian mountains, were each covered in a different vegetation type. Crayfish and salamanders were responsible for most of the standing-crop biomass in the detritivore and predator compartments, respectively, and also account for most of the fluxes in their compartments. An increase in potassium concentrations and a decrease in calcium and magnesium concentrations were associated with an increase in trophic levels. Since the food material was richer in calcium and magnesium than in potassium, detritivores concentrated proportionately more potassium than calcium or magnesium. The principal mechanism of potassium release from detritus was through leaching. For calcium and magnesium, the principal mechanism for release was the feeding activity of detritivores.

392. **Woodall, W. Robert; Wallace, J. Bruce.** The benthic fauna in four small Southern Appalachian streams. American Midland Naturalist 88: 393-407; 1972.

Monthly quantitative samples of benthic organisms were collected from streams in four different watersheds from August 1968 through July 1969. Each of the watersheds supports one of the following types of vegetation: old-field succession, hardwood forest, white pine forest with a few hardwoods, coppice forest. The kinds of organisms in the four streams were generally similar but their relative importance varied significantly. A Duncan's multiple-range test showed significant differences in the numbers of most taxa among the watersheds. The old-field stream had the greatest abundance while the coppice stream had the greatest standing crop biomass. The white pine stream had lowest

standing crops of both numbers and biomass. Most of the differences among watersheds were attributed to different inputs of allochthonous detritus.

393. **Yount, J. David.** The effect of nonremoval clear-cutting and pine reforestation on the cation composition of a hardwood forest soil. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems: Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 744-753.

Soil studies were conducted at Coweeta Hydrologic Laboratory, North Carolina, in a deciduous hardwood forest and in a white pine plantation established after clearcutting and decay of all previous vegetation. These studies demonstrate that the soil under the pine forest differs from the control hardwood forest in the opposite direction to that expected based on relative nutrient demands of young pine forests and mature hardwood forests. The principal difference is a high calcium concentration in the pine soil compared with the control and, related to that, a higher pH. Cation exchange capacity and percent base saturation were also higher in the pine plantation soil.

394. **Yount, J. David.** Forest-floor nutrient dynamics in Southern Appalachian hardwood and white pine plantation ecosystems. In: Howell, F. G.; Gentry, J. B.; Smith, M. H., eds. Mineral cycling in southeastern ecosystems: Energy Research and Development Administration Symposium Series (Conf - 740513); 1974 May 1-3; Augusta, GA. Springfield, VA: National Technical Information Service; 1975: 598-608.

Nutrient content and detrital biomass in the forest floor of a mature deciduous hardwood watershed and a 15-year-old white pine plantation at Coweeta Hydrologic Laboratory were followed through one complete annual cycle, May 1970 to May 1971. Total carbon storage is significantly greater in the white pine than in the deciduous hardwood forest floor. Forest-floor biomass is probably approaching a steady state in the pine plantation, as indicated by computed turnover times. Calcium content, which is on the order of 100 kg/ha in both forest floors, is higher in the hardwood forest floor than in the pine; this reflects a considerably higher concentration of calcium in hardwood litter. Magnesium content is an order of magnitude lower than calcium. Potassium and sodium levels are very similar in both forest floors. Nitrogen and phosphorus storage is considerably higher in the white pine than in the hardwood forest floor. Summer loss rates were computed for forest-floor components.

395. **Best, George Ronnie.** Potassium, sodium, calcium, and magnesium flux in a mature hardwood forest watershed and an eastern white pine forest watershed at Coweeta. Athens, GA: University of Georgia; 1971. 88 p. M.S. thesis.

396. **Best, George Ronnie.** Treatment and biota of an ecosystem affect nutrient cycling. Athens, GA: University of Georgia; 1976. 113 p. Ph.D. dissertation.

397. **Biever, Lawrence Joseph.** The role of mycorrhizal fungi in ecosystem energetics. Athens, GA: University of Georgia; 1982. 158 p. Ph.D. dissertation.

398. **Black, Peter Elliott.** Interception in a hardwood stand. East Lansing, MI: Michigan State University; 1957. 90 p. M.F. thesis.

399. **Boring, Lindsay Ross.** Early forest regeneration and nutrient conservation on a clearcut southern Appalachian watershed. Athens, GA: University of Georgia; 1979. 86 p. M.S. thesis.

400. **Boring, Lindsay Ross.** The role of black locust (*Robinia pseudo-acacia* L.) in forest regeneration and nitrogen fixation in the southern Appalachians. Athens, GA: University of Georgia; 1982. 173 p. Ph.D. dissertation.

401. **Brater, E. F.** An application of the unit hydrograph principle to small watersheds. Ann Arbor, MI: University of Michigan; 1937. 56 p. Ph.D. dissertation.

402. **Cornaby, Barney W.** Population parameters and systems models of litter fauna in a white pine ecosystem. Athens, GA: University of Georgia; 1973. 98 p. Ph.D. dissertation.

403. **Cromack, Kermit, Jr.** Litter production and decomposition in a mixed hardwood watershed and a white pine watershed at Coweeta Hydrologic Laboratory. Athens, GA: University of Georgia; 1973. 160 p. Ph.D. dissertation.

404. **Day, Frank P., Jr.** Primary production and nutrient pools in the vegetation on a southern Appalachian watershed. Athens, GA: University of Georgia; 1973. 133 p. Ph.D. dissertation.

405. **Day, Frank Patterson, Jr.** Vegetation structure of a hardwood watershed at Coweeta. Athens, GA: University of Georgia; 1971. 145 p. M.S. thesis.

406. **Déchant, Thomas.** Relationships between the intragravel environment and egg and alevin mortality in three southern Appalachian trout streams. Cullowhee, NC: Western Carolina University; 1979. 51 p. M.S. thesis.

407. **Deshefy, Gregory Scott.** Genetic variability in populations of the fall cankerworm, *Alsophila pometaria*, in defoliated forests in the southern Appalachians. Clemson, SC: Clemson University; 1978. 107 p. M.S. thesis.

408. **Dils, Robert E.** Changes in some vegetation, surface soil and surface runoff characteristics of a watershed brought about by forest cutting and subsequent mountain farming. East Lansing, MI: Michigan State University; 1952. 205 p. Ph.D. thesis.

409. **Drumheller, David.** Organization and function of *Desmognathus* salamander communities in southern Appalachian stream ecosystems. Clemson, SC: Clemson University; 1979. 75 p. M.S. thesis.

410. **Fallas, Jorge.** Effects of clearcutting, vegetation regrowth and reforestation on a flow duration on three Coweeta experimental basins. Ann Arbor, MI: University of Michigan; 1982. 91 p. M.S. thesis.

411. **Fox, John Daniel, Jr.** A forest hydrology model of vegetation streamflow relations. Seattle, WA: University of Washington; 1976. 275 p. Ph.D. dissertation.

412. **Freeland, Forrest Dean, Jr.** The effects of a complete cutting of forest vegetation and subsequent annual cutting of regrowth upon some pedologic and hydrologic characteristics of a watershed in the southern Appalachians. East Lansing, MI: Michigan State University; 1956. 182 p. Ph.D. thesis.

413. **Gist, Clayton S.** Analysis of mineral pathways in a cryptozoan foodweb. Athens, GA: University of Georgia; 1972. 152 p. Ph.D. dissertation.

414. **Golladay, Stephen W.** The relationship between microbial conditioning of leaf litter and food utilization by an aquatic detritivore. Blacksburg, VA: Virginia Polytechnic Institute and State University; 1981. 51 p. M.S. thesis.

415. **Gray, Gerard A.** Quantitative importance and factors affecting brook trout recruitment in interrupted tributaries. Blacksburg, VA: Virginia Polytechnic Institute and State University; 1979. 76 p. M.S. thesis.

416. **Greene, Geoffrey Edward.** The relation between stream and air temperature. Berkeley, CA: University of California; 1955. 85 p. M.S. thesis.

417. **Gurtz, Martin Edward.** Ecology of stream invertebrates in a forested and a commercially clear-cut watershed. Athens, GA: University of Georgia; 1981. 146 p. Ph.D. dissertation.

418. **Haefner, John Denis.** The effects of old field succession on stream insects in the southern Appalachians and production of two net-spinning caddisflies. Athens, GA: University of Georgia; 1980. 61 p. M.S. thesis.

419. **Hains, John J., Jr.** The response of stream flora to watershed perturbation. Clemson, SC: Clemson University; 1981. 81 p. M.S. thesis.

420. **Hargrove, William Walter.** Forest canopy consumption by arthropod herbivores: an average-availability model. Athens, GA: University of Georgia; 1983. 99 p. M.S. thesis.

421. **Helvey, J. David.** Predicting soil moisture in the southern Appalachians. Athens, GA: University of Georgia; 1971. 79 p. M.S. thesis.

422. **Hewlett, John David.** Internal water balance of forest trees on the Coweeta watershed. Durham, NC: Duke University; 1962. 122 p. Ph.D. dissertation.

423. **Hibbert, Alden Ron.** A study of commonly used hydrologic concepts and their application in runoff analysis on small mountain watersheds. Logan, UT: Utah State University; 1961. 80 p. M.S. thesis.

424. **Hornick, Lawrence Ernest.** Periphyton production in an Appalachian mountain trout stream. Blacksburg, VA: Virginia Polytechnic Institute and State University; 1978. 77 p. M.S. thesis.

425. **Iglich, Esther M.** Population age structures and dynamics of six hardwood species in a forested watershed ecosystem in the southern Appalachians. Athens, GA: University of Georgia; 1975. 87 p. M.S. thesis.

426. **Jones, LeRoy.** A watershed study in putting a hardwood forest at the Coweeta Hydrologic Laboratory in the southern Appalachian Mountains under intensive management. Athens, GA: University of Georgia; 1955. 77 p. M.F. graduate problem.

427. **Katana, Mohammed Said.** Some comparisons of precipitation, streamflow, and soil on a denuded, a grass-covered, and a forested watershed in the Copper Basin of Tennessee. Raleigh, NC: North Carolina State University; 1955. 124 p. M.F. thesis.

428. **Kent, Edward J.** Source control of storm water through joint use of constructed storage and soil management. Charlottesville, VA: University of Virginia; 1982. 112 p. Ph.D. dissertation.

429. **Knipling, Edward Byron.** Comparison of the dye method with the thermocouple psychrometer for measuring leaf water potentials. Durham, NC: Duke University; 1966. 121 p. Ph.D. dissertation.

430. **Knipling, Edward Byron.** Investigation of the Schardakow method for the measurement of diffusion pressure deficit. Durham, NC: Duke University; 1963. 72 p. M.A. thesis.

431. **Kodama, Henry Eugene.** Interception and release of nutrients by canopies of young loblolly pine stands in response to prescribed burning. Clemson, SC: Clemson University; 1977. 53 p. M.S. thesis.

432. **Kovner, Jacob Leon.** Changes in streamflow and vegetation characteristics of a southern Appalachian mountain watershed brought about by forest cutting and subsequent natural regrowth. Syracuse, NY: State University of New York, College of Forestry; 1955. 245 p. Ph.D. thesis.

433. **Lee, Martha Parker.** Reproductive studies of the perennial herb, *Parnassia asarifolia* vent. (Saxifragaceae), a southern Appalachian endemic. Cullowhee, NC: Western Carolina University; 1983. 52 p. M.S. thesis.

434. **McGinty, Douglas T.** The ecological roles of *Kalmia latifolia* L. and *Rhododendron maximum* L. in the hardwood forest at Coweeta. Athens, GA: University of Georgia; 1972. 81 p. M.S. thesis.

435. **McGinty, Douglas Trimble.** Comparative root and soil dynamics on a white pine watershed and in the hardwood forest in the Coweeta basin. Athens, GA: University of Georgia; 1976. 110 p. Ph.D. dissertation.

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437. **Malas, Diane Mary.** Microdistribution and food of three species of net spinning caddisflies in a small spring fed southern Appalachian stream. Athens, GA: University of Georgia; 1976. 32 p. M.S. thesis.

438. **Martinez, Jose Andy.** Seasonal trends of CO_2 exchange in two understory evergreen shrubs in the eastern deciduous forest. Athens, GA: University of Georgia; 1975. 94 p. M.S. thesis.

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441. **Murphy, Charles Edward, Jr.** Energy sources for the evaporation of precipitation intercepted by tree canopies. Durham, NC: Duke University; 1970. 260 p. Ph.D. dissertation.

442. **Nabholz, J. Vincent.** Small mammals and mineral cycling on three Coweeta watersheds. Athens, GA: University of Georgia; 1973. 87 p. M.S. thesis.

443. **Neal, William P.** The southern piedmont upland of the southeastern United States: a geomorphic system in a steady state of dynamic equilibrium. Athens, GA: University of Georgia; 1967. 81 p. M.A. thesis.

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451. **Richmond, Mark Stevens.** Modeling storm event precipitation in mountainous terrain for erosion control system design. Clemson, SC: Clemson University; 1983. 207 p. M.S. thesis.

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454. **Sadowski, Wayne A.** Southeastern brook trout--the importance of first order tributaries and the life history in a southeastern Virginia stream. Blacksburg, VA: Virginia Polytechnic Institute and State University; 1978. 65 p. M.S. thesis.

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467. **Webster, Jackson Ross.** Analysis of potassium and calcium dynamics in stream ecosystems on three southern Appalachian watersheds of contrasting vegetation. Athens, GA: University of Georgia; 1975. 232 p. Ph.D. thesis.

468. **Williams, Jerry G.** A study of the effect of grazing upon changes in vegetation on a watershed in the southern Appalachian mountains. East Lansing, MI: Michigan State University; 1954. 138 p. M.S. thesis.

469. **Woodall, William Robert, Jr.** A comparison of aquatic insects in four different watersheds. Athens, GA: University of Georgia; 1969. 115 p. M.S. thesis.

470. **Woodall, William Robert, Jr.** Nutrient pathways in small mountain streams. Athens, GA: University of Georgia; 1972. 118 p. Ph.D. dissertation.

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Gaskin, Julia W.; Douglass, James E.; Swank, Wayne T., comps.
Annotated bibliography of publications on watershed management and ecological studies at Coweeta Hydrologic Laboratory, 1934-1984. Gen. Tech. Rep. SE-30. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1984. 140 p.

A collection of 470 citations and annotations for papers published by scientists associated with the Coweeta Hydrologic Laboratory. Major categories in a subject index include watershed management, hydrometeorology, plant-water relationships, soil relationships, stream-flow relationships, ground water, stream ecology, and terrestrial ecology.

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ERRATA SHEET

ANNOTATED BIBLIOGRAPHY OF PUBLICATIONS ON WATERSHED MANAGEMENT AND ECOLOGICAL STUDIES AT COWEETA HYDROLOGIC LABORATORY, 1934-1984

Page 26 - #65. Authors should be Dunford, E. G.; Fletcher, P. W.

Page 59 - #179. Pages should be 131-134.

Page 128 - Top of page should be headed Theses and Dissertations.

Page 128 - First item under Theses and Dissertations should be:

Abbott, David Thomas. Woody litter decomposition at Coweeta Hydrologic Laboratory, North Carolina. Athens, GA: University of Georgia; 1980. 136 p. Ph.D. dissertation.

Page 128 - #398. Black's M.F. thesis is from Ann Arbor, MI: University of Michigan.

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