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Annotated Bibliography of Research Related to the Fernow Experimental Forest

Abstract

Contains citations for more than 500 publications, videos, and audiovisual programs that describe research on or related to the Fernow Experimental Forest in West Virginia that was conducted from 1949 through 1991. A subject index and an index of publications by year are included.

The Compilers

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Foreword

The Fernow Experimental Forest located near Parsons, West Virginia, has a long, productive research history, as evidenced by the publications listed in this bibliography. The original 7,136-acre tract was purchased by the USDA Forest Service in 1915. The Forest Service recognized the need for research to establish scientifically sound guidelines for managing public land and on May 28, 1934, the Fernow Experimental Forest was established through an act of Congress. Named in honor of Bernhard E. Fernow, a well-known German-born forester who pioneered scientific forestry in the United States, the forest initially comprised 3,640 acres and was expanded to about 4,700 acres in 1974.

The Fernow Experimental Forest serves as a field laboratory for two research projects, one on the growth and yield of central Appalachian hardwoods, the second on protection of water resources in central Appalachian forests. Forest management research began on the Fernow in 1948 when five 5-acre demonstration areas were installed near Big Springs Gap to evaluate the effects of different types of hardwood reproduction management. Forest hydrology research began in 1951 when five watersheds ranging from 38 to 96 acres were instrumented to measure precipitation and streamflow.

This annotated bibliography includes citations for more than 500 publications, videos, and audiovisual programs that describe 43 years of research on or related to the Fernow Experimental Forest. This research was conducted by Forest Service and cooperating scientists.

The citations are arranged alphabetically by senior author, and a subject index and an index of publications by year are provided.

1.

Adams, M. B.; Edwards, P. J.; Kochenderfer, J. N. 1991. **Watershed acidification on the Fernow Experimental Forest, West Virginia.** Agronomy Abstracts: 345.

Despite recent clean air legislation, acid deposition levels remain high in many parts of the United States. The effects of this acid deposition on forested watersheds is poorly understood. A unique study on the Fernow Experimental Forest in West Virginia is examining the impacts of acidic deposition on such watersheds. An 85-acre watershed has received 3 years of fertilization with ammonium sulfate at twice ambient levels of N and S deposition; an adjacent watershed of similar size and soil type serves as the untreated control. Stream chemistry and soil chemistry had been monitored prior to the study initiation in 1989. No effects of treatment on stream chemistry have been detected. Changes in soil-solution chemistry may have begun to occur, but results are not statistically significant. Additional information on nutrient cycling on the watersheds is being collected.

2.

Adams, M. B.; Kelley, J. M.; Taylor, G. E., Jr.; Edwards, N. T. 1990. **Growth of five families of Pinus taeda L. during three years of ozone exposure.** New Phytology. 116: 689-694.

Loblolly pine (Pinus taeda L.) seedlings of five half-sib families were grown for 3 years in the field in open-top chambers. The seedlings were fumigated during the growing season (approximately April-October) with ozone at the following target levels: subambient, ambient, and ambient+60. At the end of the three growing seasons, no statistically significant ozone reactions were detected. Analysis of growth trends suggest that drought during the second and third growing seasons may have interacted with the ozone treatments. The importance of long-term studies under realistic field conditions is discussed.

3.

Adams, Mary Beth; Eagar, Christopher. 1991. **Effects of acidic deposition on high-elevation spruce-fir forests in the United States.** In: Acid deposition: origins, impacts and abatement strategies. New York: Springer-Verlag: 75-89.

Large numbers of dead red spruce trees in high-elevation spruce-fir forests of the Eastern United States have been linked with elevated levels of air pollutants. These high elevation forests receive a significant amount of sulfate and nitrate from cloudwater deposition. The Spruce-Fir Research Cooperative, an integrated multi-institutional program, is investigating a number of hypothesized effects on the spruce-fir forest: (1) soil-mediated effects, (2) altered physiological processes, (3) increased foliar injury, and (4) increased susceptibility to winter injury. The results of Spruce-Fir Cooperative research are discussed.

4.

Adams, Mary Beth; Nichols, Dale S.; Federer, C. Anthony; Jensen, Keith F.; Parrott, Harry. 1991. **Screening procedure to evaluate effects of air pollution on Eastern Region wildernesses cited as Class I air quality areas.** Gen. Tech. Rep. NE-151. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 33 p.

The USDA Forest Service's Eastern Region manages eight wilderness areas that have been designated as Class I air quality areas by the Federal Clean Air Act. As part of this legislation, Federal land managers are required to consult with air pollution regulators on the potential impacts of proposed air pollution emissions including phytotoxic gases and acidic materials on the air quality-related values (AQRVs) of these wildernesses. Applications for Prevention of Significant Deterioration permits must be reviewed and commented on by the Federal land manager. This publication provides the manager with a procedure to rapidly screen these applications to determine which should have detailed review. The screening approach is a regional modification of a national model developed by the Forest Service in 1988. In 1990, the Eastern Region, Northeastern and North Central Forest Experiment Stations, and the Northeastern Area, State and Private Forestry sponsored a workshop of scientists and land managers to obtain advice on regionalizing this screening procedure. Two loading levels for various pollutants were established. The "red line" is the loading level above which AQRVs are expected to be adversely affected. The "green line" is the loading level below which no adverse impacts are expected. Within the intermediate "yellow zone" effects are uncertain. The criteria used to establish red and green-line values, the AQRVs for each wilderness, and the relation between the two are discussed.

5.

Arner, S. L.; Gansner, D. A.; Dale, M. E.; Smith, H. C. 1991. **Silvicultural cutting opportunities in oak-hickory forests of West Virginia.** In: McCormick, Larry H.; Gottschalk, Kurt W., eds. Proceedings, 8th central hardwood forest conference; 1991 March 4-6; University Park, PA. Gen. Tech. Rep. NE-148. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 360-372.

Analysis of cutting opportunities for oak-hickory forests of West Virginia reveals a storehouse of economic opportunity. The potential cut from silviculturally sound thinning, regeneration, and harvest opportunities totals 100 million cords, or 60 times the current annual harvest of growing-stock volume from the state. On the stump, the conversion value of this material totals $2.4 billion. Moreover, the good housekeeping associated with this silviculture would improve timber productivity and quality.

6.

Aubertin, G. M. 1971. **Nature, extent, and influence of macropores on subsurface water movement in forest soils.** Res. Pap. NE-192. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 33 p.

Under mixed hardwood stands in northeastern Ohio, water rapidly entered the soil and moved considerable distances downslope through macropores. Subsurface water moved through old root channels in relatively dry, fine-textured soils, while the soil surrounding the channels remained dry. Observations revealed that the number, degree of formation, and persistence of old root channels were greater in the finer textured soils. Information is presented on types, amount, and distribution of macropores within forested soils.

7.

Aubertin, G. M. 1971. **Small watershed clearcutting is compatible with sound management of forest resources.** Agronomy Abstracts: 144.

Research on the Fernow Experimental Forest has shown that prudent clearcutting of small watersheds can be compatible with sound management of forest resources. Clearcutting an 86-acre hardwood watershed revealed that first-year water yield increased by 177,000 gallons per acre during the growing season. Storm flows were only slightly increased while all dormant-season flows were unaffected. Soil erosion was negligible and limited to logging roads. Water temperature, specific conductance, pH, suspended solids, alkalinity, Ca, Mg, K, Na, Mn, Cu, Zn, S, Fe, P, ammonia-N, nitrate-N, and organic-N values were little changed. This lack of change in water composition can be attributed to nutrient recycling by the rapid, luxuriant regrowth. In terms of wildlife, it is an ecological truism that such regrowth along the edges of openings is more beneficial than vast expanses of unbroken forests. Thus, far from destroying the forest environment and despite some adverse effects, clearcutting brings on a new generation of light-demanding, high-value trees and is associated with several beneficial effects on other forest resources.

8.
Aubertin, G. M. 1973. **Problems and techniques in sampling water for analysis.** In: Use of small watersheds in determining effects of forest land use on water quality: symposium proceedings. Lexington, KY: University of Kentucky: 1-9.

Sampling is a vital part of any water quality study and can be a major source of error. Therefore, the objectives of sampling must first be clearly described before water samples are collected. A sampling plan should address where to sample, how many samples to collect, when and how to sample, sample size, possible contamination, labeling, transport, and preservation of samples.

9.
Aubertin, G. M.; Patric, J. H. 1972. **Quality water from clearcut forest land?** Northern Logger. 20(8): 14-15, 22-23.

A study of water quality effects of clearcutting was begun in 1969. First-year results indicate that clearcutting had only minimal effects on specific conductivity or nutrient concentrations of the stream water. The lack of major increase in conductance and nutrient concentrations is attributed to vigorous regrowth of vegetation and careful location, construction, and maintenance of logging roads.

10.
Aubertin, G. M.; Patric, J. H. 1974. **Water quality after clearcutting a small watershed in West Virginia.** Journal of Environmental Quality. 3: 243-249.

A 34-ha (85-acre) gaged watershed on the Fernow Experimental Forest, Parsons, West Virginia, was conventionally clearcut in 1969. Streamflow increased by 20 cm (8 inches) during the first year after cutting, but rapid and luxuriant revegetation reduced the flow increase to only 6.4 cm (2.5 inches) during the second year. Water quality remained high. Clearcutting had a negligible effect on the stream's temperature, pH, nonstorm turbidity, and concentrations of dissolved solids, Ca, Mg, Na, K, Fe, Cu, Zn, Mn, and NH_4^+-N. Storm-period turbidity, nitrate-nitrogen, and phosphate concentrations showed slight increases, while sulfate concentrations decreased. A maximum nitrate-nitrogen concentration of 1.42 ppm was recorded during a 6.4-cm (2.5-inch) rainfall. Success in avoiding damage to water quality was attributed to careful road management, retention of a forest strip along the stream, and rapid, lush vegetative regrowth after clearcutting.

11.
Aubertin, G. M.; Smith, D. W. 1972. **Streamflow quality after urea fertilization of a forested watershed.** Agronomy Abstracts: 175.

First year results show that streamflow concentrations of nitrate-nitrogen, calcium, magnesium, sodium, and potassium increased following aerial application of urea to a 74-acre forested watershed in West Virginia. Out of 829 samples analyzed, only 18 contained nitrate-nitrogen concentrations greater than the Public Health drinking water standards. During the growing season 2.4 percent of the applied nitrogen was discharged from the watershed; 15.4 percent was discharged during the dormant season. Highest ammonium-nitrogen concentrations in the stream usually occurred during the early part of a storm, before the maximum stream discharge, while nitrate-nitrogen concentrations were highest near or slightly following maximum discharge. Highest nitrogen was generated by flow-producing storms which followed dry periods in which there was little or no stream discharge. Maximum concentrations of ammonium- (4.5 ppm) and nitrate-nitrogen (19.8 ppm) were obtained during such storms.

12.
Aubertin, G. M.; Smith, D. W.; Patric, J. H. 1973. **Quantity and quality of streamflow after urea fertilization on a forested watershed: first-year results.** In: Forest fertilization symposium proceedings. Gen. Tech. Rep. NE-3. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 88-100.

Streamflow was analyzed to determine the effects on the quantity and quality of water flowing from a 74-acre calibrated watershed that had been fertilized with 500 pounds of urea per acre. During the first year after fertilization, no change was detected in the quantity of streamflow. Water quality, as determined from analysis of 829 samples, remained high. Comparison of data on nitrogen discharge for the year before and after the fertilization revealed approximately 18 percent greater discharge after fertilization. Loss of nitrogen was accompanied by increased loss of certain metallic cations.

13.
Aubertin, Gerald M. 1969. **An improved technique for taking hydraulic conductivity cores from forest soil.** Res. Note 92. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Describes a large-diameter, heavy-duty soil sampler that makes it possible to obtain a long, relatively undisturbed sample column from stony, root-filled forest soils. The resulting samples include the roots, root channels, stones, and macro-voids common to forested lands.

14.
Aubertin, Gerald M.; Leaf, Albert L. 1976. **Forest soils research priorities in the Northeast.** Report for the Northeastern Region Planning Committee, Northeastern Forest Committee and Forest Soils Sub-Committee R.P. 2.0.5. 35 p.

This research planning report was prepared as part of the Regional and National Agriculture and Forestry Research Planning System. Establishes priorities for forest soils research in the Northeastern United States, including inventory and appraisal of soil resources and soil, organism, water, and nutrient relationships.

15.
Aubertin, Gerald M.; Patric, J. H. 1975. **Comments on water quality after clearcutting a small watershed in West Virginia.** Journal of Environmental Quality. 4(2): 282-283.

16.
Aubertin, Gerald M.; Thomer, Benjamin C.; Campbell, John. 1976. **A precipitation collector and automated pH monitoring system.** Res. Note NE-220. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Describes a sensitive precipitation collector and automated pH monitoring system that provides for continuous monitoring and recording of the pH of precipitation. Discrete or composite rainwater samples are obtained manually for chemical analysis. This system can easily be adapted to accommodate a flow through specific conductance probe and monitoring components.

17.

Auchmoody, L. R. 1972. **Effects of fertilizer-nutrient interactions on red oak seedling growth.** Res. Pap. NE-239. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

Growth of red oak seedlings was examined in relationship to various levels of nitrogen (N), phosphorus (P), and potassium (K) supplied singly and in all combinations to forest soils from the Barbour series. Results showed that seedling growth was significantly affected by NxP and NxPxK interactions. Without nitrogen, P and K alone or in combination with each other did not increase growth. These findings suggest that NxP and NxPxK interactions should be considered in designing fertilization tests on soils that have P and K levels similar to or lower than those tested in this study.

18.

Auchmoody, L. R. 1972. **Epicormic branching: seasonal change, influence of fertilization and frequency of occurrence in uncut stands.** Res. Pap. NE-228. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Study of seasonal changes of epicormic branch numbers, effects of fertilization, and frequency of occurrence in uncut middle-aged Appalachian hardwoods showed that: (1) Large numbers of current branches died during the growing season. Reduction was greater on the first log than on the second for both species, and it was greater for red oak than for yellow-poplar; (2) N, P, or K fertilizers did not stimulate epicormic branches to form during either the first or second season after fertilization, but N did increase vigor and growth of established epicormic branches on high sections of the bole; (3) The number of epicormic branches on individual stems in uncut stands was a function of species and log position, but may also be influenced by genetics. Branch numbers were unrelated to tree size within the d.b.h. range of the dominant and codominant trees sampled.

19.

Auchmoody, L. R. 1972. **Foliar nutrient variation in four species of upland oak.** Agronomy Abstracts: 136.

It is common practice to restrict sampling of forest tree foliage to certain specific, often difficult to reach locations, such as the upper most sun leaves growing on the south side of the crown. A study of 60-year-old red, white, chestnut, and scarlet oaks growing near Parsons, West Virginia suggest that the easier-to-reach foliage from the lower crown is equally well-suited for nutrient sampling so long as it is not mixed with foliage from the upper crown. In this study, 10 individuals of each species were sampled (40 trees), with samples taken from the terminal, from each cardinal direction in the upper unshaded section of the crown, from each cardinal direction in the lower section, and from the interior positions. Samples were analyzed for N, P, K, Ca, Mg, Mn, and Fe; and variation within trees, among trees of similar species, and between species was determined for each element. Distinct differences in nutrient levels occurred between species for all elements except Fe. Potassium, Ca, Mg, and Fe concentrations were generally higher in the lower than in the upper crown, while N, P, and Mn concentrations were unrelated to position. Direction of foliage orientation within the crown did not influence composition, and tree-to-tree variation was approximately the same for all crown positions.

20.
Auchmoody, L. R. 1972. **Nutrient properties of five West Virginia forest soils.** Res. Note NE-145. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Nutrient levels in five well-drained forest soils of the northern mountain section of West Virginia generally were associated with type of parent rocks from which the soils had formed. But in some instances, different rock types yielded soils of similar nutrient composition. Soils formed from limestone and calcareous shale were usually higher in fertility than soils formed from acid sandstone. However, considerable variation in nutrient levels occurred within as well as among most of the different soil series.

21.
Auchmoody, L. R. 1973. **Response of yellow-poplar, red oak, and basswood to fertilization in West Virginia.** Agronomy Abstracts: 137.

Five replicated field fertilization tests with small sawlog yellow-poplar, red oak, and basswood were established in the northern mountain section of West Virginia in the spring of 1970. Treatments included P, NP, and NPK applied in two successive seasons at fixed rates. Yellow-poplar was the most responsive species, showing consistent basal-area growth increase to N. Additional response of yellow-poplar to P occurred once N requirements were met. Red oak was less responsive than yellow-poplar, and basswood was unresponsive. Second-year response was greater than in the first or third seasons. A consistent reduction in response was observed from KCl when applied with N and P. Foliar response in leaf weight and color was attributed mostly to N, though P in combination with N produced slightly heavier leaves than N only, and KCl had negative effects. Deficient foliar nutrient levels and sample-size requirements for collections are given.

22.
Auchmoody, L. R. 1974. **Nutrient composition of blades, petioles, and whole leaves from fertilized and unfertilized yellow-poplar.** Res. Note NE-198. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

Nitrogen (N) and phosphorus (P) concentrations in leaf blades and petioles obtained from three fertilized and three unfertilized yellow-poplar sample trees were determined annually during a 4-year period. Concentrations were substantially higher in blades than in petioles. Fertilization increased N and P concentrations in blades, but petioles showed only a slight increase in N and a decrease in P. Because blades were more responsive to changes in external nutrient supply than petioles, and because fertilization affected the composition of blades and whole leaves unequally, blades give a more sensitive and accurate measure of nutrient concentration than petioles or whole leaves.

23.
Auchmoody, L. R.; Hammack, K. P. 1975. **Foliar nutrient variation in four species of upland oaks.** Res. Pap. NE-331. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 16 p.

Sampling of forest tree foliage for nutrient analyses is commonly restricted to specific and often difficult-to-reach locations such as the uppermost sun leaves growing on the south side of the crown. A study of 60-year-old red, white, chestnut, and scarlet oaks growing near Parsons, West Virginia, suggests that the easier-to-reach foliage from the lower crown is equally well suited for nutrient sampling. In this study, 10 individuals of each species were sampled. Foliage samples were taken from the terminal shoot, from each cardinal point in the upper unshaded section of the crown, from each cardinal point in the lower section, and from interior positions. Samples were analyzed for N, P, K, Ca, Mg, Mn, and Fe. Variation within trees, among trees of similar species, and between species was determined for each element.

Direction of foliage orientation within the crown did not influence nutrient composition. Concentrations of K, Ca, and Mg generally were higher than in upper crown, while N, P, Mn, and Fe concentrations were unrelated to position. Tree-to-tree variation was approximately the same for all crown positions. There were many differences in foliar nutrient composition among species.

24.

Auchmoody, L. R.; Smith, H. C. 1971. **Four year effects of fertilization and lime on mineral composition of sugar maple foliage.** Agronomy Abstracts: 116.

A single broadcast application of 22.4 metric tons/ha of hydrated lime with and without varying rates of water soluble fertilizer containing N, P, K, Mg, and Zn was made in a 75-year-old sugar maple stand. Concentration changes of foliar N, P, K, Ca, Mg, Zn, Cu, and Fe, monitored annually for 4 years, were used to assess the effectiveness and longevity of nutrient treatments. N and Mg fertilization increased foliar concentrations during the first season, but had little or no effect in following years. Fertilization sharply increased Ca uptake from lime during the first season, but not thereafter. Concentrations of P, K, and micro nutrients were unaffected by fertilization. Liming increased utilization of fertilizer N during the season of application, but had no other effect on uptake during following years. Ca uptake, without fertilization, was not greatly affected by liming until the fourth season; however, Mg concentration was increased the first year and was maintained during the following seasons. Mn levels declined during the third and fourth seasons, presumably from decreased Mn availability brought about by changes in soil pH.

25.

Auchmoody, L. R.; Smith, H. Clay. 1977. **Response of yellow-poplar and red oak to fertilization in West Virginia.** Soil Science Society of America Journal. 41(4): 803-807.

Fertilization tests with small sawlog-size yellow-poplar and red oak were begun in the northern mountain section of West Virginia in the spring of 1970. Treatments were made with N, P, N-P, and N-P-K. During the first year, N was broadcast at 336 kg/ha, P at 97 kg/ha, and K at 93 kg/ha. Second-season application included 112 kg/ha of N and 97 kg/ha of P. Basal-area response to N over a 3-year period amounted to a 47-percent increase for yellow-poplar and a 29-percent increase for red oak. There was no response to P, either alone or in combination with N. Negative effects on basal-area growth were observed where KCl was applied. Foliar response in leaf weight and color was attributed mostly to N, though P in combination with N produced slightly heavier and darker green leaves than N only. Foliar N in yellow-poplar corresponding to the best basal-area growth was about 3.0-percent N.

26.

Auchmoody, L. R.; Smith, H. Clay. 1979. **Oak soil-site relationships in northwestern West Virginia.** Res. Pap. NE-434. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 27 p.

An oak soil-site productivity equation was developed for the well drained, upland soils in the northwestern portion of West Virginia adjacent to the Ohio River. The equation uses five easily measured soil and topographic variables and average precipitation to predict site index. It accounts for 69 percent of the variation in oak site index and has a standard error of 4.3 feet at the mean site index of 67.6 feet. The equation was tested with data from 61 independent plots, and the results showed a correlation of 0.83 between predicted and observed site indexes.

27.
Auchmoody, L. R.; Wendel, G. W. 1973. **Effect of calcium cyanamide on growth and nutrition of planted yellow-poplar seedlings.** Res. Pap. NE-265. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 11 p.

Calcium cyanamide, a nitrogenous fertilizer that also acts as an herbicide, was evaluated over a 3-year period for use in establishing planted yellow-poplar on an old-field site. Results show that first and second-year growth of yellow-poplar can be increased by broadcasting $CaCN_2$ around the seedling. When applied at rates of 400 to 500 pounds of nitrogen per acre, $CaCN_2$ eliminated competing ground cover and supplied nitrogen to the seedling that promoted vigor and rapid early growth.

28.
Barr, Carl R. 1955. **Safety program on the Fernow Experimental Forest.** Northern Logger. 3(12): 16-17, 33.

The safety program on the Fernow Experimental Forest is described. As a result of this training, the logging crew has an excellent safety record.

29.
Barr, Carl R. 1957. **Selling safety to woods workers.** Northern Logger. 6(2): 33, 70-71.

The logging crew on the Fernow Experimental Forest is described, and the loggers' jobs detailed. The highly effective safety program (more than 1,925 days without a lost-time accident) is described, and responses to particular hazards are presented.

30.
Barr, Carl R. 1961. **Wheel tractor skidding vs. trucking.** Northern Logger. 10(2): 18, 40-41.

Describes the use of a rubber-tired skidder on a private woodlot, and presents a cost comparison relative to trucking cost. A detailed description of the forestry operations of Elmer Grimm, a local landowner, is included.

31.
Baughman, Roger N.; Patric, James H. 1970. **SURBAL computerized metes and bounds.** Res. Note NE-110. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

A computer program has been developed at West Virginia University for use in metes and bounds surveying. Stations, slope distances, slope angles, and bearings are primary information needed for this program. Other information needed may include magnetic deviation, acceptable closure error, designed map scale, and title designation. The program prints out latitudes and departures, adjusted bearing and line lengths, closure error, acreage, and a plotting of the survey to any selected scale, all at a fraction of the cost for manual methods.

32.
Beckjord, Peter, R.; Melhuish, John L., Jr.; Crews, Jerry T.; Farr, David F. 1990. **Epigeous ectomycorrhizal fungi of oaks and pines in forests and on surface mines of western Maryland.** Tree Planters' Notes. 41(1): 15-23.

Epigeous basidiocarps of ectomycorrhizal fungi were collected for 2 years from oak forests, 1 year from conifer forests, and 1 year from oak and conifer reforested surface mines in western Maryland. Botanical, physiographic, and edaphic data were collected. In all, 291 specimens representing 18 genera and 33 identified species were obtained. Possible ecological implications for the occurrence of these fungi on these sites are discussed.

33.
Bjorkbom, John C.; Trimble, George R., Jr. 1958. **Sow seeds on logging roads...to control erosion.** Northeastern Logger. July: 18-19, 36-37, 46.

Careful location of logging roads can significantly reduce erosion hazard. A study was designed to examine the effects of seeding various grass mixtures, with and without lime and fertilizer. For best results, seeds should be used in mixture to take advantage of different individual characteristics. Lime and fertilizer applications generally are necessary.

34.
Boteler, Franklin E.; Smith, H. Clay. 1984. **Public preference for visual resources: a summary of research findings.** West Virginia Forestry Notes. 11: 1-4.

Studies concerning landscape aesthetics are reviewed. Four categories are described: studies based on deductive reasoning, regression analysis, single-variable methods, and multivariate analysis. Apparently there has been little research on the visual attributes that might be affected by timber management in the Appalachians. As a result, public land managers may find it difficult to integrate the management of visual resources with that of other resources.

35.
Brewer, Mike S.; Lee, Richard; Helvey, J. David. 1982. **Predicting peak streamflow from an undisturbed watershed in the central Appalachians.** Water Resources Bulletin. 18(5): 755-759.

Data from a small forested catchment were used to model peak streamflow as a function of basic hydrologic variables associated with 112 rain storms. Rainfall depth and initial streamflow rate accounted for 87.1 percent of peak flow variability. Forty expressions of rainfall intensity (describing both the temporal sequence of intensity for 20 equal storm intervals, and maximum intensity for 20 separate interval lengths) were used to improve the predictability of basic models. None of the intensity parameters improved predictability by more than 2 percent, apparently because the most intense rainfall bursts generally occurred near the beginning of storm periods. Mean rainfall intensity for entire storms generally was as effective as any of the shorter interval intensities, and its use helped to linearize the relationship between peak flow and rainfall depth and duration.

36.
Brock, Samuel M.; Jones, Kenneth D.; Miller, Gary W. 1986. **Felling and skidding costs associated with thinning a commercial Appalachian hardwood stand in northern West Virginia.** Northern Journal of Applied Forestry. 3: 159-163.

Detailed cost information on thinning operations is needed to develop economic guidelines for managing immature central Appalachian hardwood stands. Three thinning treatments were applied in a 50-year-old mixed-oak, cove hardwood stand in northern West Virginia. A commercial logging contractor using chain saws and a rubber-tired skidder conducted the logging operations. Time study data were used to compute production rates for felling marked trees and skidding tree-length logs to roadside landing for each thinning treatment. Production rates ranged from 2.7 to 3.0 cunits per hour depending on the residual stocking treatment. The cost of merchantable material at roadside ranged from $10.79 to $11.99 per cunit. Regression equations for predicting felling and skidding times were developed for each treatment. Data from these equations can be used in estimating production rates and cost for similar thinning operations. A nomogram is provided for estimating felling and skidding cost for a 60-percent residual stocking treatment, the current recommended silvicultural prescription for stands similar to the study area.

37.

Chenwang, Peng; Williams, Roger N.; Galford, Jimmy R. 1991. **Descriptions and key for identification of larvae of Stelidota erichson (Coleoptera:Nitidulidae) found in America north of Mexico.** Journal of the Kansas Entomological Society. 63(4): 626-633.

Mature larvae of Stelidota geminata (Say), S. ferruginea Reitter, and S. octomaculata (Say) are illustrated and described. Characters found to be constant and species specific include teeth of the mandible, color of the pronotum, length of first and second antennal segments, and setae on the mesothoracic and third abdominal segments. A key to mature larvae of these species is given.

38.

Clark, Thomas G. 1954. **The survival and growth of 1940-41 experimental planting in the spruce type in West Virginia.** Journal of Forestry. 52: 427-431.

Planting experiments begun in 1940 with red spruce, red pine, and balsam fir were revisited in 1950 to determine how the planted and seeded trees had fared. Early release cutting (first year after planting) improved survival, though time of release had little effect on height growth. The size of opening did not appreciably affect survival or height growth, and cutting of intolerant tree species to release red spruce seemed to do more harm than good. Direct seeding was not a viable alternative for the site under study.

39.

Cromer, Jack I.; Smith, H. Clay. 1968. **Sufficient deer browse produced by a wide range of cutting practices.** Transactions of the Northeastern Fish and Wildlife Conference. 25: 25-33.

Four types of cutting practices were evaluated for their impacts on deer browse: clearcutting, diameter-limit cutting, extensive single-tree selection, and intensive single-tree selection. Any type of cutting heavy enough to support an economic timber harvest provided enough browse of preferred species to maintain at least 13 deer per square mile. The most consistent browse conditions were maintained by light, frequent cuttings. The best mast production was found on medium to low-quality sites under a partial cutting method.

40.

Currier, John B.; Aubertin, G. M.; Maxwell, Jim; Manley, Thomas R. 1974. **A look at cooperative water quality investigations.** In: Proceeding, Eastern Region 9 watershed management workshop conference; Muddy, IL. 2 p.

Describes cooperative water quality studies established by the Monongahela National Forest and the Northeastern Forest Experiment Station. These studies will provide water-quality data for environmental analyses and as a basis for formulating management policies that reduce detrimental and enhance beneficial impacts of resource management.

41.

Currier, John B.; Aubertin, Gerald M. 1976. **Monitoring precipitation chemistry on the Monongahela National Forest.** In: Proceedings international symposium on acid precipitation and the forest ecosystem. Gen. Tech. Rep. NE-23. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 335. Abstract.

Personnel from the Monongahela National Forest and the Northeastern Forest Experiment Station are collaborating in forest wide monitoring of precipitation chemistry. Present monitoring facilities consist of one continuous precipitation collector/pH recorder and 12 precipitation collectors. Samples collected in these facilities are picked up and analyzed biweekly for specific conductance, pH, acidity, alkalinity, calcium, magnesium, sodium, potassium, nitrate-nitrogen sulfate, and iron. Precipitation monitored at six ranger districts is analyzed for pH and specific conductivity only. Results to date indicate substantial spatial and temporal variation, among as well as within storms. Precipitation throughout the Forest is decidedly acid; its chemical composition depends largely on the relative location of industrial centers.

42.

DeWalle, D. R.; Ribblett, G. C.; Helvey, J. D.; Kochenderfer, J. N. 1985. **Laboratory investigation of leachate chemistry from six Appalachian forest floor types subjected to simulated acid rain.** Journal of Environmental Quality. 14(2): 234-240.

To determine the role of the forest floor in neutralization of strong acidity in acid rain, simulated acid rain at pH 4.0 was applied under laboratory conditions to forest floor samples from six Appalachian forest types. Effects of forest type, storm size, and repeated storm applications on leachate chemistry were investigated. Forest-floor leachate from a hemlock forest showed significantly lower pH (mean pH 3.9) than other leachate types due to high concentrations of organic acids. Cove hardwood forests found in areas with calcareous soil parent material produced forest-floor leachate with a significantly higher pH (mean pH 6.5) than other forest types. Forest-floor leachates from mixed oak, northern hardwood, red pine, and white pine forests were intermediate in pH (mean 4.1 to 4.4) due to the acidifying influence of organic acid leaching balanced against the neutralizing effect of H^+ exchange for Ca^{2+} in the forest floor. Weak acidity concentrations obtained by Gran plots were well correlated with 400-nm wavelength transmittance and anion deficits in the leachates. Organic anions dominated leachates from hemlock and mixed oak forest types. Increasing storm sizes caused reduced ionic concentrations, especially of H^+, Mg^{2+}, and Ca^{2+}, but three repeated storms produced no consistent significant reductions in loads or concentrations.

43.

DeWalle, D. R.; Sharpe, W. E.; Edwards, P. J. 1988. **Biogeochemistry of two Appalachian deciduous forest sites in relation to episodic stream acidification.** Water, Air, and Soil Pollution. 40: 143-156.

Bulk precipitation, throughfall, and soil-water chemistry were studied from November 1983 to November 1984 at two ridge top Appalachian deciduous forest sites to isolate causes of episodic stream acidification. The Fork Mountain site in West Virginia, which exhibited little episodic stream acidification, had lower deposition of H^+ and SO_4^{2-} and greater reduction of H^+ in the water circulating through the forest canopy, forest floor, and mineral soil than the Peavine Hill site in Pennsylvania. Greater neutralization at Fork Mountain was linked to higher Ca and Mg carbonate contents in the sandstone and shale soil parent materials. Fork Mountain had greater amounts of exchangeable bases in the organic and mineral soil horizons. Neither site appeared to be accumulating SO_4^{2-} in the soil, with Peavine Hill losing 56 percent more than was received in bulk deposition. Anions in soil leachate at Fork Mountain were largely balanced by Ca^{2+} and Mg^{2+}, while at the Peavine Hill site Al^{3+} was the dominant cation. Results suggest that the typically low carbonate content of sandstone and shale soil parent materials commonly found in Appalachian forests may be a key parameter controlling soil and stream acidification. Data for the 1 year period also show that bulk deposition of H^+ was 63 percent greater at Peavine Hill than Fork Mountain.

44.

DeWalle, David R.; Sharpe, William E.; Edwards, Pamela J. 1989. **Canopy interactions with atmospheric deposition at three hardwood forest sites.** In: Proceedings, 7th central hardwood conference; 1989 March 5-8; Carbondale, IL. Gen. Tech. Rep. NC-132. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 274-277.

Annual ion fluxes in bulk precipitation and throughfall were compared at three deciduous forest sites to examine the role of hydrogen ions and organic compounds in canopy-cation exchange. Hydrogen ions explained from 31 to 83 percent of annual canopy-cation losses. Organic compounds played a significant role in canopy-cation exchange as either weak acids or neutral salts.

45.

Dubey, T.; Stephenson, S. L.; Edwards, P. J. 1991. **A preliminary study of the mycoflora of West Virginia mountain streams.** Mycological Society of America Newsletter. 42: 12.

The aquatic fungi occurring in five first-order streams located on or near the Fernow Experimental Forest in Tucker County, West Virginia, were sampled during September and October of 1990 to obtain preliminary data on the distribution and occurrence of these organisms. At present, little is known about the aquatic fungi associated with West Virginia mountain streams. All five of the streams sampled in this study are located in forested areas, and elevations at the stream sampling points range from 740 to 957 m. Water pH averaged more than 5.5 in two of the streams, whereas the others were relatively more acidic (average pH = 4.2, 4.0, and 3.2). The total number of taxa recorded from all five streams was 62 (30 Phycomycetes [chytridiaceous fungi and water molds], 20 non-Ingoldian Hyphomycetes, and 12 Ingoldian Hyphomycetes). The number of taxa found in a particular stream ranged from 12 to 34, with the lowest number present in Finley Run, the most acidic stream sampled.

46.

Dubey, Tara; Stephenson, Steven L.; Edwards, Pamela J. 1991. **A preliminary study of the possible effects of acidification on the mycoflora of West Virginia mountain streams.** In: Keller, E. C., Jr., ed. Proceedings of the West Virginia Academy of Science; 1991 April 6; Montgomery, WV. Montgomery, WV: West Virginia Institute of Technology. 63(1): 21. Abstract.

The fungi that occur in freshwater streams belong to two major taxonomic groups--the Phycomycetes (chytrids and water molds) and the Hyphomycetes (imperfect fungi). Aquatic Phycomycetes are common inhabitants of freshwater streams, where they occur as saprophytes or parasites on a wide variety of substrates, including algae, other aquatic fungi, aquatic plants, plant detritus, and microscopic aquatic animals. Aquatic Hyphomycetes play an important role in increasing the palatability and nutritional quality of plant detritus for invertebrate grazers while at the same time enzymatically degrading the detritus. The role of aquatic Hyphomycetes is especially important because many aquatic invertebrate grazers that are unable to digest cellulose and lignin are able to consume fungal biomass generated by detritus-decomposing fungi. Fungal activity appears to be most important during the initial stages of decomposition. The aquatic fungi occurring in five first-order streams located on or near the Fernow Experimental Forest in Tucker County, West Virginia, were sampled during September and October of 1990 to obtain preliminary data on the distribution and occurrence of these organisms. Water pH averaged more than 5.5 in two of the streams, whereas the others were relatively more acidic (average pH = 4.2, 4.0, and 3.2). The total number of taxa recorded from all five streams was 62 (30

Phycomycetes, 20 non-Ingoldian Hyphomycetes, and 12 Ingoldian Hyphomycetes). The number found in a particular stream ranged from 12 to 34, with the lowest number present in Finley Run, the most acidic stream sampled.

47.

Dunford, E. G.; Weitzman, Sidney. 1955. **Managing forests to control soil erosion.** In: U.S. Department of Agriculture Yearbook. Washington DC: U.S. Department of Agriculture: 235-242.

Undisturbed forests generally show little soil erosion. Forest management activities may increase erosion if care is not used. Factors that affect soil erosion include soil type, season, kind and intensity of precipitation, and topography. Erosion following logging is caused primarily by disturbance from skidding and from poorly constructed roads. Wildfires and excessive grazing can create additional erosion hazards. Control and prevention measures for road building, logging, grazing, and burning are presented.

48.

Edwards, Pamela J. 1986. **Conversion factors and constants used in forestry with emphasis on water and soil resources.** Gen. Tech. Rep. NE-113. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

Conversion factors and constants used in forestry are listed. Values applicable to forest hydrology, watershed management, and soils are emphasized. Brief explanations and derivations of some chemical parameters are given.

49.

Edwards, Pamela J.; Halverson, Howard G.; DeWalle, David R. 1983. **Changes in precipitation chemistry yielded to urban runoff by tree crowns.** In: Proceedings, 1983 international symposium on urban hydrology, hydraulics and sediment control; 1983 July 25-28; Lexington, KY. Lexington, KY: University of Kentucky: 109-113.

Throughfall quantity and quality were measured under three replicate crowns of three urban tree species to assess possible impacts on urban runoff water quality. The interception process removed 17 to 37 percent of the precipitation volume from the runoff cycle for three summer storms. The acidic nature of precipitation was partially neutralized by reactions within the tree crowns. The throughfall had an average pH of 4.19 compared with 3.72 for precipitation. Although the sodium load of precipitation was not significantly affected, the loads of nitrogen, calcium, and potassium were increased by the tree crowns.

50.

Edwards, Pamela J.; Helvey, J. D. 1988. **Long-term changes in stream water chemistry on the Fernow Experimental Forest.** In: 1988 northeast fish and wildlife conference; 1988 March 27-30; White Sulphur Springs, WV. Charleston, WV: West Virginia Department of Natural Resources. Abstract.

Concern exists over whether central Appalachian streams and watersheds are becoming more acidic due to acid deposition. To address this issue, stream water from a control watershed on the Fernow Experimental Forest was monitored to determine long-term changes in chemistry. The data show that specific conductance has increased by 0.26 uS/cm/yr since 1970, meaning that the concentrations of total dissolved solids in steam discharge have increased. Calcium, magnesium, and nitrate concentrations have increased during this period, with calcium concentrations showing the most steady and consistent increases. However, analyses of these ions' synthetic conductivities indicate that the percentages of conductivity attributable to magnesium and nitrate ions have increased since 1970, while the percentage of conductivity attributable to calcium has remained relatively constant. The magnesium contribution has increased modestly, accounting for about 10 percent of the conductivity before 1982 and about 14.5 percent since

1982. The nitrate contribution has increased significantly more, from less than 7.5 percent in the early 1970's to an average of 21 percent during the 1980's. The percentage of conductivity attributable to calcium has remained at about 18 percent since 1970. By contrast, concentrations of stream alkalinity and percentages of conductivity attributable to alkalinity have not changed significantly since 1976 when a reliable titration method was adopted. The average annual concentration has been approximately 0.83 ppm $CaCO_3$ and the percentage of conductivity attributable to alkalinity has been about 3.7 percent. The increasing calcium losses from the watershed apparently are sufficient to maintain constant stream alkalinity levels; therefore, this watershed currently is effectively buffering incoming acidic deposition. However, we do not know how long the buffering capacity can be maintained since the alkalinity levels are low, nor do we know how long calcium losses can continue to increase without depleting the nutrient status of the watershed.

51.

Edwards, Pamela J.; Helvey, J. David. 1985. **Variability of rainfall chemistry within a 40-ha field in north central West Virginia.** In: Hutchinson, B. A.; Hicks, B. B., eds. The forest-atmosphere interaction. Dordrecht, Holland: D. Reidel Publishing: 309-318.

Variations in precipitation chemistry were studied at five points in a level field using Aerochem Metrics 301 automatic wet/dry collectors. Precipitation samples collected for 11 weeks were analyzed for pH, specific conductance, cold acidity, and concentrations of NO_3-N, SO_4, Ca, Mg, K, Na, and NH_3-N. There were no significant variations in chemical concentrations among gage sites for any of the constituents. Although concentrations were poorly correlated with total weekly precipitation, there was some evidence of greater chemical dilution with larger storm sizes.

52.

Edwards, Pamela J.; Helvey, J. David. 1991. **Long-term ionic increases from a central Appalachian forested watershed.** Journal of Environmental Quality. 20: 250-255.

The electrical conductivity of stream water draining from an unmanaged and undisturbed control watershed has been increasing steadily, by about 0.3 mS m^{-1} yr^{-1}, since 1971. During this period, NO_3^- and Ca^{2+} concentrations increased and were shown to mathematically account for the ionic contribution to conductivity; therefore, they are believed to be primarily responsible for the increase. However, the percentage of conductivity explained by the two ions was different over time. The percentage of conductivity attributable to NO_3^- increased in a pattern similar to concentration. By contrast, the percentage of conductivity attributable to Ca^{2+} decreased slightly over time. The Ca^{2+} is believed to be pairing with the NO_3^- as the NO_3^- ions leach through the soil. While nitrification in mature stands can be strongly inhibited, limited nitrification, especially in forest gaps, and high anthropogenic inputs of NO_3^- probably were primary sources of the leached NO_3^-. Preferential adsorption of SO_4^{2-} rather than NO_3^- on soil colloids is given as an explanation for the lack of retention of NO_3^- in the soil system and subsequent leaching to the stream.

53.

Edwards, Pamela J.; Helvey, J. David; Kochenderfer, James N. 1988. **Artificial acidification of a 34.4 ha catchment in the central Appalachians.** In: AGU/ASLO annual meeting; 1988 December 5-9; San Francisco, CA. Transactions of the American Geophysical Union: 69(44): 1220. Abstract.

A 3-year cooperative study between the Environmental Protection Agency and the Forest Service was initiated in October 1987 at the Fernow Experimental Forest near Parsons, West Virginia. Annual atmospheric deposition of sulfur and nitrogen will be tripled by applying ammonium sulfate fertilizer. A contiguous, undisturbed catchment will be used as a control for this study. Acidification effects on streamflow chemistry will be monitored at the catchment outlet in two ways. Specific conductance and pH will be continuously recorded in situ on both streams. Grab samples also will be collected by automatic samplers when stage changes by 15 mm. All stream samples will be analyzed for specific conductance, alkalinity, and Cl, NO_3-N, SO_4, Ca, Mg, K, and Na concentrations. Selected samples will be analyzed for dissolved organic carbon and monomeric, non-labile, and total Al. Soil-water samples will be collected at three soil depths with zero-tension lysimeters after each storm and analyzed for the same constituents as streamflow samples. Acidification effects on macroinvertabrate populations will be determined by the USDI Fish and Wildlife Service. The study objectives, study design and instrumentation, and preliminary results from a similar pilot study will be presented.

54.
Edwards, Pamela J.; Kochenderfer, James N. 1991. **Artificial watershed acidification on the Fernow Experimental Forest.** In: Keller, E. C. Jr., ed. Proceedings of the West Virginia Academy of Science; 1991 April 6; Montgomery, WV. Montgomery, WV: West Virginia Institute of Technology. 63(1): 19-20. Abstract.

An artificial watershed acidification study was initiated on the Fernow Experimental Forest in May 1988. To induce acidification, ammonium sulfate fertilizer is applied aerially three times per year at an annual rate approximately double ambient N and S inputs. Stream-water chemistry, principally during storm events, soil-leachate chemistry, and soil chemistry are monitored intensively to determine if acidification can be induced and to examine some of the biogeochemical factors involved in the acidification process. To date, six applications have been made, with at least one more year of treatment planned. Other West Virginia researchers are examining the effects of acidification on terrestrial salamander populations, aquatic shredder communities, and aquatic bryophytes. These latter investigations may indicate whether certain organisms can be used as early indicators of ecosystem perturbation.

55.
Edwards, Pamela J.; Kochenderfer, James N.; Seegrist, Donald W. 1991. **Effects of forest fertilization on stream water chemistry in the Appalachians.** Water Resources Bulletin. 27(2): 265-274.

Stream-water chemistry was monitored on two watersheds on the Fernow Experimental Forest in north-central West Virginia to determine the effects of forest fertilization on annual nutrient exports. Ammonium nitrate and triple superphosphate were applied simultaneously at rates of 336 kg ha^{-1} N and 224 kg ha^{-1} P_2O_5, respectively. These rates are similar to those used in commercial forest operations. The treatment significantly increased outputs of several ions. Annual outputs of nitrate N increased as much as 18 times over pretreatment levels, and calcium and magnesium increased as much as 3 times over pretreatment levels the first year after fertilization. Outputs for these nutrients were elevated for all 3 posttreatment years. Although nitrate N increased significantly, only about 20 percent of the applied fertilizer was accounted for in stream-water exports. Outputs of phosphate P declined following fertilization, probably because the watersheds are phosphorus deficient, but by the third year, they slightly exceeded predicted values. Estimated nutrient losses to deep seepage were substantial, especially on the leakier south-facing catchment, on which some nutrient losses were equal to or greater than those in stream water. When the nutrient exports associated with both stream discharge and ground-water recharge were combined, the percentages of applied N that were lost were similar on the two watersheds, averaging 27.5 percent. Less than 1 percent of the applied P was lost from either watershed in the combination of streamflow and deep seepage.

56.
Edwards, Pamela J.; Mohai, Paul; Halverson, Howard G.; DeWalle, David R. 1989. **Considerations for throughfall chemistry sample-size determination.** Forest Science. 35(1): 173-182.

Both the number of trees sampled per species and the number of sampling points under each tree are important throughfall sampling considerations. Chemical loadings obtained from an urban throughfall study were used to evaluate the relative importance of both these sampling factors in tests to determine species differences. Power curves for detecting differences among the species derived from the noncentrality parameter developed herein indicated that the number of trees sampled per species affects power more than the number of points sampled under each tree.

57.

Edwards, Pamela J.; Phillips, James D. 1985. **The Black Fork.** Wonderful West Virginia. September: 2-5.

58.

Edwards, Pamela J.; Wood, Frederica; Kochenderfer, James N. 1991. **Characterization of ozone during consecutive drought and wet years at a rural West Virginia site.** Journal of Air and Waste Management Association. 41: 1450-1453.

Ozone concentrations at a rural-remote site in a forested region of north-central West Virginia were monitored during 1988 and 1989, a drought and wet year, respectively. During 1988, the absolute maximum average concentration for a single hour was 156 ppb compared to 107 ppb in 1989. Overall, the frequency of high concentrations was greater during 1988; the 120 ppb National Ambient Air Quality Standard was exceeded 17 times. The 7-hour period encompassing the highest growing season concentrations for this site over the 2-year period is 1100-1759 hours EST rather than 0900-1559 hours originally used by the National Crop Loss Assessment Network. The 7-hour growing season means (0900-1559 hours) of 52.6 ppb and 47.1 ppb for 1988 and 1989, respectively, compare well with those reported for the Piedmont/Mountain/Ridge-Valley area, but are higher than those for other surrounding areas. Diurnal ozone patterns as well as the distribution of concentration ranges and timing of season maxima suggest that long-range transport of ozone and its precursors is an important factor at this site given its remote and rural character.

59.

Eschner, A. R.; Patric, J. H. 1982. **Debris avalanches in eastern upland forests.** Journal of Forestry. 80(6): 343-347.

During exceptionally heavy rains, debris avalanches can occur anywhere in forested mountains of the Eastern United States. Examples from New Hampshire to North Carolina indicate that these are most probable when 5 or more inches of rain fall in a 24-hour period on steep (25 to 40°) slopes where soils are less than 36 inches deep. Risk increases with amount of summer rain and decreases with decreasing slope. As a practical matter, little can be done to prevent debris avalanching. That such disturbances may contribute large amounts of stream sediment should be considered in dealing with nonpoint stream pollution.

60.

Eschner, Arthur; Larmoyeux, Jack. 1963. **Logging and trout: four experimental forest practices and their effect on water quality.** Progressive Fish Culturist. 25(2): 59-67.

Experimental logging of watersheds caused changes in the quantity and quality of streamflow. Clearcutting resulted in significantly higher maximum stream temperatures in the growing season and lower minimum temperatures in the dormant season. Maximum stream temperatures above those generally tolerated by brook trout were noted often in the summer of 1959. Moderate cutting did not produce water-quality changes that might be harmful to trout. Streamflow was increased by the treatment in proportion to the amount of timber cut and killed. Most of the increases came late in summer and early in fall, in periods of high evapotranspiration and soil moisture recharge, when flow in many trout streams is dangerously low.

61.

Eschner, Arthur R. 1960. **Observations on a hybrid poplar test planting in West Virginia.** Stn. Note 111. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

As part of a regionwide test of hybrid poplar, dormant cuttings from 50 hybrid poplar clones were outplanted in 1951 in four replicate plots in north-central West Virginia. Seven of the 50 clones did well enough to be recommended for planting under similar climatic conditions on soils of low pH in West Virginia. Other recommendations also are presented.

62.

Fowler, W. B.; Anderson, T. D.; Helvey, J. D. 1988. **Changes in water quality and climate after forest harvest in central Washington state.** Res. Pap. PNW-388. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 12 p.

Chemical output of nitrate, calcium, magnesium, sodium, potassium, and organic nitrogen were determined on a grams-per-hectare-per-day basis for five treatment watersheds and a control watershed. Water samples were collected from April to October during three pretreatment and three posttreatment years (1978 to 1983). Except for increased calcium and sodium in several streams, regression equations comparing treatment with control showed no significant difference for pretreatment and posttreatment output. Output generally declined in the posttreatment years. Cyclic changes in output from these and other streams in the eastern Cascade Range in Washington occurred regardless of treatment and probably were related to precipitation. Mean maximum air temperature increased during the posttreatment period in all the small watersheds, but stream temperatures were relatively unaffected.

63.

Fowler, W. B.; Helvey, J. D.; Felix, E. N. 1987. **Hydrologic and climatic changes in three small watersheds after timber harvest.** Res. Pap. PNW-379. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 13 p.

No significant increases in annual water yield were shown for three small watersheds in northeastern Oregon after shelterwood cutting (30-percent canopy removal; 50-percent basal-area removal) and clearcutting. Average maximum air temperature increased after harvest and average minimum air temperature decreased by up to 2.6°C. Both maximum and minimum water temperatures decreased slightly in two streams compared with the control stream. Wind passage and velocities increased dramatically with removal of the forest cover. Both snow depth and snowpack water content increased in clearcutting.

64.

Fridley, Burley D. 1953. **Home-made equipment facilitates forest influences research.** Journal of Forestry. 51: 907-908.

Progress in a new field of research often depends to some extent on the development of new types of equipment. Such equipment often takes the form of simple gadgets which, though lacking in finished appearance, meet the immediate need and further the cause of experimentation. Three pieces of homemade equipment developed at the Fernow Experimental Forest are described: a portable stove for thawing ice and snow in rain gages, a spring clamp for holding a measuring tape, and a portable datum level for measuring erosion from a road.

65.

Fridley, Burley D. 1962. **Streamgaging instruments in use on the Fernow Experimental Watersheds.** In: Proceedings, watershed management research conference on collection and compilation of streamflow records; 1962 June 12-14; Laconia, NH. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 6-7.

The watershed management research program at the Fernow Experimental forest requires operation of nine streamgaging stations. Instrument difficulties and maintenance are described, as is the marking and tabulation of charts.

66.

Galeone, Daniel Gregory. 1989. **Temporal trends in water quality, determined by time series and regression analysis for streams on undisturbed, cut, and herbicide-treated watersheds in the Appalachian mountains.** University Park, PA: The Pennsylvania State University. 265 p. M.S. thesis.

This study was initiated to determine the effects of forest cutting and regrowth on streamwater chemistry in an area impacted by acid precipitation, and determine the applicability of univariate time-series and regression models to determine trends in streamwater chemistry data. Streamwater data (1958-82) for three headwater streams draining forested watersheds within the central Appalachians (Fernow Experimental Forest) were provided by the USDA Forest Service at in Parsons, West Virginia. Longterm and within-year trends were determined via Scheffe tests, stepwise regression, and time-series models for stream-specific electrical conductivity (SEC), pH, and alkalinity (alk) for an undisturbed watershed (W-4) and two treated watersheds (W-3 and W-7). On W-3, 91 percent of the overstory with a d.b.h. greater than 3 cm was removed from 1969 to 1970. The upper half of W-7 (1963-66) and total watershed area (1966-69) were maintained barren of vegetation via clearcutting and herbicide applications. From 1958 to 1982 for W-4, 1) mean SEC increased and mean pH and alk decreased; and 2) within-year trends for SEC, pH, and alk became more dependent over time on stream discharge (Q), with pH and alk showing a negative correlation and SEC a positive correlation to Q. The trends for W-4 indicated stream acidification and a decrease in the soil acid buffer capacity of the watershed. For W-3 after treatment, 1) annual mean SEC was stationary; and 2) annual mean pH and alk increased relative to W-4 data. Both before and after clearcutting W-3, within-year variability for pH and alk were negatively correlated to Q. SEC data for W-3 were less dependent on discharge after treatment. For W-7 after treatment, SEC decreased rapidly after increasing to 57 umhos/cm for the last year of the treatment and was stable from 1977 to 1982, and annual pH and alk increased relative to W-4 data. Pre- and posttreatment periods for W-7 showed that pH and alk but not SEC were negatively correlated to Q. Stream alkalinization after the treatments for W-3 and W-7 was caused by increased nutrient uptake by the regenerating forest. For univariate time-series modeling, analysis showed that predicted within-year trends tended to misrepresent actual trends if data were curvilinear over time. If annual trends were linear, predicted within-year trends were representative of actual trends. To minimize the effect of curvilinearity, data should be segmented into smaller time intervals.

67.

Galford, J.; Auchmoody, L. R.; Smith, H. C.; Walters, R. S. 1991. **Insects affecting establishment of northern red oak seedlings in central Pennsylvania.** In: McCormick, Larry H.; Gottschalk, Kurt W. eds. Proceedings, 8th central hardwood forest conference; 1991 March 4-6; University Park, PA. Gen. Tech. Rep. NE-148. Radnor, PA. U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 271-280.

Studies to evaluate the impacts of insects on the establishment of advance oak regeneration in Pennsylvania were initiated in 1989. The populations and species of insects feeding on germinating acorns and new seedlings, their activity periods, and the damage caused by these insects were studied in relation to overstory density (40, 60, and 100 percent relative density) and understory vegetation control (herbicided and unherbicided) at three sites on the unglaciated Allegheny Plateau in Clearfield County. These experiments showed that overstory-density levels and treatment with herbicide to eliminate the understory had negligible effects on the species of acorn-feeding insects present, their population levels, and their damage to germinating red oak acorns and new seedlings. These experiments also showed that acorn weevils (Conotrachelus posticatus Boheman), nitidulids (Stelidota octomaculata (Say)), and acorn moths (Valentinia glandulella (Riley)) are important acorn predators, that they become active during late winter and spring, and that they destroy great numbers of germinating acorns and new seedlings in central Pennsylvania oak stands, thus affecting oak regeneration.

68.

Galford, Jim; Williams, Roger. 1990. **Laboratory culture of the nitidulids Stelidota octomaculata and S. ferruginea on acorns.** Frass Newsletter. 13(1): 3. Abstract.

Stelidota octomaculata (Say) and S. ferruginea Reitter (= S. strigosa) have been reared successfully on acorns continuously for several years. Maintenance cultures are kept in the dark at 21 to 22°C in 100 x 80-mm glass dishes half filled with masonry sand. Ten to fifteen acorns with their cap ends popped out are placed in a jar and five pairs of beetles introduced. In 5 to 6 weeks the cultures should be thinned if maximum beetle production is desired because reproduction slows or ceases under crowded conditions. Studies requiring strict controls are conducted in 150 x 20 mm plastic culture dishes lined with filter paper. Two large or three small acorns are placed cut side down on the filter paper and a pair of beetles introduced. The adults are transferred biweekly to new dishes with fresh acorns until the studies are completed. Adult longevity averages about 4 to 6 months and a female will produce about 400 offspring. Mite and disease problems are minimized by using only individually reared beetles from clean, prolific cultures as breeders for new generations.

69.

Galford, Jimmy R.; Weiss-Cottrill, Deloris. 1991. **Response of insects to damaged and undamaged germinating acorns.** Res. Pap. NE-656. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 3 p.

Damaged germinating northern red oak acorns in pitfall traps were significantly more attractive to two species of acorn insects than undamaged germinating acorns. Significantly more adult of the weevil Conotrachelus posticatus Boheman and the sap beetle Stelidota octomaculata (Say) were caught in traps containing acorns cut into halves versus traps containing uncut, germinating acorns. Larvae of the acorn moth Valentinia glandulella (Riley) also preferred damaged over undamaged acorns, but few larvae were caught and the results were not analyzed.

70.

Galford, Jimmy R.; Williams, Roger N.; Beacom, Mary. 1991. **Notes on the biology and host of Stelidota ferruginea (Coleoptera:Nitidulidae)** Res. Pap. NE-654. Radnor, PA. U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

The nitidulid Stelidota ferruginea Reitter was reared from damaged acorns of laurel oak, Quercus laurifolia Michx., and live oak, Q. virginiana Mill., collected in Sarasota County, Florida. This sap beetle has been reared in the laboratory solely on northern red oak, Q. rubra, acorns for more than 3 years (27 + generations), and can breed in viable or nonviable acorns. In the laboratory, S. ferruginea can develop in the seeds of several tree species. New information on the biology of S. ferruginea is presented.

71.
Galford, Jimmy R.; Williams, Roger N.; Daugherty, Ann. 1990. **Life history and notes on the biology of Stelidota octomaculata (Coleoptera: Nitidulidae).** Res. Pap. NE-644. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

The life history of Stelidota octomaculata (Say) was studied in Ohio and Pennsylvania. This insect damages acorns and affects the establishment of oak seedlings. Acorns deployed in wire cages and pitfall traps plus a sampling of naturally occurring acorns were used to monitor insect activity. Adults overwinter in forest litter and begin feeding on undamaged germinating or damaged acorns in spring. Acorns damaged by the beetles may fail to produce seedlings. Beetle reproduction occurs in spring and early summer inside acorns both above and below ground. Reproduction ceases in late July to early August. Adult activity may continue until early December in some years. In the laboratory, a life cycle was completed in about 34 days at 22° to 26°C. The maximum number of offspring from a female was 933 and the maximum lifespan at room temperature was 238 days. Acorns of all oak species tested plus seeds of 28 other species were suitable for larval development.

72.
Gansner, David A.; Arner, Stanford L.; Dale, Martin E.; Smith, H. Clay. 1991. **Reports of demise greatly exaggerated: West Virginia has major timber potential.** Northern Logger. 40(2): 18-21.

During the early 1900's, West Virginia was a timber-producing giant. Unfortunately, "cut and move" was the rule in those days and little attempt was made to revegetate the landscape. Wildfires followed in the wake of logging operations to complete the virtual destruction of the forest. Most people believed the resource was ruined and never would return to the way it was. A recent inventory shows that West Virginia's woodlands have recovered from most of those past wounds and are once again on the road to maturity. West Virginia's oak-hickory forest exhibits virtually every stage of stand condition and development. Given the current conditions, major increases in silvicultural cutting in West Virginia would have to be spread over the next several years.

73.
Garrett, Peter W.; Funk, David T.; Hawley, Gary J.; Wendel, George W. 1989. **Heritability in sugar maple families suggest breeding for response to wounding would pay.** Northern Journal of Applied Forestry. 6: 59-61.

There was no significant variation in response to wounding related to geographic origin in a 14-year-old provenance/progency test of sugar maple. Narrow-sense heritability calculated for the 73 families was 0.38. The area of discolored wood was not correlated with tree size, suggesting the possibility of dual selection for growth and ability to compartmentalize discolored and decayed wood.

74.
Gibbs, Carter B. 1963. **Field trial of a tree injector in a weeding in West Virginia.** Res. Note NE-8. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 3 p.

Describes the field trial of a tree injector in a weeding of a 5-acre plot of mixed hardwoods in West Virginia. Thirteen species were treated and performance evaluated. Small stems were easier to kill than large ones; sugar maple seemed to be more difficult to kill.

75.
Gibbs, Carter B. 1963. **Tree diameter a poor indicator of age in West Virginia hardwoods.** Res. Note NE-11. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

A random sample of 360 trees of six species was analyzed to determine the relationship between the diameter and age in West Virginia hardwoods. Results showed that age varies widely within a narrow d.b.h. range.

76.
Gibbs, Carter B. 1964. **Spiegel-relascope reliable for measuring total height of standing hardwoods.** Journal of Forestry. 62: 580.

Height measurements taken on standing hardwoods with a Spiegel-relascope were compared with height measurements taken with a tape on the same tree after felling. There was no significant difference found between average heights measured by the two methods. Comparisons were made separately for white oak, red oak, yellow-poplar, and black cherry.

77.
Godden, Jack A.; Gibbs, Carter. 1961. **Clover Run plantation.** Northern Logger. 10(5): 10-11, 40-41.

The Clover Run white pine plantation is described and research on this unusual planting is discussed.

78.
Griffin, Gary J.; Smith, H. Clay; Dietz, Albert; Elkins, John R. 1990. **Importance of hardwood competition to American chestnut survival, growth, and blight development in forest clearcuts.** Canadian Journal of Botany. 69: 1804-1809.

Ten years after clearcutting forest stands in Virginia and West Virginia, competing hardwoods around American chestnut trees were periodically cut (managed) or not cut (control or unmanaged). Blight epidemics occurred in all clearcut plots prior to their establishment in 1984. For the control plots, the number of chestnut sprout clusters (group of stems sprouting from a single stump) with blighted live stems had decreased by 1989, but between 1985 and 1988 there was a general increase in blighted chestnut stems for the managed clearcut plots. The number of apparent cankers increased in two of three managed plots between 1986 and 1989. Survival of chestnut clusters was high in managed plots between 1985 and 1989, but decreased in one control plot to zero by 1988. Mean diameters at breast height of measurable chestnut stems (more than 0.8 cm) declined or remained constant in control plots, but generally increased in managed plots after initial declines. Similar but greater responses were observed in a plantation of American chestnut. Unmanaged clearcuts with a high survival of chestnut clusters had low stand basal areas for competing hardwoods, and vice versa. A mesic site favored American chestnut growth and apparent superficial cankers in the base of competing hardwoods.

79.
Griffith, Michael B.; Perry, Sue A. 1991. **Leaf pack processing in two Appalachian mountain streams draining catchments with different management histories.** Hydrobiologie. 220: 247-254.

Rates of leaf litter processing and densities of macroinvertebrates in leaf packs were compared at two sites that differed in catchment logging history. The processing rate of leaves of sugar maple was significantly faster in a stream draining a catchment that had been logged about 20 years ago than in one that had been undisturbed for 80 years. The faster processing rate was accompanied by significantly higher leaf-pack densities of total macroinvertebrates, shredders, and collector-gatherers. The higher densities of leaf-pack macroinvertebrates apparently resulted from differences in tree species between the two catchments.

These differences resulted in greater inputs of fast decomposing leaf litter to the stream draining the disturbed catchment and in smaller amounts of leaf litter remaining in the stream draining the disturbed catchment by spring when this study was conducted.

80.

Hamilton, J. R.; Wendel, G. W. 1967. **Specific gravity and fiber length of some hybrid poplars growing in West Virginia.** Bulletin 556T. Morgantown, WV: West Virginia University Agricultural Experiment Station. 6 p.

A study was undertaken to determine fiber length and specific gravity of 13 hybrid poplar clones selected from an outplanting of 50 clones. There were no statistically significant differences in fiber length among the 13 clones examined; average fiber length was 1.18 mm. Specific gravity differed significantly between clones, and ranged from 0.29 to 0.38.

81.

Helvey, J. D. 1980. **Opportunities for increasing water yield through vegetation management.** In: Assessment of forest and range land situation in the United States. FS345. Washington, DC: U.S. Department of Agriculture, Forest Service: 492-500.

Reviews research on effects of forest cutting on water yield from across the United States. Estimated potentials for increasing water yield from forested lands are developed and discussed for several regions in the United States.

82.

Helvey, J. D. 1981. **Flood frequency and culvert sizes needed for small watersheds in the central Appalachians.** Gen. Tech. Rep. NE-62. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Estimates of peak discharge from small watersheds (fewer than 100 acres) within the central Appalachians are presented for recurrence intervals of 5, 10, 20, and 50 years. Drainage area was well correlated with estimated peak discharge for each recurrence interval. Peak discharge was significantly greater from two watersheds that had been farmed for many years than from the drainages of similar size that had never been cultivated. Culvert sizes needed to carry the expected flow rates are presented.

83.

Helvey, J. D. 1984. **Reply to discussion by John A. Kay.** "Sampling accuracy of pit vs. standard rain gages on the Fernow Experimental Forest". Water Resources Bulletin. 20(2): 277-278.

84.

Helvey, J. D.; Edwards, Pamela J. 1987. **Time trends of precipitation and streamflow chemistry at the Fernow Experimental Forest.** In: Proceedings, Aquatic Effects Task Group VI, peer review summaries; 1987 May 17-23; New Orleans, LA. Task Group Project FS 6C-01.8. Volume II. Raleigh, NC: North Carolina State University, Atmospheric Impacts Research Program: 413-420, 465.

Precipitation and streamflow chemistry have been monitored at the Fernow Experimental Forest since 1979 and 1960, respectively. Time trends for the undisturbed control watershed were analyzed. Except for sodium, no uniform trend in precipitation chemistry between 1979 and 1985 was found. However, the concentration of several ions, particularly sodium, decreased from 1980 to 1985. Stream water pH did not change significantly between 1968 and 1985. Specific conductance and calcium, nitrate, and sulfate concentrations did increase and may be attributable to atmospheric deposition and/or the maturing of the forest.

85.

Helvey, J. D.; Fowler, W. B. 1982. **Precipitation variability in the Columbia Basin of Washington.** Northwest Science. 56(1): 27-33.

Describes time and space variability of precipitation in the semiarid climate of the Columbia Basin in Washington State. Annual variation, as indicated by the coefficient of variation, averages 24.47 percent for the 19 stations used in the analysis. Variation is greater during spring and summer months than during the fall and winter. Average annual precipitation increases about 2.47 cm for each 100-m increase in elevation. Simple correlations of annual precipitation decrease rapidly as distances between stations increase.

86.

Helvey, J. D.; Hubbard, John; DeWalle, David R. 1982. **Time trends in pH and specific conductance of streamflow from an undisturbed watershed in the central Appalachians.** In: Proceedings, Canadian hydrology symposium: associate committee on hydrology; 1982 June 14-15; Fredericton, NB. Fredericton, NB: National Research Council of Canada: 637-651.

A test for a trend in stream pH between 1951 and 1978 was inconclusive because of a problem associated with instrument changes in 1966 and 1975. However, the pH of the stream has changed little, if any, during the past 14 years. Average annual specific conductance has increased significantly since 1968, but the cause is uncertain. Precipitation acidity may be leaching increasing amounts of cations, especially calcium, from the soil matrix.

87.

Helvey, J. D.; Kochenderfer, J. N. 1990. **Soil density and moisture content on two unused forest roads during first 30 months after construction.** Res. Pap. NE-629. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Many foresters and loggers believe that trafficability, or resistance to rutting, improves with time after logging roads are built. However, no one has attempted to quantify the changes or identify the process involved. In this study, dry density and moisture content of the surface foot of soil were measured at 315 locations on two roads in the central Appalachians over a 30-month period. Density increased slightly during the measurement period at most locations. Nearly all of the density changes occurred during the first few months after construction. Moisture content decreased during the first few months after construction, then fluctuated with precipitation amounts.

88.

Helvey, J. D.; Kochenderfer, J. N.; Edwards, P. J. 1989. **Effects of forest fertilization on selected ion concentrations in central Appalachian streams.** In: Proceedings, 7th central hardwood conference; 1989 March 5-8; Carbondale, IL. Gen. Tech. Rep. NC-132; St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 278-282.

Two small forested watersheds were fertilized in April 1976 with 336 kg/ha N as ammonium nitrate and 224 kg/ha P_2O_5 as triple superphosphate to determine effects of fertilization on streamflow chemistry. Specific conductance and the concentration of nitrate-N and calcium in streamflow increased dramatically after fertilization. After reaching maximum concentrations in October 1976, fertilization effects declined gradually and concentrations were elevated only slightly in July 1979 when intensive sampling ended.

89.
Helvey, J. D.; Kunkle, Samuel H. 1986. **Input-output budgets of selected nutrients on an experimental watershed near Parsons, West Virginia.** Res. Pap. NE-584. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

The objectives of this 3-year study were to determine budgets of H^+, Ca^{2+}, Cl^-, NO_3-N, NH_3-N, and SO_4^{2-} for a 38.9-ha forested watershed, and changes in concentration of these constituents that occur in the tree canopy, the soil and bedrock, and the stream channel. Sampling points were two forest openings for bulk precipitation, 20 throughfall sites, four springs where water first seeps out of the soil, and the main stream at the watershed outlet. The most important conclusion was that sulfate is accumulating in the watershed. Average annual kg/ha of sulfate were: bulk precipitation: 39.9: throughfall: 53.0: stream: 25.1. Sulfate budgets are compared with published results from five other study sites in the hardwood region of the Eastern United States and with results from Germany.

90.
Helvey, J. D.; Kunkle, Samuel H.; DeWalle, David. 1982. **Acid precipitation. A review.** Journal of Soil and Water Conservation. 37(3): 143-148.

Acid precipitation is a major environmental concern and one that has been studied intensively for only a short time. Concerns about acid precipitation center around possible impacts on fish populations, aquatic (lake and stream) chemistry, trees, and other vegetation. Most scientists recognize that many questions about acid precipitation remain. However, some scientists view this concern as premature or an over-reaction. The economic implications are discussed.

91.
Helvey, J. D.; Patric, J. H. 1983. **Sampling accuracy of pit vs. standard rain gages on the Fernow Experimental Forest.** Water Resources Bulletin. 19(1): 87-89.

Catch in standard (unshielded) rain gages exposed 3 feet above the land surface was compared with catch in pit (buried) gages exposed 1 inch above the land surface. These tests confirmed that catch in standard rain gages underestimates point rainfall in forest openings as well as in conventional weather stations. Pit gages caught significantly more rain than standard rain gages at each of four locations tested. Catch increases ranged from 2.3 to 3.4 percent.

92.
Helvey, J. D.; Patric, J. H. 1987. **Research on interception losses and soil moisture relationships.** In: Swank, W. T.; Crossley, D. A., Jr., eds. Forest hydrology and ecology at Coweeta. Ecological studies 66. New York: Springer-Verlag: 129-137.

Reviews research on interception losses and soil-moisture relationships conducted at the Coweeta Hydrologic Laboratory. Equations for computing seasonal interception losses in eastern hardwoods are included, and research on soil-moisture fluctuations and its significance is discussed.

93.
Helvey, J. D.; Tiedman, A. R.; Anderson, T. D. 1985. **Plant nutrient losses by soil erosion and mass movement after wildfire.** Journal of Soil and Water Conservation. 40(1): 168-173.

Annual sediment yields increased as much as 180 times above pre-fire levels after wildfire destroyed all vegetation on three forested watersheds in the Entiat Experimental Forest in the eastern Cascade Range of Washington State. Sediment was transported in debris torrents, in suspension, and as bedload. Suspended sediment concentration correlated well with turbidity. Total N losses by erosion process

97.

Hewlett, J. D.; Cunningham, G. B.; Troendle, C. A. 1977. **Predicting stormflow and peakflow from small basins in humid areas by the R-index method.** Water Resources Bulletin. 14(2): 231-254.

A relatively simple nonlinear equation was fitted to 468 stormflows larger than 0.05 area-inch on 11 forested basins from New Hampshire to South Carolina, providing a predictive method for use on forests and wildlands in humid regions. Stormflow in area-inches (Q) was: $Q = 0.4 R P^{1.5} (1+I^{0.25})$ where R is the mean value of Q/P for all P larger than 1 inch, P is storm rainfall in inches, and I is the initial flow rate in $ft^3/sec/mi^2$. (SE = 0.3 inch of stormflow). Peakflow was similarly estimated (SE 26 $ft^3/sec/mi^2$). The R-index method is proposed as a practical tool in forest and wildlife management. Similar to the SCS runoff curve number method, the R-index requires no prior assumptions about infiltration capacities of forest lands, but calls for the mapping of all first-order streams for the average storage capacity index R, i.e., the mean hydrologic response of the source areas. Tested against the runoff curve method on four independent basins, predictions by the R-index method were considerably more accurate when field information normally available to planners and managers was used in both methods.

98.

Hewlett, John D.; Troendle, Charles A. 1975. **Non-point and diffused water sources: variable source area problem.** In: American Society of Civil Engineers symposium proceedings, irrigation and drainage division; 1975 August 11-13; Logan, UT. New York: American Society of Civil Engineers: 21-46.

Discusses the land and channel-phase runoff process in typical first-order basins of humid regions. Hortonian and variable source theories are presented and discussed.

99.

Holcomb, Carl J. 1952. **A history of the Monongahela National Forest.** Davis and Elkins College History Magazine. 5: 29-34.

The physiographic, topographic, and physical characteristics of the Monongahela National Forest are described, as is the Forests history, which began in 1911 with the laying out of the Monongahela Purchase Unit. This unit later was set aside as the Fernow Experimental Forest.

100.

Holcomb, Carl J. 1954. **Improvement cuttings on farm woodlands bring good dividends.** Stn. Note 31. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 2 p.

A study was conducted to determine the growth and income that could be obtained from an annual harvest on a managed small forest. The improvement cuts provided good returns, and income should increase as the quality and size of trees increase.

101.

Holcomb, Carl J.; Bickford, C. Allen. 1952. **Growth of yellow-poplar and associated species in West Virginia as a guide to selective cutting.** Stn. Pap. 52. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 28 p.

Yellow-poplar is a dominant species in two forest types found in West Virginia and can be a valuable asset to a landowner. Management of yellow-poplar stands by partial cutting requires a good indication increased from a pre-fire average of 0.004 kg/ha/yr to 0.16 kg/ha/yr. Available P losses increased from 0.001 ka/ha/yr before the fire to 0.014 kg/ha/yr. The combined erosion loss of Ca, Mg, K, and Na increased from an average of 1.98 kg/ha/yr before the fire to 54.3 kg/ha/yr. Greatest nutrient losses occurred with mass soil movement (debris torrents). Material deposited in alluvial fans represented losses of 13.5 kg/ha/yr of total N, 3.4 kg/ha/yr available P, and 3,850 kg/ha/yr of Ca, Mg, K, and Na combined. An unmeasured but large quantity of soil and rock entered the river during the debris flow. Nutrient losses on eroded soil, though greater than solution losses, were insignificant to site productivity and stability compared with the physical effects of channel scouring associated with greater runoff, higher peak flows, and debris torrents following fire.

94.

Helvey, J. David; Kochenderfer, James. 1987. **Effects of limestone gravel on selected chemical properties of road runoff and streamflow.** Northern Journal of Applied Forestry. 4(1): 23-25.

Limestone gravel applied to two logging roads built in acidic soil on the Fernow Experimental Forest significantly increased the concentration of calcium as well as levels of alkalinity, specific conductance, and pH of road runoff water. A heavy gravel application to 5 km of road adjacent to a naturally acidic stream near Thomas, West Virginia, caused significant changes in the chemical characteristics of that stream. The application of these results to the practical problem of decreasing stream acidity is discussed.

95.

Helvey, J. David; Kochenderfer, James N. 1988. **Culvert sizes needed for small drainage areas in the central Appalachians.** Northern Journal of Applied Forestry. 5: 123-127.

Within the central Appalachians, peak discharge from small watersheds (54 to 96 acres) was well correlated with drainage area for recurrence intervals of 10, 20, and 50 years. Culvert sizes to carry the expected flow rates are tabulated for standard conditions where: (1) the water surface at the culvert inlet is the same elevation as the top of the pipe, (2) the outlet is not submerged, and (3) the culvert slope is at least 2 percent. Culvert sizes are presented for drainage areas in the central Appalachians between 10 and 200 acres, and the results are tested for applicability in the Northeast. This limited test indicated that the required culvert size for forested watersheds increases with latitude north of the central Appalachians.

96.

Helvey, J. David; Kochenderfer, James N. 1991. **Time trends in selected chemical characteristics of streamflow from an undisturbed watershed in West Virginia.** In: Rennie, P. J.; Robitaille, G., eds. Effects of acid rain on eastern forests: proceedings of the conference; 1983 June 14-17; Sainte-Foy, PQ. Sainte-Foy, PQ: Forestry Canada: 429-437.

Stream chemistry records for a 38.9-ha watershed, undisturbed since 1910, were analyzed for time trends in pH between 1968 and 1982, specific conductance between 1958 and 1982, and calcium, magnesium, and sodium concentrations between 1970 and 1982. The pH analysis was inclusive because of an instrument change in 1975, but changes, if they occurred, were small. There was no change in levels of sodium, potassium, or magnesium, but specific conductance and calcium concentrations have increased slightly in recent years. The cause of these changes is uncertain, but precipitation acidity could be influencing the chemical content of streamflow from this watershed.

of the rate of tree growth. A method is described for estimating the growth rate of tulip poplar based on vigor classes.

102.

Holcomb, Carl J.; Weitzman, Sidney; Hutnik, Russell J. 1957. **Farm woods management at the Mountain State Research Center--a five year report.** Bulletin 251. Blacksburg, VA: Virginia Polytechnic Institute Agricultural Extension Service. 18 p.

Two areas occupied by 40-year-old second-growth timber with a scattering of old residuals were set aside for research in farmwoods management. Each year a cut was made, removing a volume approximately equal to the annual growth. This cut was limited as nearly as possible to one product--mine timbers, pulpwood, or sawlogs. The first five annual cuts were improvement cuts; only the poorest trees were cut each year. An inventory of volume, tree quality, and reproduction was made before the first cut and at the end of five growing seasons. After five annual cuts, the farm woods had: (1) a good permanent system of roads and landings; (2) almost no worthless trees; (3) about one-fourth of the volume in high-value trees; and (4) even more merchantable volume than before. Not only were the farm woods vastly improved, but the five annual cuts yielded nearly 80,000 board feet of salable material or $1,200 after equipment expenses had been paid. This returned $0.72 and $1.15 per hour for labor in farm woods No. 1 and 2, respectively.

103.

Hornbeck, J. W. 1964. **The importance of dew in watershed management research.** Res. Note NE-24. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

An exploratory study of dew deposition was conducted during the summer of 1962 in an open flat area near the Fernow Experimental Forest. The total amount of dew measured was small, only 1 percent of the mean August precipitation. Thus, the amount of dew measured at this location probably is too small to warrant its being measured in studies of watershed management.

104.

Hornbeck, J. W. 1968. **Protecting water quality during and after clearcutting.** Journal of Soil and Water Conservation. 23(1): 19-20.

A study to demonstrate the effects of heavy cutting and careful logging was begun in 1963. The area of forest floor seriously disturbed during clearcutting was less than 1 percent of the total area, and runoff occurred only on skid roads, resulting in low turbidity. Except on rare occasions, streamflow from both clearcut areas remained pure enough for drinking.

105.

Hornbeck, J. W. 1970. **The radiant energy budget of clearcut and forested sites in West Virginia.** Forest Science. 16: 139-145.

Components of radiant energy budgets were measured over a clearcut site and a hardwood forest site on a gaged watershed in West Virginia. Results showed that clearcutting caused changes in values for both albedo and upward thermal radiation. The magnitude of these changes varied by season of the year. The clearcutting had an albedo that was nearly constant at 14 percent during snowfree conditions but ranged up to 83 percent of snow cover. By contrast, the forest albedo ranged from 14 percent for a leafless and snowfree period to about 20 percent for full leaf conditions and to 32 percent during periods of snow cover.

The clearcutting had greater losses in upward thermal radiation except during periods of snow cover when both sites were nearly identical. Despite the seasonal variability, net radiation for the two sites did not differ greatly during periods of snow cover.

106.
Hornbeck, J. W.; Troendle, C. A. 1969. **Effects of abandoned farmland on streamflow.** West Virginia Agriculture and Forestry. 2(1): 9-10.

Between 1950 and 1959, the number of farms in West Virginia decreased from 81,434 to 44,011. During this same period, 1.4 million acres of open farmland, including both cropland and pasture, reverted to forest. In the fall of 1957 researchers with the Northeastern Forest Experiment Station at Parsons, West Virginia, installed stream-gaging stations on two abandoned farmland watersheds in the northeastern section of the state. Although streamflow measurements did not begin until approximately 17 years after the abandonment, they serve as a indicator of what can be expected now from farms abandoned during the 1950's. The findings indicate that water quality may be greatly improved after farm abandonment. The ample and well-distributed precipitation over much of West Virginia assures a rapid catch of natural vegetation on all but the most severely eroded areas, eliminating turbidity sources in a very few years. Eventual natural reforestation provides further protection. There was no significant increases or decreases in streamflow as the watersheds reforested.

107.
Hornbeck, James. 1965. **Accuracy in streamflow measurements on the Fernow Experimental Forest.** Res. Note NE-29. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

To determine how accurately streamflow is being measured at the Fernow Experimental Forest, four factors that influence the accuracy of the records were studied: stream gaging instrumentation, stream-discharge relation, manual checking of stage, and compilation of data. The total estimated percent error in annual streamflow values is 3 percent. Implications are discussed.

108.
Hornbeck, James. 1967. **Clearcutting and the erosion hazard.** Northern Logger. 16(4): 14-15, 38-39, 48.

Four watersheds were logged in 1957-58, including a commercial clearcutting as one of the treatments. Two additional watersheds logged in 1963-64 have large clearcut areas similar to those used in even-age management. Erosion rates and stream turbidities were higher on the watersheds that received the heavier cuts. However, more thorough examination showed that turbidity was more closely related to logging methods than to the amount of timber cut. Skid roads should be located well away from streams. The grade and drainage of the skid road is also important, maximum grade of 10 percent is preferred. Care in locating and constructing skid roads should not be a burden to the logger for this can pay off in decreased efficiency and reduced logging costs.

109.
Hornbeck, James; Reinhart, K. G. 1964. **Water quality and soil erosion as affected by logging in steep terrain.** Journal of Soil and Water Conservation. 19(1): 23-27.

The influence of different forestry practices on streamflow has been investigated since 1951 on five forested watersheds on the Fernow Experimental Forest in West Virginia. The experiment demonstrated that excessive damage to water quality can be avoided even when logging on steep terrain. Measured maximum turbidities of streams were 56,000 ppm on the commercial clearcut area and only 25 ppm on the intensive selection-cut watershed. Most of the damage to water quality occurred during and after logging.

110.
Hornbeck, James W. 1962. **Compilation of stream discharge from chart data.** In: Proceedings, watershed management research conference on collection and compilation of streamflow records; 1962 June 12-14; Laconia, New Hampshire; Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 8-10.

The compilation of stream discharge from chart data is described, and time and cost estimates are presented.

111.
Huff, D. D.; Swank, W. T.; Troendle, C. A.; Henderson, G. S.; Waide, J. B.; Haynes, T. 1979. **Element cycles and water budget analyses applied to forest management in the eastern United States.** In: North American forest: gateway to opportunity: proceedings of the Society of American Foresters 1978. Washington DC: Society of American Foresters: 77-89.

Ecosystem science has made significant advances in the past several years that can provide information useful in evaluating environmental and resource management issues. Examination of nutrient budgets has shown that concentrations of all dissolved nutrients in steam discharge from watersheds altered by cutting, species conversions, and change 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. Further, nitrogen depletion may increase with increasing time of management, and complete-tree harvest probably results in the greatest nitrogen depletions of any cutting alternative.

112.
Hutnik, R. J. 1958. **Converting all-aged stand tables by 1-inch diameter classes to 2-inch classes.** Journal of Forestry. 56: 142-143.

A technique for converting stand tables from 1-inch diameter classes to 2-inch classes is presented. The method is applicable to stands with a typical all-age diameter distribution. An example of the use of this technique on stand data from the Fernow Experimental Forest is included.

113.
Hutnik, R. J. 1958. **Three diameter-limit cuttings in West Virginia hardwoods–a 5-year report.** Stn. Pap. 106. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 13 p.

A study was begun in 1950 to test the suitability of three diameter-limit cuttings (16-inch, 13-inch, 8-inch) as methods of forest management for the production of mine timbers. The best growth after 5 years was in the area cut back to 13 inches (2.4 square feet of basal area per acre per year, or 63 cubic feet). The better performance in this cutting area was due to better site, more favorable stand structure, and removal of low-vigor 14- and 16-inch holdovers from the original stand. Reproduction was plentiful and well distributed in all of these areas. Sugar maple was the most abundant, followed by sassafras. The first diameter-limit cut should be followed by the selection system.

114.
Hutnik, Russell J.; Weitzman, Sidney 1957 **Gentle-grade roads mean faster skidding.** Stn. Note 71. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

A time study was conducted on a commercial logging operation on the Fernow Experimental Forest to determine optimum skidder grades. Results show that the average skidding speed over a given distance is faster on gentle grades of 5 to 15 percent than on level terrain or steeper grades.

115.
Hutnik, Russell J.; Yawney, Harry. 1961. **Silvical characteristics of red maple.** Stn. Pap. 142. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 18 p.

Silvical characteristics of red maple including where it grows, habitat conditions, life history, defects, enemies, special features, and genetics, are discussed.

116.
Kidd, Walter J.; Kochenderfer, James N. 1973. **Soil constraints on logging road construction on steep land east and west.** Journal of Forestry. 71: 284-286.

Developers of logging roads encounter similar constraints on steep lands in both the Eastern and Western United States. Common road-building problems include the erosion hazard of the particular soils, slumping caused by soil mantle failure, compaction of the soil by heavy equipment, lack of proper drainage from the road surface, and unstable soil and rock types. The use of a high-lead system, careful road planning and construction, and careful treatment of skid trails can minimize many of the problems associated with the construction of logging roads on steep lands.

117.
Kidd, William E., Jr.; Patric, James H.; Smith, H. Clay. 1989. **Woodlot management: how it grows. Woodlot owners' guide to how forests grow: a primer on forest growth in the Appalachian region.** Supplement to video program: Woodlot management: how it grows. Morgantown, WV: West Virginia University Extension Service and U.S. Department of Agriculture. 29 p.

118.
Kidd, William E., Jr.; Smith, H. Clay. 1988. **Regenerating Appalachian hardwoods: workshop objectives, terminology, and expectations.** In: Smith, H. Clay; Perkey, Arlyn W.; Kidd, William E., eds. Guidelines for regenerating Appalachian hardwood stands: workshop proceeding; 1988 May 24-26; Morgantown, WV. SAF Publ. 88-03. Morgantown, WV: West Virginia University Books: 1-4.

Provides foresters and landowners with information on how to regenerate Appalachian hardwood stands. Topics range from common harvesting methods practiced on public, private, and industrial forest lands to evaluating how seed dispersal is influenced by birds and mammals. This information should help landowners and practicing foresters work together to understand the necessary hardwood regeneration techniques needed to satisfy specific objectives.

119.
Kidd, William E., Jr.; Smith, H. Clay. 1990. **Woodlot management: helping it grow. Woodlot owners' guide to helping trees grow: a primer on helping trees grow in the Appalachian region.** Supplement to video program: Woodlot Management: helping it grow. Morgantown, WV: West Virginia University Extension Service and U.S. Department of Agriculture. 19 p.

120.
Kochenderfer, J.; Lee, R. 1973. **Indexes to transpiration by forest trees.** Oscologia Plantartum. 8(2): 175-184.

Five indexes to transpiration of forest trees were tested for consistency among four deciduous species and one coniferous species. The phytometer, quick-weighing, leaf-disc, water stress, and stomatal indexes were remarkably consistent among species. Black cherry transpired at the highest rate per unit area of leaf surface in all of the tests, at different times during the growing season, and under a variety of environmental conditions. Differences among other species were less clearly defined.

121.
Kochenderfer, J. N. 1971. **Soil moisture under white pine and mixed hardwood forest.** Transactions of the American Geophysical Union: 52(4): 201 Abstract.

Soil moisture has been measured for 2 years on three pairs of plots, each containing five neutron moderation access tubes, in a 38-year-old white pine plantation and in an adjoining 50-year-old oak-hickory stand. Depletion patterns were markedly different between deciduous hardwoods and evergreen pine. Depletion in both stands began at the same time in April but occurred much faster under the pine (0.80 inch per day compared with 0.03 inch) and was consistent during both years of study. During the summer, the hardwoods transpired at a slightly higher rate (0.01 to 0.03 inch) than the pine. Depletion continued later and fall recharge was much slower under pine. Soil-moisture storage capacity always was 1 to 2 inches greater under pine from mid-May into October. These findings suggest that converting poor hardwood stands to pine or planting reservoir shores to pine could reduce water supplies for human use because of greater interception and transpiration losses by the pine. Associated with this is a greater potential rainfall storage potential under the pine, possibly a factor in reducing summer flood peaks. These observations are consistent with comparable soil-moisture and streamflow data elsewhere.

122.
Kochenderfer, J. N. 1977. **Area in skidroads, truck roads, and landings in the central Appalachians.** Journal of Forestry. 75(9): 507-508.

In nine central Appalachian areas logged with wheeled skidders, there was 1 mile of road for every 19.8 acres; roads and landings occupied 10.3 percent of the area. In two areas logged with jammers, there was 1 mile of road for every 31.1 acres; roads and landing occupied 7.8 percent of the area.

123.
Kochenderfer, J. N. 1979. **Some thoughts on forest roads.** West Virginia Tree Farm News. Issue 3. March.

Forest management activities require access, and that means roads. A good road system is of continuing value to the landowner, so careful planning and layout of a road system is essential. Road grades should not exceed 10 to 12 percent and should be at least 100 feet from live streams, with skid roads at least 200 feet apart. Proper drainage and water control also is important. Good road systems will cost approximately $2,000 per mile, but will be a valuable investment.

124.
Kochenderfer, J. N. 1980. **Some thoughts on forest roads.** CFM News. Covington, VA: Westvaco: 10.

125.
Kochenderfer, J. N.; Edwards, P. J.; Helvey, J. D. 1990. **Land management and water yield in the Appalachians.** In: Riggins, Robert E.; Jones, E. Bruce; Singh, Ranvir; Rechard, Paul A., eds. Proceedings, IR conference, watershed management, IR DIV/ASCE, watershed planning and analysis in action symposium; 1990 July 9-11; Durango, CO. New York: American Society of Civil Engineers: 523-532.

Papers presented at the 1990 Watershed Management Symposium discuss research on such topics as: 1) the impact of climatic changes, 2) the use of geographic information systems, 3) the effect of forest cover, 4) the process of water erosion, and 5) the influence of tillage on hydrology. The interrelationship of scientific research and practical applications is stressed.

126.
Kochenderfer, J. N.; Helvey, J. D. 1984. **Soil losses from a "minimum-standard" truck road constructed in the Appalachians.** In: Peters, P. A.; Luchok, J. eds. Proceedings, mountain logging symposium; 1984 June 5-7; Morgantown, WV. Morgantown, WV: West Virginia University: 215-225.

Soil losses from 11 road sections in the central Appalachians were measured. Nine of the sections were located on a newly constructed "minimum-standard" truck road and two were on graveled higher standard road. Average annual soil losses on the minimum-standard truck road ranged from 44 tons/acre for ungraveled road sections to 5 tons/acre for the sections surfaced with 3 inches of clean limestone gravel. Soil losses on the graveled sections of the minimum-standard road were similar to those measured on the higher standard road.

127.
Kochenderfer, J. N.; Helvey, J. D. 1984. **Some effects of forest harvesting on water quality: Fernow Experimental Forest, West Virginia.** In: 1984 Penn State forestry issues conference, forest management and water quality; 1984 March 13-14; University Park, PA. University Park, PA: The Pennsylvania State University, School of Forest Resources and Cooperative Extension Service: 44-52.

Reviews 25 years of research at the Fernow Experimental Forest, assessing the impacts of road construction and timber harvest on sediment yield, stream temperature, and nutrient export. Results show that careless logging practices can greatly accelerate sediment yield from a watershed. When reasonable care is used in road construction and timber removal, sediment yields can be held to levels only slightly above rates for undisturbed forest. The temperature of headwater streams increases when flowing water is exposed to insolation, but revegetation returns water temperature to normal. Dissolved nutrient losses are minimal under a sawlog-only harvest, but may be higher with whole-tree harvesting.

128.
Kochenderfer, J. N.; Helvey, J. D. 1987. **Using gravel to reduce soil losses from minimum-standard forest roads.** Journal of Soil and Water Conservation. 42(1): 46-50.

Soil losses were monitored for 4 years on 11 sections of forest road in the central Appalachians. The roads were used for both timber management and recreation. Nine road sections were located on a newly constructed, "minimum-standard" truck road and two sections were on a graveled higher standard road. Average annual soil losses ranged from 47 tons per acre on the ungraveled road sections to 6 tons/acre on the sections surfaced with 3 inches of clean limestone gravel. After the first year, traffic counts averaged 33 per week on the minimum-standard road and 60 per week on the higher standard road. Soil losses on the graveled sections of the minimum-standard road were similar to those measured on the higher standard road.

129.
Kochenderfer, J. N.; Helvey, J. D. 1989. **Hydrologic impacts of mechanized site preparation in the central Appalachians.** In: Proceedings 7th central hardwood conference; 1989 March 5-8; Carbondale, IL. Gen. Tech. Rep. NC-132. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 283-289.

The effects of mechanized site preparation on sediment yield, streamflow chemistry, water temperature, and water yield were evaluated for a 4-year period on a 28.6-acre watershed. Annual sediment yields were slightly higher after site preparation. Growing-season steamflow increased by 3.9, 2.8, and 1.5 inches during the first, second, and third growing seasons after the treatments, respectively. Nitrate concentrations of streamflow increased slightly, but stream temperature did not change.

130.
Kochenderfer, J. N.; Helvey, J. D.; Wendel, G. W. 1987. **Sediment yield as a function of land use in central Appalachian forests.** In: Hay, R. L.; Woods, F. W.; DeSelm, H., eds. Proceedings, 6th central hardwood forest conference; 1987 February 23-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 497-502.

Total sediment yield was measured for up to 6 years from three forested watersheds with different land use histories. Average annual sediment yield was 31 lb/acre from a 96-acre watershed that had not been logged for 80 years; 166 lb/acre from a 94.4-acre watershed that was partially logged in 1977; and 253 lb/acre from a 28.6-acre watershed that was farmed for many years and then allowed to revegatate naturally during the past 50 years. Sediment deposition in a 2.6-acre reservoir at the mouth of an intensively managed 1,600-acre forested drainage averaged 463 lb/acre/yr over an 18-year period. A comparison of suspended sediment (mg/l) and turbidity in nephelometric turbidity units based on more than 500 samples from each of two watersheds showed excellent correlation.

131.
Kochenderfer, J. N.; Wendel, G. W. 1978. **Cable logging research in the central Appalachians.** Allegheny News. Winter: 1.

132.
Kochenderfer, J. N.; Wendel, G. W. 1978. **Skyline harvesting in Appalachia.** Res. Pap. NE-400. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9 p.

The URUS, a small standing skyline system, was tested in the Appalachian Mountains of north-central West Virginia. Problems encountered with this small, mobile system are discussed. From the results of this test and observation of skyline systems used in the Western United States, machine characteristics that would be desirable for use in the Appalachians are suggested.

133.
Kochenderfer, J. N.; Wendel, G. W. 1980. **Costs and environmental impacts of harvesting timber in Appalachia with a truck-mounted crane.** Res. Pap. NE-456. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9 p.

A truck-mounted crane was used to yard and load timber from a 30-acre sale in a 140-acre watershed in the mountains of north-central West Virginia. The total logging cost, excluding road costs, of $44.35/M bm for logs delivered to a mill 20 miles away was comparable to that reported for wheeled skidders. Road costs with gravel would add $55/M bm or $26/M bm without gravel. Roads built to these standards held sediment production within the range (0.05 to 0.10 ton/acre/yr) expected for undisturbed forested watersheds. Residual stand damage caused by this system also was comparable to other systems and was concentrated on small trees.

134.
Kochenderfer, J. N.; Wendel, G. W. 1982. **Effects of fertilization and aspect on leaf biomass, leaf size, and leaf area index in central Appalachian hardwood stands.** In: Muller, Robert N., ed. Proceedings, 4th central hardwood forest conference; 1982 November 8-10; Lexington, KY. Lexington, KY: University of Kentucky: 102-112.

Leaf-biomass production and leaf area indexes (LAI) were determined on four small hardwood forested watersheds in the central Appalachians of West Virginia. Leaf-area predictive equations were developed from leaf parameters for red oak, chestnut oak, red maple, and sugar maple. Two of the watersheds had southern exposures and two had northwestern exposures. One of each watershed pair was fertilized with 336 kg nitrogen/hectare and 224 kg phosphorous/hectare. Results showed that leaf-biomass production was not significantly related to fertilization or watershed aspect, but there was a significant difference among years. The best predictor of leaf area was the product of maximum width and maximum leaf length with R^2 values between 0.87 and 0.93. R^2 values for the correlation between leaf area and leaf weight ranged from 0.61 to 0.79. LAI for the watersheds averaged 4.91 and was not significantly correlated with watershed aspect or fertilization. Average leaf weight for each species differed significantly among watersheds, but the differences were small. Leaf area for each species except chestnut oak did not differ significantly among watersheds. There were no significant differences in streamflow among watersheds, nor were annual differences in leaf-biomass production related to annual or growing-season precipitation.

135.
Kochenderfer, J. N.; Wendel, G. W. 1983. **Plant succession and hydrologic recovery on a deforested and herbicided watershed.** Forest Science. 29(3): 545-558.

The recovery of a 60-acre watershed that had been maintained nearly barren of vegetation for several years with herbicides was monitored. Increases in water yield returned rapidly to pretreatment levels. Above-ground biomass increased as the woody vegetation became dominant, averaging 14.7 ovendry ton/acre at the end of 10 growing seasons. There was a close relationship between biomass, height, percent ground cover, and increases in growing-season streamflow. Specific conductance of streamflow increased from a pretreatment level of 19 to 57 umho/cm when the treatment was terminated. As the vegetation regrew, specific conductance decreased to about 24 umho/cm 10 years later. Considering the drastic treatment of this watershed, the area has become well stocked with 3,300 stems/acre of commercial tree species.

136.
Kochenderfer, J. N.; Wendel, G. W.; Smith, H. Clay. 1984. **Cost of and soil loss on "minimum-standard" forest truck roads constructed in the central Appalachians.** Res. Pap. NE-544. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

A "minimum-standard" forest truck road that provides efficient and environmentally acceptable access for several forest activities is described. Cost data are presented for eight of these roads constructed in the central Appalachians. The average cost per mile excluding gravel was $8,119 (range: $5,048 to $14,424). Soil loss was measured from several sections of a minimum-standard road. Traffic was regulated the first year and unrestricted the second year. Losses ranged from 44 tons per acre on ungraveled road sections to 5 tons per acre on graveled sections. Soil loss from the graveled sections on the minimum-standard road was about the same as that from higher standard graveled roads.

137.
Kochenderfer, James N. 1970. **Erosion control on logging roads.** In: Forest engineering workshop on forest roads proceedings; Morgantown, WV. Morgantown, WV: West Virginia University. 71(1-4): 10.

A brief look at the history of logging shows that our regard for the environment has often left something to be desired. Now, people are more concerned about pollution and the environment than ever before. In addition to worrying about getting logs to the mill profitably and preventing damage to water resources, loggers are faced with another concern--aesthetics. Timber can be harvested with a minimum of erosion and stream pollution, but problems arise when other forest values and the rights of other forest users to enjoy those values unimpaired are ignored. Timber harvests over poorly located and maintained road systems not only can erode and muddy streams but mar the forest landscape permanently. If this continues, the result could be unwanted legislation.

138.
Kochenderfer, James N. 1970. **Erosion control on logging roads in the Appalachians.** Res. Pap. NE-158. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 28 p.

Practical methods fore controlling erosion on logging roads are summarized through the different stages-planning, location, drainage, maintenance, and care after logging. The material was derived from existing literature, road lore, contact with experienced land managers, and personal experience.

139.
Kochenderfer, James N. 1971. **Erosion control on logging roads.** New York Forests. 28(1): 8.

Because much damage to forest streams is caused by erosion on logging roads, this paper was prepared to summarize what land managers know about preventing and controlling erosion on logging roads in the Appalachians. Recommendations are given for planning the road system, logging-road location, drainage, maintenance, traffic regulation, and care after logging, including seeding.

140.
Kochenderfer, James N. 1971. **Some hydrologic effects of clearcutting forested watersheds.** Morgantown, WV: West Virginia Geobotany Conference: 3. Abstract.

Clearcutting entire forested watersheds in the eastern United States can be expected to increase water yields by 4 to 17 inches annually. Increases in yield occur primarily in the summer months of normally low

148.

Lamson, N. I. 1978. **Fertilization increases growth of sawlog-size yellow-poplar and red oak in West Virginia.** Res. Pap. NE-403. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Sawlog-size, even-aged hardwood stands in north-central West Virginia were fertilized with N, P, and K, singly and in combinations. Applications of N alone increased annual basal-area growth of yellow-poplar more than that of red oak during the first 7 years after fertilization, whereas P alone increased annual basal-area growth of red oak more than that of yellow-poplar. NP did not stimulate the growth of yellow-poplar more than N alone and did not increase the growth of red oak more than P alone. The 7-year cumulative basal-area growth of yellow-poplar was increased 34 percent by N, while that of red oak was increased 20 percent by P. NPK usually increased the growth of both species over that of the control trees, but usually not more than that of N or P, singly or combined. N fertilization could increase the 7-year volume growth of pure stands of sawlog-size yellow-poplar by about 30 percent in this region.

149.

Lamson, Neil. 1980. **Effect of fertilization on four species in mature Appalachian hardwood stands.** In: Garrett, Harold; Cox, Gene S., eds. Proceedings, central hardwood forest conference; Columbia, MO. Columbia, MO: University of Missouri: 449-457.

Four 70-year-old, even-aged Appalachian hardwood stands in north-central West Virginia were studied for their response to fertilization. The red oak site index of the four stands was about 65 feet. Two stands were fertilized with 300 pounds per acre N as ammonium nitrate plus 100 pounds per acre P_2O_5 as triple superphosphate. A total of 249 codominant red oak, black cherry, red maple, and yellow-poplar trees in the four stands were equipped with band dendrometers at breast height; diameter growth was measured annually for 2 years before and 4 years after fertilization. Red oak showed a 17-percent increase in periodic diameter growth during the 4 years after fertilization. Basal-area growth increased by about 21 percent during the same period. Maximum response was during the second and third years after treatment. For black cherry, periodic diameter and basal-area growth increased by about 40 percent. Increases occurred during the second, third, and fourth years after fertilization. Fertilization did not increase the growth of red maple and yellow-poplar.

150.

Lamson, Neil. 1980. **Site index prediction tables for oak in northwestern West Virginia.** Res. Pap. NE-462. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

Prediction tables for even-aged stands of white, chestnut, northern red, scarlet, and black oaks can be used to estimate the site index of forest land in 13 counties of northwestern West Virginia. The half-width of the 95-percent confidence interval of the predicted site index is included; it can be used to determine the number of sample trees necessary to attain given levels of precision, or to determine the precision of a site-index prediction for different numbers of sample trees.

151.

Lamson, Neil I. 1976. **Appalachian hardwood stump sprouts are potential sawlog crop trees.** Res. Note NE-229. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Uneven-age management using a "q" technique for structure control is discussed for Appalachian mixed hardwoods. The success in attaining stand-structure goals with periodic selection cuts was evaluated. Where these goals had not been reached, the authors speculated, on the basis of current stand conditions, whether they would be reached, and if so, when. For successful control of stand structure, reasonable guidelines must be used for choosing maximum-size trees, residual basal area, and a "q" that is applicable to the tree species and stand conditions. Under this system of management, the future stands will contain primarily tolerant species that produce lower volumes per acre than those currently composing the overstory.

152.
Lamson, Neil I. 1983. **Precommercial thinning increases diameter growth of Appalachian hardwood stump sprouts.** Southern Journal of Applied Forestry. 7(2): 93-97.

In West Virginia, crop trees were selected from 7 or 12-year-old yellow-poplar, basswood, red maple, black cherry, and northern red oak stump sprouts. Crop trees were dominant or codominant, well-formed sprouts that originated not more than 6 inches above groundline and did not fork in the lower 17 feet. Four treatments were evaluated: (1) control; (2) thinning; (3) pruning; and (4) thinning plus pruning. Five years after treatment, the d.b.h. growth of thinned sprouts was 1.5 times greater than that of control sprouts. Pruning did not cause a significant increase in 5-year d.b.h. growth. Height growth was not affected by the treatments. Most of the epicormic branches produced by pruning were dead 5 years after treatment. Natural pruning was reduced by thinning; the average clear bole length of thinned sprouts was about 2 feet shorter than that of the control sprouts. Survival was nearly 100 percent.

153.
Lamson, Neil I. 1985. **Thinning increases growth of 60-year-old cherry-maple stands in West Virginia.** Res. Pap. NE-571. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

In north-central West Virginia, previously unmanaged, 60-year-old cherry-maple stands were thinned to 60 percent relative stand density. Thinning reduced mortality, redistributed growth onto fewer, larger stems, and increased individual-tree growth. Five-year periodic basal-area growth per acre was 1.2 times greater in thinned stands than in unthinned stands. Periodic basal-area growth of individual trees was greater in thinned stands than in controls: 3 times for all stems and 1.3 times for dominants and codominants. Relative stand density in the thinned stands increased by 1.6 percent annually.

154.
Lamson, Neil I. 1987. **DBH/crown diameter relationships in mixed Appalachian hardwood stands.** Res. Pap. NE-610. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 3 p.

Linear regression formulae for predicting crown diameter as a function of stem diameter are presented for nine species found in 50- to 80-year-old mixed hardwood stands in north-central West Virginia. Generally, crown diameter was closely related to tolerance; more tolerant species had larger crowns.

155.
Lamson, Neil I. 1987. **Estimating northern red oak site-index class from total height and diameter of dominant and codominant trees in central Appalachian hardwood stands.** Res. Pap. NE-605. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 3 p.

Northern red oak site-index (SI) class is estimated using height and diameter of dominant and codominant trees for five Appalachian hardwood species. Methods for predicting total height as a function of diameter are presented. Because the total height of 4- and 6-inch trees varies less than 5 feet for the three northern red oak SI classes, use trees that are at least 8 inches in d.b.h. when estimating site class.

156.
Lamson, Neil I. 1988. **Precommercial thinning and pruning of Appalachian stump sprouts--10-year results.** Southern Journal of Applied Forestry. 12(1): 23-27.

In northern West Virginia, 7-year-old American basswood and 12-year-old red maple, black cherry and northern red oak stump sprout clumps received one of four treatments: unthinned control; thinned to the best one or two codominant sprouts per clump; branch pruned up to 75 percent of total height; or thinned plus pruned. Analysis of 10-year growth data showed that height growth was not affected by any treatment. For all species, pruning slightly increased the length of clear stem and decreased periodic diameter growth. Thinning increased survival of basswood, red oak, and red maple crop stems. Thinning increased the 10-year diameter growth by 0.1 to 0.8 inch. Recommendations for thinning 10- to 20-year-old sprout clumps are presented. Pruning is not recommended. To maintain maximum diameter growth, thinning of individual sprout clumps should be followed by stand crop-tree release in about 10 years.

157.
Lamson, Neil I. 1988. **Role of stump sprouts in regenerating Appalachian hardwood stands.** In: Smith, H. Clay; Perkey, Arlyn W.; Kidd, William E., eds. Proceedings, guidelines for regenerating Appalachian hardwood stands; 1988 May 24-26; Morgantown, WV. SAF Publ. 88-03. Morgantown, WV: West Virginia University Books: 31-37.

Stump sprouts are an important source of regeneration in Appalachian hardwood stands. Tables are presented that show sprouting frequency and the percentage of stumps that produce sprouts. Generally, sprouting from cut stumps decreases as stump size and tree age increase. Recommendations are given for increasing or decreasing the number of sprouts in newly regenerated stands.

158.
Lamson, Neil I. 1989. **Silvicultural treatments in sapling stands.** In: Clark, F. Bryan, tech. ed.; Hutchinson, Jay G., ed. Central hardwood notes. Note 6.03. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 6.03-1-6.03-3

Four silvicultural treatments are described that can be used in sapling stands: cleaning, thinning by basal-area control, liberation cutting, and crop-tree release. Guidelines are provided for the application of each silvicultural treatment.

159.
Lamson, Neil I. 1991. **Betula lenta L. Sweet birch.** In: Burns, Russel M.; Honkala, Barbara H. tech. coords. Silvics of North America. Volume 2. Hardwoods. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture: 148-152.

Sweet birch, also commonly referred to as black birch or cherry birch, was at one time the only source of oil of wintergreen. It is the aroma of wintergreen emanating from crushed leaves and broken twigs to which this birch owes its common name, sweet. Its specific name, lenta, is derived from the tough yet flexible twigs that characterize the species. The wood also is unique: when exposed to air it darkens to a color resembling mahogany. In times past, sweet birch was used as an inexpensive substitute for the more valued tropical wood.

160.

Lamson, Neil I. 1991. **Morus rubra L. Red mulberry.** In: Bums, Russell M.; Honkala, Barbara H., tech. coords. Silvics of North America. Volume 2. Hardwoods. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture: 470-473.

Red mulberry, called moral in Spanish, is widespread in the Eastem United States. It is a rapid-growing tree of valley, flood plains, and low moist hillsides. This species attains its largest size in the Ohio River Valley and it reaches its highest elevation (600 meters or 2,000 feet) in the southern Appalachian foothills. The wood is of little commercial importance. The tree's value is derived from its abundant fruits, which are eaten by people, birds, and small mammals.

161.

Lamson, Neil I.; McCay, Roger E. 1979. **How to determine whether forest fertilization pays.** In: Proceedings, central hardwood forest conference 2; 1978 November 14-16; West Lafayette, IN. West Lafayette, IN: Purdue University: 320-327.

Calculations to determine whether fertilization pays can be made in four different ways. Rate of retum on the investment is the traditional way. Calculating the volume increase needed, the timber value needed, or the fertilization cost needed are the other methods that the landowner may find easier to understand. Each method is demonstrated for fertilizer applied to sawlog red oak trees in north-central West Virginia.

162.

Lamson, Neil I.; Miller, Gary W. 1982. **Logging damage to dominant and codominant residual stems in thinned West Virginia cherry-maple stands.** In: Muller, Robert N., ed. Proceedings, 4th central hardwood forest conference; 1982 November 8-10; Lexington, KY. Lexington, KY: University of Kentucky: 32-38.

Previously unmanaged 60-year-old, even-aged stands of cherry-maple in West Virginia were thinned using the Allegheny hardwoods stocking guide. A marked cut was computed for 75, 60, and 45 percent of full stocking; no trees smaller than 17.78 cm d.b.h. were marked for commercial removal. Thinning was done with a truck-mounted crane or a rubber-tired skidder. In stands thinned with the truck-mounted crane, 4, 2, and 5 percent of the residual dominant and codominant trees (17.78 cm d.b.h. plus) were seriously abraded (with 645.2 cm^2 or more of exposed sapwood) in the 75, 60, and 45 percent treatments, respectively. In stands thinned with the skidder, 7, 13, and 22 percent of the residual dominant and codominant trees were seriously abraded in the 75, 60, and 45 percent treatments, respectively.

163.

Lamson, Neil I.; Rosier, Robert L. 1984. **Wires for long-term identification of trees.** Joumal of Forestry. 82: 110-111.

Describes a method used to mark trees on the Femow Experimental Forest that consists of driving a 2-foot length of stiff wire about 1 inch into the base of the tree with an iron-pipe driver and attaching a metal tag. It is fast and easy, and the wire should last at least 40 years.

164.

Lamson, Neil I.; Smith, H. Clay. 1978. **Response to crop tree release: sugar maple, red oak, black cherry, and yellow-poplar saplings in a 9-year-old stand.** Res. Pap. NE-354. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Crop trees were released in an Appalachian hardwood stand (site index 70 for northem red oak) that had been clearcut 9 years earlier. In all, 134 yellow-poplar, red oak, black cherry, and sugar maple stems of seedling origin were released to a 5-foot radius around the bole of each study tree; 140 comparable stems were not released. These trees were dominant, codominant, or intermediate, and all trees were released to a dominant crown position. On the basis of results 5 years after treatment, we do not recommend releasing crop trees of seedling origin for the species, site, and methods used in this study. Grapevines seriously damaged about one of four trees that were living 5 years after treatment.

165.

Lamson, Neil I.; Smith, H. Clay. 1987. **Precommercial treatments of 15- to 40-year-old northern hardwood stands.** In: Nyland, Ralph, ed. Managing northern hardwoods: proceedings of a silvicultural symposium; 1986 June 23-25; Syracuse, NY. Faculty of For. Misc. Publ. No. 13 (ESF87-002). SAF Publ. 87-03. Syracuse, NY: State University of New York: 160-175.

Precommercial treatments of 15- to 40-year-old northern hardwood stands may improve species composition and quality of the residual stand, and may significantly shorten the rotation. In general, a cleaning should not be used where crop trees are not released, and basal-area thinnings are not recommended. A crop-tree release is recommended over other precommercial stand treatments. Crop trees should be of desirable species and high quality, have good vigor, and be in the dominant or codominant crown position. Released trees can be either stump sprouts or seedlings. Guidelines for releasing crop trees by the crown-touching method are included.

166.

Lamson, Neil I.; Smith, H. Clay. 1988. **Effect of logging wounds on diameter growth of sawlog-size Appalachian hardwood crop trees.** Res. Pap. NE-616. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 3 p.

In previously thinned, even-aged Appalachian hardwood stands, 5-year diameter growth of 102 wounded and 102 unwounded codominant trees was compared. A wounded crop tree was defined as one with at least one exposed sapwood logging wound at least 100 in^2 in size. An unwounded crop tree of the same species and size was selected near each of the 102 wounded trees. Five-year diameter growth of wounded crop trees averaged 1.34 inches, while unwounded crop trees averaged 1.40 inches. A paired t-test showed no significant differences in 5-year diameter growth between wounded and unwounded crop trees.

167.

Lamson, Neil I.; Smith, H. Clay. 1988. **Thinning cherry-maple stands in West Virginia: 5-year results.** Res. Pap. NE-615. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

In northern West Virginia, 60-year-old cherry-maple stands were thinned to 75, 60, and 45-percent relative stand density. Analysis of 5-year growth showed that basal-area growth was not reduced by thinning. Cubic-foot and board-foot volume growth decreased slightly. Individual-tree growth of all trees, dominant/codominant trees, and the 50 largest diameter trees per acre was significantly increased by thinning. Dominant/codominant trees in the 45-percent plots grew about 0.42 inch more in 5 years than those in control plots. Optimum stand density probably is less than 60-percent relative stand density.

168.
Lamson, Neil I.; Smith, H. Clay. 1989. **Crop-tree release increases growth of 12-year-old yellow-poplar and black cherry.** Res. Pap. NE-622. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Precommercial thinning was done in a 12-year-old Appalachian hardwood sapling stand in West Virginia. Two crop-tree release techniques were used--crown touching and crown touching plus 5 feet. Results indicated that both treatments significantly increased 5-year d.b.h. growth for released yellow-poplar and black cherry crop trees. Although there was a major increase in d.b.h. growth, caution is suggested when using the crown-touching plus 5 feet treatment as butt-log quality response was not conclusive. Releasing crop trees with the crown-touching approach seems appropriate in sapling stands when applied to desirable stems on better sites.

169.
Lamson, Neil I; Smith, H. Clay. 1991. **Stand development and yields of Appalachian hardwood stands managed with single-tree selection for at least 30 years.** Res. Pap. NE-655. Radnor, PA. U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Appalachian hardwood stands in West Virginia were managed for 30 or more years using single-tree selection practices. Data on stand yield suggest that current stand growth will provide economical harvest cuts for several future cutting cycles. This case study indicates that single-tree selection has potential for landowners who want to maintain continuous overstory and are willing to accept the gradual species shift to more shade-tolerant species.

170.
Lamson, Neil I.; Smith, H. Clay; Miller, Gary W. 1984. **Residual stocking not seriously reduced by logging damage from thinning of West Virginia cherry-maple stands.** Res. Pap. NE-541. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

In north-central West Virginia, unmanaged 60-year-old cherry-maple stands were thinned to 75, 60, and 45-percent residual stocking. Cut trees were skidded tree length by a rubber-tired skidder. Logging destroyed or severely bent over 22, 23, and 45 percent of the unmarked stems in the 75, 60, and 45-percent stocked plots. Because 99 percent of the destroyed and bent trees were less than 5.0 inches d.b.h., the effect on basal area and residual stocking was slight. Damage reduced the stocking by 5, 8, and 8 percent in the 75, 60, and 45-percent plots; 18, 38, and 42 percent of the residual stems in those plots received wounds that exposed sapwood. Results indicate that marking guidelines for trees larger than 5.0 inches d.b.h. need not be adjusted to account for logging damage.

171.
Lamson, Neil I.; Smith, H. Clay; Miller, Gary W. 1985. **Logging damage using an individual-tree selection practice in Appalachian hardwood stands.** Northern Journal of Applied Forestry. 2(4): 117-120.

Four West Virginia hardwood stands managed by individual-tree selection for the past 30 years were examined after the third and, in one instance, the fourth periodic harvest to determine the severity of logging damage. On existing skid roads, trees were removed with a rubber-tired skidder or a crawler tractor with a rubber-tired arch. Logging damage reduced residual stand basal area by 6 percent, or 6.1 ft^2 per acre. Damage was concentrated in the saplings--85 percent of the stems lost to logging damage were less than 5.0 in d.b.h. An adequate number of undamaged stems in all diameter classes remained after logging to achieve individual-tree selection goals for stand structure.

179.
Lull, Howard; Reinhart, K. G. 1963. **Logging and erosion on rough terrain in the East.** In: Proceeding of the Federal inter-agency sediment conference. Misc. Publ. 970. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service: 43-47.

Four watersheds on the Fernow Experimental Forest were cut in 1957-58 and a fifth was left uncut as a control. Cutting treatments ranged from a commercial clearcutting with logger's choice skidroads to a conservative selection cutting with carefully planned and constructed skidroads. Maximum turbidities occurred during the logging operation and ranged from 25 to 56,000 ppm. The range of values and frequency distribution were clearly related to logging practices. Results suggest that logging should be completed as soon as possible, and that more attention must be paid to preventing erosion during logging operations.

180.
Lull, Howard W.; Reinhart, Kenneth G. 1967. **Increasing water yields in the Northeast by management of forested watersheds.** Res. Pap. NE-66. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 45 p.

In forests of the Northeast, 40 to 60 percent of all precipitation is returned to the atmosphere via evaporation or transpiration. Water yields from forested watersheds can be increased: clearcutting, partial cutting, and the use of herbicides. Effectiveness during drought is discussed, as are the effects of reforestation, forest protection, and fire on water yield, and safeguards for water quality.

181.
Lynch, James A.; Patric, James H.; Aubertin, Gerald M. 1976. **Forests and water quality.** In: A water problem analysis related to the forest urban interface. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 15-29.

Urbanization in the Northern United States has changed the natural landscape, with implications for water quality. This problem analysis examines the relationship between forests and water yield. Included is a review of literature on effects of timber harvesting, species conversion, defoliation, herbicides, reforestation, fertilization, snow management, economics, land use changes, and animal influences. Political, legal, and social constraints are discussed.

182.
Lynch, James A.; Patric, James H.; Aubertin, Gerald M. 1977. **Forests and water quantity.** In: Lynch, J. A.; Corbett, E. S., eds. Water resources at the forest-urban interface. Publ. PA-2. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Pinchot Institute of Environmental Forest Research: 8-11.

Evaporation loss from forests can be managed crudely; usually it is reduced from timber harvest, and water quantity (i.e., streamflow) is increased accordingly. The effects of other forest treatments such as type conversion, herbiciding, and reforestation are considered. It is concluded that current environmental concerns preclude large-scale efforts to increase water quantity by any of these treatments.

183.
Marquis, Ralph W.; Weitzman, Sidney; Holcomb, Carl. 1954. **Cutting mountain hardwood stands.** Stn. Pap. 73. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 19 p.

Five-year results of four experimental cutting treatments on the Fernow Experimental Forest in north-central West Virginia are compared. The treatments include a commercial clearcut, a 16-inch diameter-limit cut, an extensive selection cut, and an intensive selection cut. Regeneration, growth, quality, cutting cycles, and costs are contrasted.

184.
Marty, Robert; Trimble, George R., Jr. 1967. **Planning for timber-tract development.** Res. Pap. NE-64. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 15 p.

Once a forest owner has decided to develop his or her property for timber production, decisions must be made as to the direction, optimum level, and speed of development. An example of timber-tract development is given using a 600-acre compartment of the Fernow Experimental Forest.

185.
Maurer, Brian A.; McArthur, Lawrence B.; Whitmore, Robert C. 1981. **Effects of logging on guild structure of a forest bird community in West Virginia.** American Birds. 35(1): 11-13.

186.
Maurer, Brian A.; Whitmore, Robert. 1980. **Foraging changes by canopy birds in a clearcut forest.** West Virginia Forestry Notes. (8): 7-12.

Changes in foraging habits of canopy feeding birds were examined as a function of structural changes in a forest due to clearcutting. There was a general tendency for all species to forage higher in the mature forest, and to do more flycatching in the mature forest. All species groups demonstrate changes in the use of tree species that paralleled changes in the relative abundance of trees.

187.
McCauley, Orris D.; Trimble, George R., Jr. 1972. **Forestry returns evaluated for uneven-aged management in two Appalachian woodlots.** Res. Pap. NE-244. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

Twenty-year records of two 31-acre tracts on the Fernow Experimental Forest provide data for an economic evaluation of stand management using single-tree selection practices. Internal rate of return, present net worth, and net future value are suggested as measures of economic evaluation depending on the objectives of the investor.

188.
McCauley, Orris D.; Trimble, George R., Jr. 1975. **Site quality in Appalachian hardwoods. The biological and economic response under selection silviculture.** Res. Pap. NE-312. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 22 p.

The relative or percentage value response after 12 years of selective cutting practices on low and high-quality sites in Appalachian hardwoods amounted to a 119-percent increase on the low-quality site and 145 application includes variations of injection, basal spraying, and cut-stump treatments after mechanical felling. Total costs per acre for these methods and for chainsaw felling were compared for a precommercial thinning in a hardwood sapling stand.

198.

Miller, Gary W. 1989. **Economic considerations of managing stands.** In: Clark, F. Bryan, tech. ed.; Hutchinson, Jay G., ed. Central hardwood notes. Note 7.01. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 7.01-1-7.01-4.

Understanding the economic elements of managing central hardwood stands can help landowners make good choices and improve the productivity of their land. Important considerations are clarify goals, know markets, think crop trees, plan road system, and sell when prices are high. The relative merits of even-age versus uneven-age management are discussed.

199.

Miller, Gary W. 1991. **Economic residual stand structure goals for single-tree selection in central Appalachian hardwoods.** In: Coleman, Sandra S.; Neary, Daniel G., comps., eds. Proceedings of the 6th biennial southern silvicultural research conference; 1990 October 30-November 1; Memphis, TN. Gen. Tech. Pap. SE-70. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. (2): 821-831.

Periodic harvests in hardwood stands managed under single-tree selection can be controlled by using goals for residual stand structure to guide marking. Cut trees are marked to achieve a desired number of residual trees per acre in each diameter class, which provides for both regeneration after each harvest and sustained yield of wood products. A practical method for defining the most profitable residual stand structure is presented that uses a linear programing model to solve for cutting-cycle length and residual number of trees in each d.b.h. class. Constraints such as minimum residual basal area and largest diameter tree can be added for multiple objectives. The impact of adding basal area, largest tree, and diameter-distribution constraints are evaluated.

200.

Miller, Gary W. 1991. **Practicing uneven-age management: does it pay? Some economic considerations.** In: Vodak, Mark C., ed. Proceedings, uneven-aged management of hardwoods in the Northeast; 1991 April 9-10; Lambertville, NJ. New Brunswick, NJ: Rutgers University: 47-59.

Uneven-age silvicultural practices can be used to regenerate and manage many eastern hardwood stands. Single-tree cutting methods are feasible in stands where a desirable shade-tolerant commercial species can be regenerated following periodic harvest. Partial harvest practices including single-tree selection and diameter-limit cutting have been used for 30 years or more to manage central Appalachian hardwoods on the Fernow Experimental Forest near Parsons, West Virginia. Results from these research areas will help forest managers evaluate financial aspects of partial cutting. Observed volume growth, product yields, changes in species composition, and changes in quality of the residual stand are used to evaluate potential financial returns. Practical economic considerations for applying partial cutting are discussed.

201.

Miller, Gary W.; Hanks, Leland F.; Wiant, Harry V., Jr. 1986. **A key for the Forest Service hardwood tree grades.** Northern Journal of Applied Forestry. 3: 19-22.

A dichotomous key organizes USDA Forest Service grade specifications for hardwood trees into a stepwise procedure for those learning to grade hardwood sawtimber. The key addresses major grade factors, tree size, surface characteristics, and allowable cull deductions in a series of paired choices that lead the user to a decision regarding tree grade. Subtle grading rules, previously presented as footnotes to the major specifications, are included in the key. This simplifies the process so that the beginner can learn the system quickly.

202.

Miller, Gary W.; Lamson, Neil I.; Brock, Samuel M. 1984. **Logging damage associated with thinning central Appalachian hardwood stands with a wheeled skidder.** In: Peters, Penn A.; Luchok, John, eds. Proceedings, mountain logging symposium; 1984 June 5-7; Morgantown, WV. Morgantown, WV: West Virginia University: 125-131.

In north-central West Virginia, unmanaged 53-year-old, mixed oak-cove hardwood stands were thinned to 75, 60, and 45-percent residual stocking. Cut trees were skidded tree-length with a rubber-tired skidder. Logging destroyed or severely bent 26, 29, and 34 percent of the unmarked stems in the 75, 60, and 45 percent plots, respectively. Because 94 percent of the destroyed and bent trees were less than 5.0 inches d.b.h., the effect on basal area and residual stocking was slight. Damage reduced the stocking by 6, 4, and 5 percent in the 75, 60, and 45 percent plots, respectively. When plots were combined, 14 percent of the residual stems sustained broken tops, which affected only 3 percent of the residual basal area. Less than 10 percent of the residual stems received wounds that resulted in exposed sapwood. Results indicate that marking guidelines in the merchantable portion of the stand need to be adjusted to account for logging damage.

203.

Miller, Gary W.; Sarles, Raymond L. 1986. **Costs, yields, and revenues associated with thinning and clearcutting 60-year-old cherry-maple stands.** Res. Pap. NE-582. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Logging costs, product yields, and harvest revenues were determined for three thinning treatments (75, 60, and 45-percent residual stocking) and clearcutting in 60-year-old cherry-maple stands. The study area was logged by a three-person crew using chain saws and a wheeled skidder. Time-study and yield data indicated that production rates and costs were similar among the four treatments. Production rates ranged from 18.5 to 19.3 cunits per day depending on treatment. Total logging costs, including felling, bucking, skidding, loading, hauling, and roads, ranged from $44 to $35 per cunit, decreasing as the cut increased. Sawlog yields ranged from 1,621 to 13,281 board feet per acre (International 1/4-inch rule), while pulpwood yields ranged from 630 to 1,897 cubic feet per acre. Harvest revenues were sufficient to pay for roads and timber-sale costs in all treatments except the lightest thinning treatment.

204.

Miller, Gary W.; Smith, H. Clay. 1991. **Applying group selection in upland hardwoods.** In: Johnson, James E., ed. Uneven-aged silviculture of upland hardwood stands: workshop notes; 1991 February 25-27; Blacksburg, VA. Blacksburg, VA: Virginia Polytechnic Institute and State University: 20-25.

Group selection should be viewed as a relatively intensive stand-management practice with several silvicultural methods applied at the same time in different parts of the stand. Currently, there is growing opposition to clearcutting. When desirable, the use of group selection or other regeneration methods where

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Group selection should be viewed as a relatively intensive stand-management practice with several silvicultural methods applied at the same time in different parts of the stand. Currently, there is growing opposition to clearcutting. When desirable, the use of group selection or other regeneration methods where openings are established may satisfy aesthetic and silvicultural objectives while providing the opportunity to grow mature Appalachian hardwoods for monetary return. Suggestions for applying group selection are provided.

205.
Miller, Gary W.; Smith, H. Clay. 1991. **Comparing partial cutting practices in central Appalachian hardwoods.** In: McCormick, Larry H.; Gottschalk, Kurt W., eds. Proceedings, 8th central hardwood forest conference; 1991 March 4-6; University Park, PA: The Pennsylvania State University. Gen. Tech. Rep. NE-148 Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 105-119.

Variations of diameter-limit and perhaps single-tree selection harvesting are used to regenerate and manage central Appalachian hardwood sawtimber stands. In practice, these methods differ in terms of cut rules, control of stand structure, and cultural treatment of immature stems. Preliminary information is provided for comparing the effects of two different harvest practices on residual stand--species composition, tree quality, stand structure, and return on residual-stand value. Data were obtained from second-growth central Appalachian hardwood stands managed under a given harvesting practice for 30 to 40 years. Results indicate that for the short term, many single-tree selection goals can be achieved with an easy-to-apply diameter-limit harvest of mature trees. Economic considerations for practical application and potential long-term impacts of each harvesting method are discussed.

206.
Mitchell, Wilfred; Webster, Henry H. 1961. **Ten years' earnings from two small woodland properties.** Stn. Pap. 145. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 31 p.

Two 30-acre demonstration woodlots on the Fernow Experimental Forest were managed for 10 years and cost and returns measured. Four owner scenarios were used in the analyses of the data, and projections were developed for future economic prospects.

207.
Mitchell, Wilfred C.; Trimble, G. R., Jr. 1959. **How much land is needed for the logging transport system?** Journal of Forestry. 57: 10-12.

Experimental logging on the Fernow Experimental Forest was evaluated to determine land requirements for logging transport systems. Road systems for skidding with tractor and arch result in less area use permanently disturbed than with typical West Virginia methods of horse logging, and less than in many western ground-logging operations where disturbances of 10 percent or more of the area are reported to be common. With the system used on the Fernow, most of the area disturbed by logging is limited to skid roads. Careful planning can reduce the area in skid roads by about 40 percent.

208.
Myers, John R.; Miller, Gary W.; Wiant, Harry V., Jr.; Barnard, Joseph E. 1986. **Butt-log grade distributions for five Appalachian hardwood species.** Res. Pap. NE-590. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Tree quality is an important factor in determining the market value of hardwood timber stands, but many forest inventories do not include estimates of tree quality. Butt-log grade distributions were developed for northern red oak, black oak, white oak, chestnut oak, and yellow-poplar using USDA Forest Service log grades on more than 4,700 trees in West Virginia. Butt-log grade distributions indicate the probabilities associated with each grade for each species and d.b.h. class. These estimates are useful for predicting the value of timber stands for which stand tables are available.

209.

Nik, Abdul Rahim Hj.; Lee, Richard; Helvey, J. D. 1983. **Climatological watershed calibration.** Water Resources Bulletin. 19(1): 47-50.

This study tested the hypothesis that climatic data can be used to develop a watershed model so that streamflow changes following forest harvest can be determined. Measured independent variables were precipitation, daily maximum and minimum temperature, and concurrent relative humidity. Computed variables were humidity deficit, saturated vapor pressure, and ambient vapor pressure. These climatic variables were combined to compute a monthly evaporation index. Finally, the evaporation index and monthly precipitation were regressed with monthly streamflow and the monthly estimates of streamflow were combined for the hydrologic year. A regression of predicted versus measured annual streamflow had a standard error of 1.5 inches (within 6.1 percent of the measured value). When 10, 15, and 20 years of data were used to develop the regression equations, predicted minus measured streamflow for the last 7 years of record (1972-78) was within 16.8, 11.5, and 9.7 percent of the measured mean, respectively. Although single-watershed calibration can be used in special conditions, the paired-watershed approach is expected to remain the preferred method for determining the effects of forest management on the water resource.

210.

Norris, L. A.; Kochenderfer, J. N.; Troendle, C. A.; Montgomery, M. L. 1978. **2,4,5-T persistence in a West Virginia watershed.** Champaign, IL: Weed Science Society of America. Abstract.

Residue levels of 2,4,5-T in vegetation, forest floor, soil, and water can be used to evaluate toxic hazards associated with use of this herbicide in forestry. Samples of four kinds of vegetation, forest-floor material, and soil at two depths were collected initially and at 1, 4, 13, 26, and 52 weeks after helicopter application of 2.24 kg/ha 2,4,5-T low-volatile ester. Initial concentrations of 2,4,5-T in plant material ranged from 90 to 300 ppm immediately after application. The following percentages of the original residue levels remained at various times after application: 1 week--40 percent, 4 weeks--16 percent, 13 weeks--5 percent, 26 weeks--3 percent, and 52 weeks--less than 0.1 percent. The forest floor had 94 mg 2,4,5-T per m^2 immediately after application with 52 percent remaining after 1 week, 43 percent after 4 weeks, 26 percent after 12 weeks, 20 percent after 26 weeks, and 6 percent after 52 weeks. There was relatively little leaching of herbicide through the floor into the soil. The maximum of 2,4,5-T level in the 0 to 15-cm soil zone was 0.5 ppm, with only barely detectable concentrations in the 15- to 30-cm soil zone. Residue levels in water indicate that relatively little 2,4,5-T left the watershed in streamflow.

211.

Norris, Logan A.; Montgomery, M. L.; Loper, B. R.; Kochenderfer, J. N. 1984. **Movement and persistence of 2,4,5-trichlorophenoxyacetic acid in a forest watershed in the Eastern United States.** Environmental Toxicology and Chemistry. 3: 537-549.

Approximately 98 percent of a 22-ha forest watershed in West Virginia was treated with 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) at a rate of 2.24 kg/ha. The average herbicide residue in the foliage and the tips of four species of vegetation was 151 mg/kg immediately after application, 61 mg/kg after 1 week, and 24, 7.9, 4.6, 0.07, and less than 0.01 mg/kg after 1, 3, 6, 12, and 24 months. The concentration in 0 to 15 cm soil decreased by 90 percent in 1 month and then remained relatively constant. No 2,4,5-T (< 0.01 mg/kg) was found deeper than 15 cm after 3 months. Throughfall precipitation transferred 34 mg/m^2 to the forest floor, with 80 percent occurring the first 2 weeks after application, during which time there was 16.9 cm of precipitation. About 6 mg/m^2 was transferred to the forest floor in freshfall litter. The highest concentration of 2,4,5-T in stream water during application was 0.012 mg/l, and the highest concentration during more than 2 years of measurement was 0.05 mg/l measured 5 hours after beginning application and about 1 hour after 0.18 cm precipitation. No 2,4,5-T was found in stream water more than 13 days after application; 8.4 g (0.017 percent of the amount applied) of 2,4,5-T were discharged from the watershed in streamflow. The concentrations of 2,4,5-T in this forest floor are substantially below those likely to cause adverse effects in animals.

212.

Northeastern Forest Experiment Station. 1987. **Forest research: Fernow Experimental Forest.** NE-INF-75-87. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

The history, characteristics, and research program of the Fernow Experimental Forest are described.

213.

Northeastern Forest Experiment Station. 1964. **The Fernow Experimental Forest.** Misc. Publ. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

214.

Northeastern Forest Experiment Station. 1964. **Timber and Watershed Laboratory at Parsons, West Virginia.** Misc. Publ. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

215.

Olson, Richard; Cech, Franklin; Wendel, G. W. 1981. **Ten-year results of a limited range eastern white pine seed source study: variation in growth and specific gravity.** In: 27th northeastern forest tree improvement conference proceedings; 1980 July 29-31; Burlington, VT. Burlington, VT: University of Vermont, School of Natural Resources: 138-149.

After 10 growing seasons, analysis of a limited-range eastern white pine provenance study showed that there were significant differences among provenances for height, d.b.h., and radial growth. Most provenances from Georgia, North Carolina, and Tennessee were superior to other sources, including the five from various areas in West Virginia. There were significant positive correlations between height and d.b.h. Differences in extracted specific gravity were slight, but significant among sources. There were significant negative correlations between extracted specific gravity and height and diameter. Narrow sense heritability for extracted specific gravity was small (0.114).

216.

Patric, J. H. 1968. **Review of: Role of forests in water conservation.** Journal of Soil and Water Conservation. 23(5): 189.

217.

Patric, J. H. 1970. **Logging roads and water quality.** In: Forest engineering workshop on forest roads proceedings. Morgantown, WV: West Virginia University. 71(1-4): 11-16.

The major forest pollutant to streams is eroded soil. Tree cutting has little effect on water quality if the litter and organic layers in forest soil remain relatively intact. However erosion begins when the soil is exposed through burning or skidding logs or road building. Fertilizer pollution of forest streams is a minor problem in West Virginia because forest roads are seldom fertilized. Petroleum pollution from logging can be minimized by keeping logging roads and equipment from forest streams.

218.
Patric, J. H. 1970. **Some principles of forest hydrology pertinent to even-aged management of eastern hardwoods.** Northern Logger. 19(1): 14-15, 26-27, 29.

Forest hydrology research in the United States began in the early 1900's. Since that time, a number of principles have evolved that have direct relevance to even-age management of eastern hardwood forest: (1) Overland flow rarely occurs on forest land, (2) Almost any complete green cover will maintain land free of overland flow if there is a minimum of disturbance to the forest floor, (3) Most impurities in streams related to timber activities originate on forest roads, (4) Any substantial reduction in density of forest stands will increase streamflow temporarily.

219.
Patric, J. H. 1975. **Timber harvest as an agent of forest stream channel modification.** In: Proceeding of symposium on stream channel modification; 1975 August 15-17; Harrisonburg, VA. [Place of publication unknown]: [Publisher name unknown]: 108-116.

Some popular beliefs are contrasted with research results concerning timber harvest as a modifier of forest stream channels. A few commonly used terms are defined but no new research results are presented. Logging in or too close to streams is identified as the major and indefensible cause of most unwanted channel modification. Tree cutting, log skidding, and road building can cause soil erosion and stream sedimentation but these intermittent activities seldom cause major channel modifications. Evidence is accumulating that timber harvest with minimal stream damage can become the rule if loggers observe well-known precautions to protect soil and water resources.

220.
Patric, J. H. 1976. **Soil erosion in the eastern forest.** Journal of Forestry. 74(10): 671-677.

Provides an overview of what is known about forest soil erosion in Eastern United States. By mass accounting, erosion from undisturbed as well as carefully managed forest land is 0.05 to 0.10 ton/acre/year; that is less than the geologic norm (0.18 to 0.30) and far less than maximum tolerable rates for agricultural land (1 to 5 tons/acre/year). Eroded material is about equal parts of particulate and dissolved matter. Responsibly managed timber harvest causes only minor increases in forest soil erosion, usually from channels and logging roads, but irresponsible timber harvest can increase erosion of particulate matter to unacceptable levels.

221.
Patric, J. H. 1978. **Forest research news note.** Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. September 1978. 5 p.

Describes soil erosion processes in forests, research on soil erosion in the Eastern United States, and includes recommendations for reducing erosion in logging operations.

222.

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

For the Eastern United States there is overwhelming evidence that neither the productivity of forest soil nor the quality of forest water is 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.

223.

Patric, J. H. 1979. **What happens to rain before and after a forest is cut?** West Virginia Tree Farm News. 3(March): 4.

Average annual precipitation for West Virginia is 43 inches per year. In the forest, some of that rain never reaches the ground. Perhaps 10 to 15 percent of the annual rainfall is lost this way. All of the rainfall that does fall to the ground is absorbed into the soil, a process technically called infiltration. The more trees that are cut, the less are interception and transpiration losses. Tree cutting has no effect on how much or how fast rain enters the unabused forest soil. Less rain is lost by interception, more rain enters the soil, less soil moisture is lost by transpiration, and forest soils are wetter after trees are cut. In general, the heavier the cutting, the wetter the soil. It is extra-wet soil that causes streamflow to increase after forest cutting.

224.

Patric, J. H.; Aubertin, G. M. 1977. **Long-term effects of repeated logging on an Appalachian stream.** Journal of Forestry. 75(8): 492-494.

Watershed 2 on the Fernow Experimental Forest has been logged four times since the turn of the century. While little is known of how streams were affected by logging after 1901 or during World War II, the effects of diameter-limit cutting in 1958 and 1972 are well documented. Both cuts caused small increases in streamflow but had little effect on water quality by any criterion except turbidity, which was increased by poorly located and ill-managed logging roads. The evidence suggests that if responsible road practices are followed, continued diameter-limit cutting will not harm forest streams.

225.

Patric, J. H.; Brink, L. K. 1977. **Soil erosion and its control in the eastern forest.** In: Soil erosion: prediction and control. Ankeny, IA: Soil Conservation Society of America: 362-367.

Current knowledge about soil erosion in eastern forests is discussed. Erosion in undisturbed and well-managed forests is compared, and methods of estimating soil loss from forest lands are discussed.

226.

Patric, J. H.; Campbell, John. 1969. **A substitute for 2,4,5-T in eastern hardwood sprout and brush control.** Northeastern Weed Control Conference Proceedings. 23: 320-328.

Two experimental watersheds on the Fernow Experimental Forest were clearcut and maintained barren with 2,4-D and 2,4,5-T. With 2,4,5-T presently unavailable, a mixture of TBA, 2,4-D, and 2,4-DP has been substituted successfully. Under our condition of use, the substitute is as effective and economical as 2,4-D and 2,4,5-T for controlling revegetation by eastern hardwoods.

227.

Patric, J. H.; Caruso, Stanley. 1979. **Solar radiation at Parsons, West Virginia.** Res. Note NE-272. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Twelve years of solar-radiation data measured with a Kipp-Zonen pyranometer were recorded near Parsons, West Virginia. The data agree well with calculated values of potential and average radiation for the vicinity and are applicable to the central Appalachian region.

228.

Patric, J. H.; Fridley, B. D. 1969. **A device for soil frost measurement.** Res. Note NE-94. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

A water-filled plastic tube buried vertically in the soil in a copper casing allowed repeated observation of frost depth without damage to the sampling site. The device is simple and inexpensive and provides data on soil freezing at least as accurate as direct observation by digging through frozen soil.

229.

Patric, J. H.; Gorman, J. L. 1978. **Soil disturbance caused by skyline cable logging on steep slopes in West Virginia.** Journal of Soil and Water Conservation. 33(1): 32-35.

A URUS mobile skyline system removed an average volume of 32.6 cubic meters (4,500 board measure) per hectare of hardwood logs from 16 hectares (40 acres) of steep forest land in West Virginia. Six months after logging, we evaluated the area's hydrologic performance. There was no evidence of reduced bulk density, overland flow, or accelerated erosion except on heavily used skid trails. The soil was severely disturbed (B horizon exposed) on less than 3 percent of the logged land; more than 90 percent was undisturbed.

230.

Patric, J. H.; Goswami, Niranjan. 1968. **Evaporation pan studies--forest research at Parsons.** West Virginia Agriculture and Forestry. 1(4): 6-10.

Evaporation loss was measured at a laboratory site and at two openings (small and large) in the forest near Parsons, West Virginia. During the dormant season, there was no relationship between opening size and evaporation. After leaf expansion, however, evaporation was inversely related to opening size. Annual evaporation averages about 22 inches. Problems and implications of evaporation research are discussed.

231.

Patric, J. H.; Helvey, J. D. 1986. **Some effects of grazing on soil and water in the eastern forest.** Gen. Tech. Rep. NE-115. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 25 p.

Conservationists continue to decry grazing in the eastern forest, now only one-seventh its 1930 extent, for its presumed ill effects on soil and water. Grazing damages trees and trampling compacts the soil, reducing water infiltration and percolation rates. These hydrologic effects usually are innocuous because only severe trampling reduces infiltration and percolation below usual rates of rainfall intensity. Overland flow is little increased for that reason; it is prerequisite for delivering most soil and other pollutants to streams, so water quality is little affected. Bacterial pollution rises when animals have access to streams, and declines soon after excluding them. The universal soil loss equation, predicated on ubiquitous overland flow, is widely misused to predict erosion from grazed forest land where overland flow seldom occurs.

precipitation, streamflow, interception losses, and soil-moisture change estimated to comparable levels of precision, the water-balance equation was solved for transpiration with sufficient sensitivity to demonstrate the effect of tree-leaf growth. After leaves were fully grown, calculated evaporative losses from the forested watershed somewhat exceeded potential rates so long as unmeasured runoff (leakage) was disregarded. With all components of the water balance quantified, including leakage, estimated loss of soil moisture by transpiration was at rates close to potential. Estimated leakage seemed consistent with observed stream behavior.

240.

Patric, James H. 1974. **Multi-project research in the U.S. Forest Service.** In: Connecticut Caliper. Storrs, CT: University of Connecticut Forestry Club: 18-20.

For nearly 50 years, the USDA Forest Service has carried on single-discipline research. Recently, the Forest Service began experimenting with team approaches to focus the skills of several specialists on problems of broad interest. This paper describes one such team approach, the Multi-Project Program of Research for the Central Appalachians.

241.

Patric, James H. 1974. **River flow increases in central New England after the hurricane of 1938.** Journal of Forestry. 72: 21-25.

The New England hurricane of 1938 uprooted or broke off vast number of trees in watersheds of the Connecticut and Merrimack Rivers. Annual flow in both rivers increased about 5 inches during the first year after the hurricane. Another 5 inches of increased flow ran off at diminishing rates during the next 2 or 3 years. At least half of these flow increases occurred in July, August, and September when streams normally are at the lowest levels of the year. There was no evidence of increased flow 5 years after the hurricane when forest regrowth was well underway.

242.

Patric, James H. 1974. **Soil-water relationships in uncut and cut forests.** In: Notebook for logging road and skid trail workshops. Morgantown, WV: West Virginia Cooperative Extension Service. [Unpaginated].

Average annual precipitation in West Virginia is 43 inches per year. The fate and movement of that precipitation is outlined. Also discussed are interception, transpiration, infiltration, runoff, and streamflow, and effects of forest cutting on these processes.

243.

Patric, James H. 1974. **Water relations of some lysimeter-grown wildland plants in southern California.** Misc. Publ. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 130 p.

One of the world's largest lysimeter installations was operated from 1937 until 1960 near Los Angeles, California. Lysimeters were covered with excelsior, grass, and wildland species (grass, chaparral, and coulter pine) for 3, 6, and 14 years, respectively. Evapotranspiration from bare soil was less than from grass, and from grass was less than from woody vegetation. Diminished growth by lysimeter plants and disproportionately large surface runoff suggest that these results must be applied cautiously to forested watersheds.

244.

Patric, James H. 1975. **Announcement: Report on lysimeter studies at San Dimas Experimental Forest.** Forest Science. 21: 195.

The most extensive study of plant-soil-water relations carried out in this country by means of lysimeters was conducted at the San Dimas Experimental Forest from 1938 to 1960. This publication summarizes the results and describes the final report on the project.

245.

Patric, James H. 1976. **Effects of wood products harvest on forest soil and water resources with emphasis on clearcutting in moist climates.** In: The scientific base for silviculture and management decisions in the National Forest System: selected papers. Washington, DC: U.S. Department of Agriculture, Forest Service: 39-51.

There is little evidence that a conventional wood products harvest including clearcutting--will deplete nutrient levels in most forested soils. Depletion following greater wood utilization on shorter rotations is possible and must be guarded against carefully. Soil erosion can be accelerated during poorly regulated logging operations regardless of the silvicultural system used. Soil erosion usually can be held to acceptable levels by intelligent regulation of logging practices. A number of forest cutting practices increase the low flows typical of forest streams in late summer. This cutting usually has little adverse effect on water quality or on regional flooding. Flow increases tend to be least in dry climates while the adverse effects on water quality may be greater than those characteristic of the moist climate forest.

246.

Patric, James H. 1976. **Forest and water relationships research priorities in the Northeast.** Report for the Northeastern Regional Planning Committee, Northeastern Forest Committee and Water Relations Sub-Committee. R.P. 2.05. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 29 p.

247.

Patric, James H. 1976. **Review of: Water pollution control in low-density areas.** Journal of Forestry. 74: 171.

248.

Patric, James H. 1977. **Soil erosion and its control in eastern woodlands.** Northern Logger. 25(11): 4-5, 22-23, 31, 51.

Because overland flow is rare in the eastern hardwood forest, there is no mechanism to transport particulate matter across the forest floor. Eroded material consisting equally of particulate matter and dissolved solids originates primarily in stream channels. This material averages about 0.05 to 0.10 ton per acre per year. Tree cutting does not cause overland flow so it has only a negligible and temporary effect on soil erosion rates and on stream pollution. Logging, especially in streams, can cause erosion rates to increase greatly, but logging roads more frequently are sites of accelerated erosion. Erosion rates will not be accelerated materially if loggers stay out of stream channels and apply to logging roads what is known about controlling overland flow.

249.

Patric, James H. 1978. **Forest management and organization, hydrology.** In: The McGraw-Hill encyclopedia of science and technology. New York: McGraw-Hill.

elsewhere in the Nation. In the other 700 reports, there were no significant differences among sediment yields in streams draining predominantly forested land of the Eastern United States and of western regions other than the Pacific Coast. About one-third of these eastern and western observations denoted sediment yields not exceeding 0.02 ton per year, and three-fourths of the total did not exceed 0.25 ton. About one-fourth fell between 0.25 and 1 ton, and a few exceeded 1 ton per acre annually. Nonforest land use within some of the larger watersheds may account for many of the higher sediment yields. These nationwide results are consistent with regional compilations. A long-term average of not more than 0.25 ton per acre per year in streams of the Eastern and Western United States (but not of the Pacific Coast) can provide a first approximation of sediment yield from predominantly forested land. Amounts derived by prediction equations should be questioned if they greatly exceed 0.25 ton per acre per year.

258.

Patric, James H.; Gould, Ernest M. 1976. **Shifting land use and the effects on river flow in Massachusetts.** Journal of American Water Works Association. 68(1): 41-45.

Accompanying the shift from farm to forest to urban-dominated landscapes in central Massachusetts is a three-stage precipitation-streamflow relationship. Maximum flows probably occurred when 60 percent or more of the land was farmed. When less than 60 percent of the watersheds were farmed, annual flow in these rivers averaged 1.5 inches less flow during peak farming period. Increasing annual flow accompanied urbanization, beginning about 1950.

259.

Patric, James H.; Lyford, Walter H. 1980. **Soil-water relations at the headwaters of a forest stream in central New England.** Harvard For. Pap. 22. Cambridge, MA: Harvard University. 24 p.

Water behavior in forest soil was observed on a 14.86-acre watershed near Petersham, Massachusetts. Soils (Gloucester catena), land use (forest), precipitation (44 inches per year), and relief (gently rolling) are typical of the region. Soils were designated by position on slope: well drained (ridges), poorly drained (swales), and imperfectly drained (between ridges and swales). Levels of soil saturation were recorded continuously in four shallow wells. Water content of soil was measured frequently in 29 access tubes with a neutron probe. Water loss was not measurably different from soils growing red pine and mixed hardwoods. Lack of steep hydraulic gradients on this watershed strongly influenced levels of soil saturation and rates of soil drainage. Infiltration and percolation were rapid in all soils, but lateral drainage of well-drained and imperfectly drained soil was impeded when poorly drained soil was saturated. Well-drained soils never saturated to their surfaces; poorly drained soils remained near saturation throughout the dormant season and after heavy rains in the growing season. Soils were always wet to maximum water content during spring snowmelt. Overland flow occurred only when soils were saturated to their surfaces. Soil-water relations, even on this gently sloping land, show that precipitation is routed through forest soil to streams as postulated by the concept of variable source area.

260.

Patric, James H.; Reinhart, Kenneth G. 1971. **Hydrologic effects of deforesting two mountain watersheds in West Virginia.** Water Resources Research. 7: 1182-1188.

The upper half of one watershed and the lower half of another watershed were deforested and maintained barren from 1965 to 1967. Forest on the remaining halves was cut in 1968. Increase in water yield from both watersheds averaged nearly 6 inches during the half deforested stage and rose to more than 10 inches after complete deforestation. The duration of the flows increased greatly on both watersheds. Other hydrologic effects (instantaneous peak flows, stream temperature, specific conductance, and turbidity) were greater on the lower half watershed. These results show that forest cutting causes substantial increases in streamflow and represent landmark values on hydrologic effects of complete deforestation.

261.

Patric, James H.; Smith, David W. 1975. **Forest management and nutrient cycling in eastern hardwoods.** Res. Pap. NE-324. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

The literature was reviewed for reports on nutrient cycling in the eastern deciduous forest, particularly with respect to nitrogen, and for effects of forest management on the nutrient cycle. Although most such research has dealt with conifers, a considerable body of literature relates to hardwoods. Usually, only those references that dealt quantitatively with nutrient cycling were cited. The nutrient content of the forest stand is a relatively small part of the total nutrient pool contained in soil. Under current practices of harvesting stem wood on a 50- to 100-year rotation, nutrient deficiency as a result of crop removal seems unlikely on most forest land. The probability of deficiency increases as the trend continues toward shorter rotations and more complete utilization of branchwood, thinning culls, and brush left on the site to nourish regeneration after cutting. Nutrient deficiencies that develop as a result of product harvest can be resolved by modifying cutting or by fertilization, or both.

262.

Patric, James H.; Studenmund, W. Russell. 1975. **Some seldom-reported statistics on precipitation at Elkins, West Virginia.** West Virginia Agriculture and Forestry. 6(2): 14-16.

Analysis of storm data over a 10-year period (1964-73) revealed the following conclusions: (1) storms are most likely to start between midnight and sunrise; (2) a storm can be expected about every third day; (3) weather with or without storms seldom persists for longer than a week.

263.

Patric, James H.; Trimble, George R., Jr. 1972. **Transition in research on small forested watersheds in West Virginia.** In: Proceedings, national symposium on watersheds in transition: Proc. Ser. No. 14. Urbana, IL: American Water Resources Association: 272-275.

The Fernow watersheds are described, the research on them is summarized, and the hydrologic concepts and other factors that determined research priority are reviewed.

264.

Patric, Jim. 1979. **What happens to rain when a forest is cut?** CFM News. Covington, VA: Westvaco: 3.

265.

Pauley, Thomas; Little, Michael; Edwards, Pamela; Kochenderfer, James. 1990. **The effects of 1988 drought on surface abundance of terrestrial salamanders.** In: Proceedings, West Virginia Academy of Science, 65th annual session; 1990 April 7; Shepherdstown, WV. Montgomery, WV: West Virginia Institute of Technology: 62(1): 19. Abstract.

The effect of drought on two species of terrestrial salamanders (Plethodon cinereus and Desmognathus ochrophaeus) were compared on two watersheds on the Fernow Experimental Forest. In each watershed, surface abundance and population size were determined monthly by capturing and marking salamanders under five natural and five artificial objects in 28 plots (25 m^2 each). The plots were arranged in parallel transects, 20 and 40 m on either side of the creek. The Schnabel method was used to convert numbers of recaptured individuals into an estimate of total population size. These species of salamanders are active on the forest floor from May through October. During this period, 27.60 and 38.69 inches of precipitation were recorded in the drought year (1988) and nondrought year (1989), respectively. The effects of the drought were most pronounced from June through July. During 1989 (nondrought year), D. ochrophaeus was most active during the relatively wet months of June, July, and August. Populations of P. cinereus declined during this same period and peaked in October. However, during the drought of 1988, D. ochrophaeus abundance decreased concomitantly with precipitation as populations of P. cinereus atypically increased. The capacity of P. cinereus to remain active during periods of drought was substantiated by laboratory studies in which P. cinereus was significantly more tolerant of desiccation than D. ochrophaeus.

266.

Perkey, Arlyn W.; Lamson, Neil I. 1987. **Culturing crop trees in commercially operable stands.** Forest Management Update. 7: 6-10.

Selecting crop trees should be based on landowner objectives. Nontimber as well as timber benefits are addressed. Crop-tree management is discussed. Direct communication with the landowner is advised.

267.

Potter, H. S.; Weitzman, Sidney; Trimble, George R., Jr. 1951. **Reforestation of strip-mined lands in West Virginia.** Stn. Pap. 43. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 28 p.

Data on natural regeneration and related factors were examined for 105 unplanted strip mines varying in size from less than an acre to several acres. The physical and chemical characteristics of strip-mined lands are described, as are the impacts on both natural and artificial revegetation. Recommendations for reforestation of strip-mined lands are included.

268.

Reinhart, K. G. 1958. **Calibration of five small forested watersheds.** Transactions of the American Geophysical Union. 38: 933-936.

On the Fernow Experimental Forest in West Virginia, five forested watersheds, 38 to 96 acres in area, have been gaged by the USDA Forest Service since 1951. The watersheds are close together, for the most part contiguous, and are similar in topography, soil, forest cover, and streamflow characteristics. The methods and problems of calibration should interest other investigators in this field because seldom has a group of watersheds been calibrated for forest watershed research to determine the effects of a range of cutting treatments. After calibration, four watersheds will be cut over using four cutting practices; a fifth watershed will be used as a control. Effects of treatment on streamflow will then be measured. Methods of Wilm and of Kovner and Evans were used to determine length of calibration period based on an analysis of annual, monthly, peak, and low flows. Problems of treatment assignment are discussed.

269.

Reinhart, K. G. 1960. **A simple filter dam for small streams.** Stn. Note 107. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Four simple dams were installed in the lower reaches of a small stream with a gradient of 10 percent and steep banks, and evaluated for their effectiveness in keeping sediment out of the stream. In the year since the logging job began, the four filter dams caught of 350 cubic feet of sediment.

270.
Reinhart, K. G. 1961. **The problems of stones in soil moisture measurement.** Soil Science Society of America Proceedings. 25: 268-270.

The presence of stones in soil poses a serious problem in soil-moisture measurement, especially in forest soils. In gravimetric sampling, estimates of moisture content can be improved by removing stones from the samples and deducting their weight from the total soil weight and the weight of moisture in the stones from the weight of moisture in the sample. Adjustments also must be made in determining soil bulk density when moisture content by volume is desired and in applying soil-moisture values to soil areas that include stone.

271.
Reinhart, K. G. 1962. **Maximum permissible rise in stage before breaking curve in point-picking method.** In: Proceedings watershed management research conference on collection and compilation of streamflow records; 1962 June 12-14; Laconia, NH. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 49-55.

In the point-picking method of determining quantity of discharge from the hydrograph, it is necessary to place some limitation on the stage allowed in each interval for which discharge is computed. The Table of Permitted Rise in use on the Fernow Experimental Forest is described and the error inherent in the table is evaluated. Actual rises are consistently less than permitted rises.

272.
Reinhart, K. G. 1963. **Efficient logging protects water quality.** Southern Lumberman. 206(2567): 39, 42.

Logging in steep mountain country often leads to excessive erosion and muddy streamflow. Many logging operators believe that this cannot be avoided without raising costs and taking much of the profit out of the logging operation. Besides, protecting the water quality brings no income to either the landowner or the logger. However, recent research by the USDA Forest Service on the Fernow Experimental Forest of West Virginia has shown that many of the measures that can be taken to increase logging efficiency and reduce the cost also will protect water quality.

273.
Reinhart, K. G. 1964. **Approximating soil-moisture storage on the experimental watershed using stream-gaging records.** Soil Science Society of America Proceedings. 28: 575-578.

An estimate of total soil-moisture storage capacity of an experimental watershed is needed to understand its hydrology. A reliable estimate may be difficult to obtain, particularly in a forested watershed, because of variations in and difficulties of measuring soil and root depth, texture, bulk density, stone content, and moisture content. A method is suggested for approximating storage from precipitation and streamflow records. Precipitation minus runoff in selected periods when ample precipitation follows a dry spell provides the estimate of soil-moisture storage capacity. This method is illustrated with data from the Fernow Experimental Forest in West Virginia and is applied to two other watersheds in the Northeast. Limitations of the method are discussed.

274.
Reinhart, K. G. 1964. **Effect of a commercial clearcutting in West Virginia on overland flow and storm runoff.** Journal of Forestry. 62: 167-171.

A commercial clearcutting was made on a 74-acre gaged watershed on the Fernow Experimental Forest; skid roads were "loggers' choice" without limitations as to grade or provisions for drainage. After-logging infiltration rates in the watershed remained well above maximum rainfall intensities except on portions of the skid roads. Overland flow occurred only from the skid roads; it resulted from the combination of rain directly on the skid roads and interception of subsurface flow by the road cuts. Increased storm runoff in the growing seasons--up to a maximum of about 1/2 acre inch in any one storm--was largely the result of decreases in field-moisture deficiency rather than changes in the proportions of surface and subsurface flow. This study indicates that in judging hydraulic condition of logged areas, perhaps as much emphasis should be placed on road conditions and forest floor disturbance as on the amount of timber cut and condition of the stand.

275.
Reinhart, K. G. 1964. **Forest watershed research by the U.S. Forest Service in West Virginia.** In: West Virginia water resources research symposium proceedings. 1963: 55-56.

Outlines research began in 1948 at the Fernow Experimental Forest near Parsons, West Virginia. Results have shown that erosion from logging operations can be controlled by practical and economical methods, that most of the harmful effect of logging is the result of disturbance of the forest floor, and that forest management does influence water yield. Future research will investigate the energy budget and potential evapotranspiration, snowmelt, and forest microclimate.

276.
Reinhart, Kenneth G. 1964. **Frequency of streamflow measurements required to determine forest treatment effects.** Res. Note NE-23. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Most of the stream-discharge measures for experimental watersheds are taken by continuous measurements. But the question arises: are continuous measurements necessary to determine effects of forested treatments? Data from two watersheds--a commercial clearcutting and a control watershed--were useful. Treatment effects were compared for these six frequencies of measurement: (1) continuous; (2) daily; (3) semi-weekly or 3 1/2-day (Monday and Thursday); (4) weekly or 7-day (Monday); (5) semi-monthly or 15-day (the 8th and 23rd); and (6) monthly or 30-day (the 15th). For the 6 years, the daily estimates ranged from 95 to 106 percent of the continuous measurement record; 30-day estimates ranged from 54 to 302 percent. Generally, estimates based on daily measurement are fairly close to the continuous-measurement discharges; for less frequent measurements, the estimates are not so close. In almost all cases, when the discontinuous method showed significance, the continuous record substantiated it. The discontinuous method can be used to determine treatment effects, but four qualifications must be made. First, the records for this comparison were based on carefully constructed gaging stations, painstaking maintenance, and meticulous data collection. Second, the treatment tested (clearcutting) was a drastic one, with sizable treatment effects. If the treatment had been less severe, results might not have been so promising. Third, the significance of effects here depends largely on the 6-year calibration period. Fourth, simultaneous measurement at both watersheds was assumed. Results suggest that under some situations, much might be learned from relatively few measurements.

277.
Reinhart, Kenneth G. 1965. **Streamflow records on experimental watersheds of the Northeastern Forest Experiment Station.** In: U.S. Forest Service work conference on analysis of hydrological data. Fort Collins, CO. [Place of publication unknown]: [Publisher name unknown].

278.
Reinhart, K. G. 1965. **Herbicidal treatment of watersheds to increase water yield.** Northeast Weed Control Conference Proceedings. 19: 546-551.

Two gaged watersheds were clearcut and sprayed with 2,4,5-T at 6 lb a.e. to examine the effects on water yield of complete vegetation elimination. Preliminary analyses indicate an increase of 200,000 gallons of additional water yield per acre treated. To evaluate the treatment proper, we will have to measure water yields over a longer period of time.

279.
Reinhart, K. G. 1965. **Increasing water production through manipulation of vegetation.** Ext. Serv. Publ. 446. Amherst, MA: University of Massachusetts: 17-21.

Experiments in the United States and in other countries have shown that vegetation management can result in increases in annual yield up to about 16 area-inches. Savings result from a reduction in summer transpiration, in evaporation from snow, or both. In some places, increased streamflow from transpiration savings is concentrated in the growing season; in others, in the dormant season. Snow-evaporation savings increase flow during the spring melt period. Opportunities to increase yields are greatest in areas of ample and well-distributed precipitation, but some yield improvement may be possible in drier areas. The prospect also may be encouraging in areas of heavy snow accumulation. We know a good deal about watershed management to improve yields but what we know is exceeded by the amount we need to learn.

280.
Reinhart, K. G. 1965. **Thirteen million pounds.** Virginia Forests. 20(3): 9-10.

Forests play an important role in protecting Appalachian soils from the bombardment of 13 million pounds of water (in precipitation) annually. Forests decrease the impact of rainfall through interception, improved infiltration (and thus reduced erosion), and evapotranspiration. When timber was harvested on four watersheds on the Fernow Experimental Forest, with logging practices ranging from commercial clearcutting with "loggers' choice" of skid roads to a light selection cutting, water quality was seriously affected by haphazard logging on the commercial clearcutting; water from the carefully managed watershed was not adversely affected. Heavy cutting resulted in increases in water yield of up to 5 acre-inches a year during the first year after cutting. This effect diminished to almost negligible about 5 years after clearcutting.

281.
Reinhart, K. G.; Eschner, A. R.; Trimble, G. R., Jr. 1967. **Effect on streamflow of four forest practices in the mountains of West Virginia.** (In Japanese) Translation of U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Res. Pap. NE-1, 1963. 52 p.

Four watersheds on the Fernow Experimental Forest were cut using different logging practices to determine the effects on streamflow. A fifth uncut watershed was kept as a reference or control watershed. Cutting of the forest cover increased annual streamflow up to 5 inches (on the clearcut watershed the year after treatment), augmented low flows, and had variable effects on high flows. Effects of treatment are diminishing with time.

282.
Reinhart, K. G.; Eschner, Arthur. 1962. **Effect on streamflow of four different forest practices in the Allegheny Mountains.** Journal of Geophysical Research. 67: 2433-2445.

After a 6-year calibration, four watersheds in the Fernow Experimental Forest in West Virginia were logged during 1957-58. Practices ranged from a commercial clearcutting with "loggers' choice" skid roads to a light selection cutting with planned skid roads on moderate grades. The treatments did not seriously disturb the forest floor. Annual flow increased up to 5 acre-inches on the clearcut watershed the year after treatment. Increases fell into a logical pattern with volume cut. Most of the increase came in the growing season; from May to October 1959, increases were 3.0, 1.8, 1.4, and 0.3 acre-inches for per-acre cuts of 8.5, 4.2, 3.7., and 1.7 thousand board feet, respectively. Low flows were augmented, especially for the two heavily cut watersheds. Effect on high flows was variable; on the clearcut watershed some storm-period flows in the growing season were more than doubled, where as some snowmelt flows were less than expected. Care in the logging operation was reflected in water quality; maximum turbidities ranged from 56,000 ppm on the watershed with unplanned skid roads and no provisions for drainage to 25 ppm on the watershed with carefully planned skid roads. Effects of treatment are diminishing with time.

283.
Reinhart, K. G.; Eschner, Arthur; Trimble, G. R., Jr. 1963. **Effect on streamflow of four forest practices in the mountains of West Virginia.** Res. Pap. NE-1. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 79 p.

Four watersheds on the Fernow Experimental Forest were cut by different logging practices to determine the effects on streamflow. A fifth uncut watershed was kept as a reference or control. Cutting of the forest cover increased annual streamflow up to 5 inches (on the clearcut watershed the year after treatment), augmented low flows, and had variable effects on high flows. Effects of treatment are diminishing with time.

284.
Reinhart, K. G.; Lull, Howard W. 1965. **Manipulating forests for water.** American Forests. 71: 35-37, 44.

Four experimental watersheds on the Fernow Experimental Forest were logged in 1957-59, using different cutting practices. After three years of post cutting measurements, the following conclusions can be made: (1) a sizable increase in water yield will require a sizable cut; (2) for any single year, the increase in water yield after cutting will depend in part on the amount and distribution of rainfall; (3) regrowth will rapidly reduce water yields from cutting; (4) care and common sense in logging will keep sediment out of the stream.

285.
Reinhart, K. G.; Phillips, John J. 1959. **Poor logging makes muddy streams.** West Virginia Conservation. 22(11): 20-23.

An experimental watershed on the Fernow Experimental Forest was clearcut using an unplanned road system. Soon after logging began turbidity of the water was greater than 2,000 ppm, 200 times greater than on an uncut watershed. The results point out how poor logging practices raise havoc with a stream.

286.
Reinhart, K. G.; Pierce, Robert. 1964. **Stream-gaging stations for research on small watersheds.** Agric. Handb. 268. Washington, DC: U.S. Department of Agriculture. 37 p.

One of the accepted research techniques in watershed management is the measurement of streamflow from small experimental watersheds. This handbook provides detailed information on selecting a stream-gaging site, choosing the stream-gaging station design and construction, instrumentation, operating, and maintenance procedures.

287.
Reinhart, K. G.; Trimble, G. R., Jr. 1962. **Forest cutting and increased water yield.** Journal of American Water Works Association. 54: 1464-1472.

Streamflows of five small forested watersheds (38 to 96 acres) on the Fernow Experimental Forest have been gaged since the spring of 1951. Timber was harvested on four of the watersheds by four different practices ranging from commercial clearcutting with unplanned skid roads to intensive-selection management with carefully planned skid roads. Increases in annual flow were directly related to amount of timber cut, and effects were transitory. Storm peaks and volumes increased significantly only on the commercial clearcut watershed. Turbidity increased during logging but decreased immediately after logging ceased.

288.
Reinhart, Kenneth; Leonard, Raymond; Hart, George. 1961. **Automatic devices to take water samples and to raise trash screens at weirs.** Stn. Note 112. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Describes devices for taking water-quality samples and manipulating weir trash screens. Installed on weirs on the Fernow Experimental Forest in West Virginia and the Hubbard Brook Experimental Forest in New Hampshire, these devices operate automatically when streamflow reaches predetermined stages.

289.
Reinhart, Kenneth G. 1966. **Watershed calibration methods.** In: International symposium on forest hydrology: proceeding of a National Science Foundation advanced science seminar; 1965 August 29-September 10; University Park, PA. Oxford, UK: Pergamon Press: 715-723.

A variety of streamflow characteristics can be subjected to analysis; these characteristics can be related to a number of measurable parameters to explain most of their variation. The covariance method of analysis is discussed along with changes in procedure to meet different conditions. The natural correlation of the characteristics under study and the parameters to which it is related is the most important factor affecting success. The control-watershed approach has given the best correlations; these might be improved by the addition of precipitation and antecedent-discharge variables. It is no longer enough to determine whether a given treatment has a significant effect; we also need to know the amount of change. New and better methods are needed to attain precision for testing mild treatments on portions of watersheds and to evaluate action programs.

290.

Reinhart, Kenneth G. 1962. **What we want from streamflow records.** In: Proceedings, watershed management research conference on collection and compilation on streamflow records; 1962 June 12-14; Laconia, NH. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 2-5.

Uses of streamflow records are described, and necessary analysis included along with standards of accuracy and prediction equations.

291.

Rexrode, Charles O.; Smith, H. Clay. 1990. **Occurrence of gum spots in black cherry after partial harvest cutting.** Res. Pap. NE-634. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Bark beetles, primarily the peach bark beetle, Phlosotribus liminoris (Harris), are the major cause of gum spots in sawtimber-size black cherry. Approximately 90 percent of all gum spots in the bole sections are caused by bark beetles. Gum spots were studied in 95 black cherry trees near Parsons, West Virginia. More than 50 percent of the bark beetle-caused gum spots occurred during the first 2 years following partial harvest cuts. The cambium miner Phytobia fruni (Gross) and the peach tree borers Synanthedon pictipes (Grote and Robinson) and S. exidiosa (Say) caused little degradation in the quality zone of veneer logs or in factory grade 1 and 2 sawlogs.

292.

Ribblett, Gary C.; DeWalle, David R.; Helvey, J. David. 1982. **Chemistry of leachate from six different Appalachian forest floor types subjected to simulated acid rain.** University Park, PA: Pennsylvania State University, Institute for Research on Land and Water Resources. 40 p.

The chemistry of leachate from six different Appalachian forest floor types subjected to simulated acid rain storms was compared for three storm sizes and three repeated storm applications. Acid rain with a mean pH of 4.0 and a representative concentration profile of major anions and cations was applied in storms of 0.5, 1.0, and 2.0 cm over 1 hour time periods to samples from a cove hardwood, mixed oak, northern hardwood, red pine, white pine, and hemlock stand. Forest type significantly affected leachate chemistry with cove hardwoods producing significantly higher leachate pH (mean pH: 6.5) and hemlock producing significantly lower leachate pH (mean pH: 3.9) than the other forest types. Differences in leachate pH and acidity were related to cation exchange, leaching of organic acids, and nitrification processes. Organic acid content of leachates, as represented by weak acidity measurements, were well related to leachate transmittance at 400 nm wavelength. Concentrations of most ions (except manganese, sulfate, and chloride) decreased significantly with storm size due to dilution. Repeated applications caused a significant decline in concentration for sulfate, total phosphorus, weak acidity, and transmittance.

293.

Sander, Ivan L.; Smith, H. Clay. 1989. **Managing mature, even-aged stands.** In: Clark, F. Bryan, tech. ed.; Hutchinson, Jay G., ed. Central hardwood notes. Note 6.07. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 6.07-1-6.07-4.

For mature even-aged hardwood stands there are two management options: active management or no management. These options are described and recommendations for their application are given.

294.

Sartz, Richard S.; Trimble, George R., Jr. 1956. **Snow storage and melt in a northern hardwood forest.** Journal of Forestry. 54: 499-502.

Knowledge about the formation and melt of snowpacks under hardwood stands is meager. To find out more about the influence of northern hardwood forests on snow, a study was begun in the White Mountains of New Hampshire in 1955. This study showed that snow accumulation in hardwood forests can be increased and melting of the snowpack prolonged by cutting narrow openings in an east-west direction. The width of openings that would be the most effective depends on latitude, aspect, slope percent, and height of trees.

295.

Schuler, Thomas M.; Simpson, Brian. 1991. **User's guide for the Northeast Stand Exam program (NEST version 2.1).** Gen. Tech. Rep. NE-149. Radnor PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experimental Station. 15 p.

Explains the Northeast Stand Exam (NEST Version 2.1) program. The NEST program was designed for use on the Polycorder 600 series electronic portable data recorder to record information collected from the standard permanent plot as described by the Stand Culture and Stand Establishment Working Groups of the Northeastern Forest Experiment Station.

296.

Shallenberger, Scott W.; Carvell, Kenneth L.; Smith, Clay. 1986. **Crown/stem diameter relationship of four Appalachian hardwoods.** West Virginia Forestry Notes. 12: 4-6.

In 1983, research was initiated at the West Virginia University Forest to determine the response of black cherry to various degrees of release late in the rotation, and to compare the crown diameter d.b.h. ratio with those of associated species (red oak, yellow-poplar, and red maple). There was a strong significant relationship between crown diameter and d.b.h. for all species studied. Northern red oak and red maple have larger crown diameters at a given d.b.h. than yellow-poplar and black cherry. The significant differences between the equations for each species suggest that greater accuracy in predicting d.b.h. from aerial measurements of crown diameter can be obtained using equations derived for each species rather than a general equation for all species.

297.

Smith, H. Clay. 1965. **Effects of clearcut openings on quality of hardwood border trees.** Journal of Forestry. 63: 933-937.

The forest manager interested in producing high-quality material cannot afford to ignore effects of epicormic branching. A study of border trees left in patch cutting in West Virginia indicated that epicormic branching generally was more prevalent on trees of lower crown class and on the upper stems. Among the three species studied--northern red oak, black cherry, and yellow-poplar--epicormic branching was greatest on red oak and least on yellow-poplar. For this reason, yellow-poplar probably should be left as a border tree in preference to the other species.

308.
Smith, H. Clay. 1980. **An evaluation of four uneven-age cutting practices in central Appalachian hardwoods.** Southern Journal of Applied Forestry. 4(4): 193-200.

Uneven-age cutting practices discussed include individual-tree selection, group selection, diameter limit, and financial maturity. Of these, only the individual-selection practice has the necessary guidelines to regulate stand composition in the uneven-age management system. Group-selection, diameter-limit, and financial-maturity cuts are regeneration methods used to produce uneven-aged stands. The strengths, weaknesses, and methods of application for each cutting practice are described as they relate to central Appalachian hardwoods.

309.
Smith, H. Clay. 1980. **Beech–sugar maple.** In: Eyre, F. H., ed. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters: 33-34.

This eastern hardwood forest cover type is described in detail. Included are descriptions of associated tree species and vegetation, geographic distribution, type variants, and ecological relationships.

310.
Smith, H. Clay. 1981. **Diameters of clearcut openings influence central Appalachian hardwood stem development–a 10-year study.** Res. Pap. NE-476. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Appalachian hardwood stands in West Virginia were studied to determine how reproduction establishment and development were influenced by circular clearcut openings of different sizes, postlogging herbicide treatments, and site quality. Ten-year results indicate that circular clearcuts should be at least 1/2 acre to gain the silvicultural effects of larger clearcuts. Smaller openings on both fair and good sites produced adequate numbers of trees, but diversity in species composition was lacking. Herbicide treatments reduced stump sprouting. After 10 years, 15 to 20 percent of the good dominant or codominant trees were of stump-sprout origin where the herbicide treatment was most intensive. Without the postlogging treatment, about 40 percent of the good dominant-codominant trees were of stump-sprout origin.

311.
Smith, H. Clay. 1981. **Managing central Appalachian hardwood stands.** In: Proceedings, national silviculture workshop-hardwood management; 1981 June 1-5; Roanoke, VA. Washington, DC: U.S. Department of Agriculture, Forest Service: 185-195.

Central Appalachian hardwood stands are extremely variable and complex. They contain a variety of tree age classes and species with different growth rates and silvical characteristics. Management practices for immature and sawlog-size stands are discussed.

312.
Smith, H. Clay. 1981. **Normal hardwood silvicultural and management systems-eastern hardwoods.** In: Proceedings, national silviculture workshop-hardwood management; 1981 June 1-5; Roanoke, VA. Washington, DC: U.S. Department of Agriculture, Forest Service: 66-76.

Silvicultural cutting methods used in the eastern hardwoods for the even-age and uneven-age management are discussed. These methods include clearcutting, shelterwood, and seed tree for even-age management and individual-tree selection for uneven-age management.

313.
Smith, H. Clay. 1981. **U.S. Forest Service, American Chestnut Cooperators' meeting.** Gen. Tech. Rep. NE-64. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 20 p.

Includes abstracts from 43 talks presented at a two-day meeting of the USDA Forest Service American chestnut cooperators held in Princeton, West Virginia. Topics discussed included laboratory studies of Endothia parasitica, field studies of hypovirulence, and virology-biochemistry.

314.
Smith, H. Clay. 1982. **USDA Forest Service cooperative research chestnut program 1978 to 1982.** In: Smith, H. Clay; MacDonald, William L., eds. Proceedings, USDA Forest Service American chestnut cooperators' meeting; 1982 January 5-7; Morgantown, WV. Morgantown, WV: West Virginia University Books: 14-17.

Cooperators in the USDA Forest Service American chestnut hypovirulent research program are identified. From 1978 to 1982, there have been 8 cooperators involving 15 studies. Approximately $400,000 has been obligated for this Federal cooperative research effort.

315.
Smith, H. Clay. 1983. **Growth of Appalachian hardwoods kept free to grow from 2 to 12 years after clearcutting.** Res. Pap. NE-528. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Free-to-grow, sapling-size yellow-poplar of seedling origin outgrew similar black cherry and red oak in both d.b.h. and total height (especially on good sites). Yellow-poplar consistently grew faster in d.b.h. throughout the study, particularly on the better oak sites. Black cherry had an edge over yellow-poplar in total height during the early years of the study, but yellow-poplar began to outgrow black cherry about 5 and 10 years after clearcutting on the good and fair sites, respectively. Sugar maple did not respond to the annual release treatment. With the annual release techniques used in this study, free-to-grow yellow-poplar grew faster than black cherry in height and d.b.h. with red oak a distant third during the first 10 to 12 years after clearcutting. However, red oak is more competitive with these intolerants on fairer sites.

316.
Smith, H. Clay. 1984. **Forest management guidelines for controlling wild grapevines.** Res. Pap. NE-548. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 15 p.

Grapevines (Vitis spp.) are becoming a major problem for forest managers in the Appalachians, especially when clearcutting is done on highly productive hardwood sites. Grapevines can reduce tree quality and growth, and eventually kill the tree. Silvical characteristics of grapevines are discussed and forest management guidelines are given for controlling their growth. The control guidelines are applied to mature and immature stands using herbicides and mechanical treatments. The grapevine-arbor concept is suggested as a means of regulating control treatments for timber and wildlife interests.

317.
Smith, H. Clay. 1988. **Herbicides in timber stand improvement.** In: Vodak, Mark C. ed. Proceedings of conference on forestry herbicides in the northeast; 1988 March 15-16; sponsored by New Jersey Division, Society of American Foresters, Rutgers Cooperative Extension Service, Cook College, and U.S. Department of Agriculture, Forest Service. New Brunswick, NJ: Rutgers Extension Service, Cook College: 64-72.

Herbicide application treatments are discussed for several timber stand improvement practices, including removing undesirable species, releasing crop trees, liberating regeneration, controlling sprout clumps, releasing conifers, and controlling grapevines.

318.
Smith, H. Clay. 1988. **Possible alternatives to clearcutting and selection harvesting practices.** In: Smith, H. Clay; Perkey, Arlyn W.; Kidd, William E., eds. Guidelines for regenerating Appalachian hardwood stands: workshop proceedings; 1988 May 24-26; Morgantown, WV. SAF Publ. 88-03. Morgantown, WV: West Virginia University Books: 276-289.

The key to forest management begins with landowner objectives. Once these are known, foresters need a variety of silvicultural alternatives with which to begin stand management and gain landowner confidence. Possible alternatives and modifications are suggested for clearcutting and selection-harvesting practices. These relate to improving aesthetics in the instance of clearcutting and regenerating more intolerant species when selection cutting. Leaving residual trees, using longer cutting cycles, and applying the diameter-limit concept are some of the possibilities.

319.
Smith, H. Clay. 1989. **Poor upland hardwood stands: to start over or continue to let it grow?** In: Johnson, James E., ed. Problems of regenerating upland hardwood stands: workshop notes; 1989 November 2-3; Front Royal, VA. Blacksburg, VA: Virginia Polytechnic Institute and State University: 4-6.

A number of concerns are raised in deciding when to rehabilitate marginal timber stands. Recommendations are presented for stands on marginal sites.

320.
Smith, H. Clay. 1989. **Response of sapling stands to cultural treatments.** In: Clark, F. Bryan, tech. ed.; Hutchinson, Jay G., ed. Central hardwood notes. Note 6.04. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 6.04-1-6.04-3.

The following cultural treatments for sapling stands are discussed: cleaning and thinning using basal-area guidelines, and crop-tree release. Growth responses to these treatments are described.

321.
Smith, H. Clay. 1989. **Wild grapevine management.** In: Clark, F. Bryan, tech. ed.; Hutchinson, Jay G., ed. Central hardwood notes. Note 6.13. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 6.13-1-6.13-4.

Wild grapevines are a problem for forest managers in many areas of the central hardwood forest. The keys to controlling grapevines are in canopy shading or herbicides. Grapevine management is discussed.

322.
Smith, H. Clay. 1991. **Carya cordiformis (Wangenh.) K. Koch Bitternut hickory.** In: Burns, Russell M.; Honkala, Barbara H., tech. coords. Silvics of North America. Volume 2. Hardwoods. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture: 190-197.

Bitternut hickory (Carya cordiformis), also called bitternut, swamp hickory, and pignut hickory, is a large pecan hickory with commercial stands located mostly north of other pecan hickories. Bitternut hickory is cut and sold in mixture with the true hickories. It is the shortest lived of the hickories, living to about 200 years. The dark brown close-grained hardwood is highly shock resistant, which makes it excellent for tools. It also makes good fuelwood and is planted as an ornamental.

323.
Smith, H. Clay. 1991. **Carya tomentosa (Poir.) Nutt. Mockernut hickory.** In: Burns, Russell M.; Honkala, Barbara H., tech. coords. Silvics of North America. Volume 2. Hardwoods. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture: 226-233.

Mockernut hickory (Carya tomentosa), also called mockernut, white hickory, whiteheart hickory, hognut, and bullnut, is the most abundant of the hickories. It is long lived, sometimes reaching the age of 500 years. A high percentage of the wood is used for products where strength, hardness, and flexibility are needed. It also makes excellent fuelwood.

324.
Smith, H. Clay. 1991. **Magnolia acuminata L. Cucumbertree.** In: Burns, Russell M.; Honkala, Barbara H., tech. coords. Silvics of North America. Volume 2. Hardwoods. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture: 433-438.

Cucumbertree (Magnolia acuminata), also called cucumber magnolia, yellow cucumbertree, yellow-flower magnolia, and mountain magnolia, is the most widespread and the hardiest of the eight magnolia species in the United States, and the only magnolia native to Canada. They reach their greatest size in moist soils of slopes and valleys in the mixed hardwood forest of the southern Appalachian Mountains. Growth is fairly rapid and maturity is reached in 80 to 120 years. The soft, durable, straight-grained wood is similar to yellow-poplar. They often are marketed together and used for pallets, crates, furniture, plywood, and special products. The seeds are eaten by birds and rodents and this tree is suitable for planting in parks.

325.
Smith, H. Clay. 1991. **Managing hardwoods, alternative to single-tree selection "how to".** In: Vodak, Mark C., ed. Proceedings, uneven-aged management of hardwoods in the Northeast; 1991 April 9-10; Lambertville, NJ. New Brunswick, NJ: Rutgers University: 66-74.

Alternatives to single-tree selection are suggested for managing hardwood stands. It is assumed that alterative practices must leave a partial residual stand overstory at all times. Practices include modifications of diameter limits such as financial maturity-improvement cutting. Two-age silviculture combined with crop-tree management is a possible alternative.

326.
Smith, H. Clay; DeBald, Paul S. 1975. **Economics of even-aged and uneven-aged silviculture and management in eastern hardwoods.** In: Proceedings of symposium on uneven-aged silviculture and management in the United States; 1975 July 15-17. Washington, DC: U.S. Department of Agriculture, Forest Service: 121-137.

Many factors influence the choice between even-age and uneven-age management systems: species composition, growth, regulation, markets, logging cost, water values, aesthetics, wildlife and monetary return. A theoretical example that compares volume and value yields of the two management systems was developed. In this example, the difference in monetary returns between the two systems is not great, and other factors may be as important.

327.
Smith, H. Clay; Della-Bianca, Lino; Fleming, Harvey. 1983. **Appalachian mixed hardwoods.** In: Silvicultural systems for the major forest types of the United States. Agric. Handb. 445. Washington, DC: U.S. Department of Agriculture: 141-144.

Describes the Appalachian mixed hardwood forest type, also known as cove hardwoods. Extent, stand makeup, reproduction, and silvics are described.

328.
Smith, H. Clay; Della-Bianca, Lino; Fleming, Harvey. 1984. **Appalachian mixed hardwoods.** In: Final environmental impact statement for regional guide-eastern region. Milwaukee, WI: U.S. Department of Agriculture, Forest Service, Eastern Region: D-4-14.

329.
Smith, H. Clay; Eye, Maxine C., eds. 1986. **Proceedings, guidelines for managing immature Appalachian hardwood stands.** 1986 May 28-30. SAF Publ. 86-02. Morgantown, WV: West Virginia University Books. 283 p.

Provides field foresters and landowners with an update of currently available information for managing immature Appalachian hardwood stands. Basically, guidelines are "guides" and workshop participants were asked to make recommendations based on the current literature, their knowledge, and experience.

330.
Smith, H. Clay; Lamson, N. I. 1975. **Grapevines in 12- to 15-year-old even-aged central Appalachian hardwood stands.** In: Proceedings, 3rd annual hardwood symposium of the Hardwood Research Council: Cashiers, NC. Cashiers, NC: Hardwood Research Council: 145-150.

During the early 1960's, nine areas were cut using a seed-tree practice. These areas were evaluated in February 1975 for estimating the number of grapevines and percentage of woody stems with grapevines. On the good (oak SI 70) oak sites, grapevines averaged about 900 vines per acre and about 75 percent of the saplings had grapevines in their crowns. The excellent sites averaged 450 vines per acre and about 50 percent of the saplings had grapevines. Grapevines averaged less than 16 vines per acre on the fair sites (SI 60). The significance of grapevine damage to young even-aged hardwood stands is so severe that without adequate control measures, future stand development may be set back for years, possibly decades.

331.
Smith, H. Clay; Lamson, N. I. 1977. **Stand development 25 years after a 9.0-inch diameter-limit first cutting in Appalachian hardwoods.** Res. Pap. NE-379. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

A case history of stand development 25 years after a 9.0-inch diameter-limit cutting in a primarily second-growth 40- to 45-year-old Appalachian hardwood stand. Some old residual trees from the early 1900 logging era were scattered throughout the stand. In 1950, a 9.0-inch diameter-limit cutting removed 8,650 board feet per acre and reduced the basal area from 97 to 24 square feet per acre. Twenty-five years after this 1950 cutting, the total sawlog volume was 7,425 board feet per acre with a basal area of 98 square feet per acre. Oaks accounted for 42 percent of the sawlog-size trees and 45 percent of the sawlog stand volume.

332.
Smith, H. Clay; Lamson, Neil I. 1982. **Number of residual trees: guide for selection cutting.** Gen. Tech. Rep. NE-80. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 33 p.

Marking trees for removal by an individual-tree selection cutting is described. The number of desirable residual trees is computed for given ranges of residual basal areas, largest diameter trees to grow, and q-values. Included are guidelines for applying this selection-cutting practice.

333.
Smith, H. Clay; Lamson, Neil I. 1983. **Precommercial crop-tree release increases diameter growth of Appalachian hardwood saplings.** Res. Pap. NE-534. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Codominant seedling-origin crop trees 25 to 39 feet tall in even-aged, precommercial-size hardwood stands were released in West Virginia. Trees were located on two sites: good oak site index 75 and fair oak site 63. Species studied were black cherry, sweet birch, and yellow-poplar. Three-year results indicated that the trees generally responded to release; the 3-year d.b.h. growth of released trees was 0.2 to 0.4 inch greater than that of unreleased trees. Height growth did not increase.

334.
Smith, H. Clay; Lamson, Neil I. 1986. **Cultural practices on Appalachian hardwood sapling stands--if done, how to do them.** In: Smith, H. Clay; Eye, Maxine C., eds. Proceedings, guidelines for managing immature Appalachian hardwood stands; 1986 May 28-30; Morgantown, WV. Morgantown, WV: West Virginia University: 46-61.

Recommendations on the use of cleaning, liberation cuts, thinning, and crop-tree release in Appalachian hardwood sapling stands are presented. In general, cleaning is not recommended. Good judgment is necessary in deciding whether to use liberation cuts. When thinning fully stocked sapling stands by a low thinning technique, one-third to one-half of the basal area should be removed to obtain acceptable growth. Recommendations for crop-tree release include selecting 50 to 75 crop trees per acre and releasing them by a crown-touching method in stands where the average height of codominant trees is at least 25 feet. Guidelines are provided for selecting and releasing crop trees of both seedling and stump-sprout origin.

335.
Smith, H. Clay; Lamson, Neil I. 1986. **Wild grapevines--a special problem in immature Appalachian hardwood stands.** In: Smith, H. Clay; Eye, Maxine C., eds. Proceedings, guidelines for managing immature Appalachian hardwood stands; 1986 May 28-30; Morgantown, WV. Morgantown, WV: West Virginia University: 228-239.

Wild grapevines are highly desirable to wildlife but often are detrimental to timber production. Information is available on controlling the growth of grapevines in immature Appalachian hardwood stands. Overstory shading and cutting of grapevines near groundline are the keys to control. Suggestions are provided that allow the forest manager and landowner to make decisions on grapevine management to satisfy objectives ranging from maximum wildlife interest to maximum production of quality timber.

336.
Smith, H. Clay; Lamson, Neil I.; Miller, Gary W. 1989. **An esthetic alternative to clearcutting?** Journal of Forestry. 87(3): 14-18.

Six 10- to 15-acre deferment areas were established on northern red oak sites (SI70). A deferment cut was done on each of these areas and growth and reproduction evaluated on two sites after 5 years. Both tolerant and intolerant commercial species were abundant, and the overstory deferment trees did not appear to hinder stand development. Reproduction was similar to what would be expected if the areas had been completely clearcut. After 5 years, d.b.h. growth, value of the deferment trees, and regeneration were silviculturally acceptable. Deferment cutting also may be useful for other resource objectives.

337.
Smith, H. Clay; MacDonald, William L., eds. 1982. **Proceedings, USDA Forest Service, American chestnut cooperators' meeting.** 1982 January 4-5. Morgantown, WV: West Virginia University Books. 229 p.

Summarizes research program on the American chestnut. Discusses the current status of five selected research topics related to hypovirulence: vegetative, compatibility, cultural studies, host-parasite interactions, molecular aspects, and dissemination of hypovirulence.

338.
Smith, H. Clay; McCay, Roger E. 1979. **Estimating time required to cut grapevines in young, even-aged hardwood stands.** Southern Journal of Applied Forestry. 3(3): 125-127.

Man-hours were recorded for cutting grapevines in young even-aged hardwood stands in north-central West Virginia. An equation was developed to predict the number of man-hours per acre needed to cut a given number of grapevines per acre. The predicted times ranged from 1 man-hour to cut 50 grapevines per acre to about 6 manhours to cut 1,000 grapevines per acre.

339.
Smith, H. Clay; Miller, Gary W. 1987. **Economic considerations of uneven-age hardwood management.** In: Economics of eastern hardwood management, Penn State forest resource issues conference; 1986 March 9-11; University Park, PA. University Park, PA: The Pennsylvania State University: 97-110.

Three partial-cutting harvesting methods (single-tree selection, diameter-limit, and financial maturity) are described and evaluated for improving the economic feasibility of even-age timber management in eastern hardwood stands. The financial-maturity silviculture method has the highest overall potential for field application because aesthetic needs are satisfied, some intolerant species will develop, and guidelines for basal area and volume guidelines are sufficient to prevent overcutting. Broad economic guidelines for applying these methods are presented.

340.

Smith, H. Clay; Miller, Gary W. 1987. **Managing Appalachian hardwood stands using four regeneration practices--34-year results.** Northern Journal of Applied Forestry. 4(4): 180-185.

Adjacent Appalachian hardwood stands in West Virginia established on excellent growing sites were managed for a 34-year period using four regeneration practices. These practices included a commercial clearcut, 15.5-inch diameter-limit, and two single-tree selection practices. An uncut area was maintained as a control. Stand development, growth response, and some stumpage-revenue data were summarized for each treatment. At 34 years after the initial treatments, the commercial clearcut produced the greatest variety of tree species for future management. This stand was dominated primarily by yellow-poplar and black locust. Selection and 15.5-inch diameter-limit treatments promoted sugar maple on these excellent sites. Stand quality improved through management. After 34 years, the control area was worth $1,554/acre and an intensively managed selection was worth $1,214/acre but the control area contained twice the sawtimber volume. Other preliminary value comparisons indicate that landowners benefit from some type of management compared to doing nothing.

341.

Smith, H. Clay; Miller, Gary W. 1991. **Deferment cutting in Appalachian hardwoods: the what, whys, and hows.** In: Johnson, James E., ed. Uneven-aged silviculture of upland hardwood stands: workshop notes; 1991 February 25-27; Blacksburg VA. Blacksburg, VA: Virginia Polytechnic Institute and State University: 33-37.

Deferment cutting is an alternative regeneration method to consider when the establishment and development of shade-intolerant and shade-tolerant species is the silvicultural objective. Experience indicates that desirable reproduction can be established and will develop into an acceptable stand for future management. When considering the deferment of two-age silviculture practice and depending on the length of the rotation, a forester could recommend a regeneration cut every 40 to 100 years. Deferment cutting can be useful in Appalachian hardwoods in providing many of the silvicultural benefits from clearcutting while satisfying landowner objectives in selecting leave trees. Although it represents a compromise for both the forest manager and the landowner, deferment cutting may be one silvicultural tool that will allow more landowner control through the selection of specific residual trees.

342.

Smith, H. Clay; Miller, Gary W. 1991. **Releasing 75- to 80-year-old Appalachian hardwood sawtimber trees: 5-year D.B.H. response.** In: McCormick, Larry H.; Gottschalk, Kurt W., eds. Proceedings, 8th central hardwood forest conference; 1991 March 4-6; University Park, PA. Gen. Tech. Rep. NE-148. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 403-413.

Mature trees on good growing sites are seldom thinned or released. Instead, the trees are harvested at maturity. Data were summarized from study areas in north-central West Virginia (northern red oak site index 70 and above) where mature trees were released on all sides of the crown (full release). Data on 5-year d.b.h. growth and rates of return indicate that several species respond to release. Yellow-poplar and northern red oak were the fastest growing species, averaging 1.8 and 1.6 inches d.b.h. Thus, some mature trees will respond and it may be economical in some instances to retain mature trees for aesthetics, seed production, and other purposes, while continuing to earn a good rate of return.

343.
Smith, H. Clay; Naughton, Gary G. 1989. **Choosing a silvicultural system.** In: Clark, F. Bryan, tech. ed.; Hutchinson, Jay G., ed. Central hardwood notes. Note 2.04. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 2.04-1-2.04-3.

Considerations for selecting a silviculture system are listed, along with a description of common silvicultural systems. General recommendations for choosing a silvicultural system are presented.

344.
Smith, H. Clay; Perkey, Arlyn W.; Kidd, William E., Jr., eds. 1988. **Proceedings, guidelines for regenerating Appalachian hardwood stands.** 1988 May 24-26; Morgantown, WV. SAF Publ. 88-03. Morgantown, WV: West Virginia University Books. 293 p.

Provides foresters and landowners with information on how to regenerate Appalachian hardwood stands. Topics range from common harvesting methods practiced on public, private, and industrial forest lands to evaluating how seed dispersal is influenced by birds and mammals.

345.
Smith, H. Clay; Rosier, Robert L.; Hammack, K. P. 1976. **Reproduction 12 years after seed-tree harvest cutting in Appalachian hardwoods.** Res. Pap. NE-350. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 11 p.

Woody reproduction 12 years after a seed-tree harvest cutting was evaluated for three central Appalachian hardwood sites in West Virginia, including species composition, size, number, and distribution; stem quality; effects of early cultural treatments; and influence of grapevines. Reproduction ranged from 1,250 to 1,700 stems per acre in the 1.0- to 4.9-inch d.b.h. class. Partial estimates revealed that about 250 potential dominant and codominant crop trees per acre were present on oak site index 70 and about 500 on site index 60. Sweet birch, sugar maple, yellow-poplar, and black cherry were the most numerous species on the excellent sites, with sugar maple, sassafras, red oak, red maple, and yellow-poplar the most numerous on the good sites, and sassafras, red maple, red oak, chestnut oak, and sweet birch most prevalent on the fair sites.

346.
Smith, H. Clay; Sander, Ivan L. 1989. **Silvicultural systems for harvesting mixed hardwood stands.** In: Clark, F. Bryan, tech. ed.; Hutchinson, Jay G., ed. Central hardwood notes. Note 2.07. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 2.07-1-2.07-6.

Silvicultural systems for harvesting mixed hardwood stands are described. Silvicultural options include even-age methods such as clearcutting, shelterwood, and seed-tree practices, and uneven-age management (single-tree and group selection). Recommendations are given for applying of these methods.

347.
Smith, H. Clay; Smithson, Paul M. 1975. **Cost of cutting grapevines before logging**. Res. Note NE-207. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

To reduce damage to hardwood stems by grapevines, it is recommended that grapevines be cut near ground level several years before the harvest cutting. Cost of completing this practice on 117 acres supporting 22 vines per acre was found to be about $3.50 per acre.

348.
Smith, H. Clay; Trimble, George R., Jr. 1970. **Mistblowing a hardwood understory in West Virginia with "D-T" herbicide.** Res. Note NE-115. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

A 40-pound ahg solution of 2,4-D and 2,4,5-T herbicide was successfully mistblown on an undesirable hardwood understory on a good site in West Virginia. After 2 years, many of the stems 1 to 15 feet tall had been killed or severely damaged. The possibilities of obtaining desirable shade-tolerant reproduction on the site were improved by the application of this "D-T" herbicide mistblowing treatment.

349.
Smith, H. Clay; Trimble, G. R., Jr.; DeBald, Paul S. 1979. **Raise cutting diameters for increased returns.** Res. Pap. NE-445. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Diameter-limit cutting is widely used to harvest logs in eastern hardwoods. Studies show that cutting limits are often set so low that they sacrifice financial returns. The value of lumber cut from logs is largely dependent on diameter, grade, and tree species. As tree size increases, so does the proportion of higher grade lumber; this is reflected in improved log grades. Small trees, even though they are of sawlog size, produce little high-grade lumber. The maximum grade log that can be obtained from a 12-inch d.b.h. tree is a 3. By contrast, a 16-inch d.b.h. tree has the potential for producing a Grade 1 butt log. Leaving the tree to grow from 12 to 16 inches may increase value of the tree by several fold. This increase in tree value with increasing tree size and grade can be expressed in increases in annual percentage value.

350.
Smith, H. Clay; Wendel, G. W. 1976. **Potential for strip-clearcutting in Appalachian hardwoods.** West Virginia Forestry Notes. 5: 16-19.

To provide forest managers with information about another even-aged timber management practice, a strip-clearcutting study was begun on the Fernow Experimental Forest and the Monongahela National Forest in 1974. This practice entails the clearcutting of long narrow strips at periodic intervals until the entire area is cut in one rotation. The major advantages of strip clearcutting are that it would reduce regulatory concerns compared with patch cutting and minimize adverse aesthetic impacts associated with clearcutting in large blocks. With strip clearcutting it is possible to systematically change a relatively even-aged forest into a series of even-aged stands. However, during the initial cuts, volume production may be sacrificed by cutting in immature stands or by delaying the cutting in mature stands.

351.
Smith, Joseph H.; Patric, James H. 1976. **Skyline cable logging.** Wonderful West Virginia. 40(9): 23-24.

Skyline cable logging may provide a more aesthically appealing alternative for timber harvesting. A skyline system tested in West Virginia is described and subsequent benefits evaluated.

352.
Smithson, Paul; Phillips, Ross A. 1970. **Skidroads for logging operations in the Appalachians.** In: Proceedings, forest engineering workshop on forest roads; Morgantown, WV. Morgantown, WV: West Virginia University. 71:(1-4): 17-23.

Planning and location are the most important aspects of building a skid road, as a well-planned and well-located road is relatively easy to construct and maintain. The planning, location, construction, maintenance, and cost of a skid road in the Appalachians are discussed.

353.
Staley, John M. 1965. **Decline and mortality of red and scarlet oak.** Forest Science. 11: 2-17.

Declining and dying northern red and scarlet oak were found to be affected by leaf roller defoliation, root rot, Agrilus attack, late spring frost, drought, and unfavorable soils. Symptoms of decline were reproduced artificially by defoliation of red oak saplings. Root rot, drought, and frost are considered secondary causal factors. The initial symptoms of decline reflect a diminished availability of carbohydrates for growth, and final symptoms of subsequent mortality reflect extreme moisture stress. A similar decline of European oaks is pointed out.

354.
Stephenson, Steven L.; Studlar, Susan M.; Edwards, Pamela J.; Ruggles, Kimberly K. 1991. **The possible effects of acidification on stream bryophyte communities.** In: Keller, E. C., Jr., ed. Proceedings of the West Virginia Academy of Science; 1991 April 6; Montgomery, WV. Montgomery, WV: West Virginia Institute of Technology. 63(1): 21. Abstract.

Various species of bryophytes (mosses and liverworts) are the major primary producers in many mountain streams, which often are virtually free of higher plants. Five first-order streams located on or near the Fernow Experimental Forest in Tucker County, West Virginia, were sampled during 1989 and 1990 to obtain data on the structure and composition of the bryophyte communities present. Average water pH was greater than 5.5 in two of the streams, whereas the others were relatively more acidic (average: 4.2, 4.0, and 3.2). At least 26 species of bryophytes (20 mosses and 6 liverworts) were encountered in the transects used to sample the five streams. On the basis of values calculated for relative frequency and relative cover, Scapania nemorosa was the single most important species. Other studies have demonstrated that patterns of species distribution for stream-associated bryphytes are strongly influenced by water pH. In this study, the general pattern was for bryophyte species richness to decrease with decreasing pH, and no bryophytes were recorded from Finley Run, the most acidic of the five streams.

355.
Stephenson, Steven L.; Studler, Susan Moyle; Edwards, Pamela J. 1990. **Composition and structure of the communities of bryophytes associated with West Virginia mountain streams.** In: Proceedings, West Virginia Academy of Science, 65th annual session; 1990 April 7; Shepherdstown, WV. Montgomery, WV: West Virginia Institute of Technology. 62(1): 21. Abstract

Various species of bryophytes (mosses and liverworts) are the major primary producers in many mountain streams, which are often virtually free of vascular plants. However, these stream bryophyte communities have received relatively little study. During the 1989 field season, in an effort to characterize the structure and composition of the communities of bryophytes associated with West Virginia mountain streams, quantitative data were obtained for the bryophytes present in the streams of Watersheds 3 and 4 on the Fernow Experimental Forest near Parsons in Tucker County. Twenty-four species of bryophytes (19 mosses and 5 hepatics) were encountered in the 50 line transects used to sample the two streams. Scapania nemorosa, Sciaromium lescurii, Thuidium delicatulum, and Fissidens bryoides were the most widely distributed species present in the two streams; each was recorded from more than 30 percent of the transects.

356.
Strickland, T. C.; Wildensee, F. 1990. **Sulfur and nitrogen cycling in soils of two watersheds in the Fernow Experimental Forest in the central Appalachian mountains.** Agronomy Abstracts: 340.

Traditional input-output studies do not consider rates or timing of soil transformation processes controlling stream response to acidic deposition. At the Fernow Experimental Forest, two streams have been selected that drain adjacent watersheds and exhibit similar chemistries. Studies of soil transformations are being conducted to describe the role of soil processes in stream acidification. Over an 18 month period A- and B-horizon soil samples from the Berks and Calvin series (Typic Dystrochrept) were collected quarterly and leachate water monthly or bimonthly (zero-tension lysimeter). Soil and leachate samples were analyzed for sulfur and nitrogen species. Seasonal pattem of the sulfur and nitrogen cycle are presented accompanied by estimates of in situ net acidity generation, and N and S retention via organic combination versus inorganic adsorption mechanisms.

357.

Stringer, Jeffrey W.; Miller, Gary W.; Smith, H. Clay. 1988. **Residual stand damage from crop tree release felling operations in white oak stands.** Tech. Rep. 8801. Lexington, KY: University of Kentucky, Department of Forestry. 15 p.

Felling trees in pole and small sawtimber white oak stands to release 20 to 34 crop trees per acre did not cause significant damage to residual crop trees. The majority of damage occurred to the smaller trees on the plot. Felled trees were not removed from the stump, though cut-tree volumes were economical. Crop trees were selected, marked, and then released by a crown-touching technique.

358.

Stringer, Jeffrey W.; Miller, Gary W.; Wittwer, Robert F. 1988. **Applying a crop-tree release in small-sawtimber white oak stands.** Res. Pap. NE-620. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastem Forest Experiment Station. 5 p.

Small-sawtimber white oak crop trees in Kentucky were released by a crown-touching technique. In two cutting treatments, 20 and 34 crop trees were released per acre at a total cost of $35 and $42, respectively. Both treatments yielded commercial volumes of cut material. Total mean merchantable volume (> 5.0 inches d.b.h.) in cut trees was 693 cubic feet/acre, with approximately 2,400 board feet/acre in sawtimber (> 11.0 inches d.b.h.). On the basis of early crop-tree stem response, the released trees are growing 0.16 inch/year compared with 0.13 inch/year for the unreleased trees.

359.

Sundeen, Kerry D.; Ponce, Stanley L.; Striffler, W. D.; Aubertin, Gerald M. 1978. **A method to predict baseline water quality on wildland watersheds.** Transactions of the American Geophysical Union. 59(12): 1072. Abstract.

As a result of recent legislation on water quality, land-management agencies have been called upon to assess the impact of land management on water quality. The objective of this study was to develop a predictive model that can be used by field-based land managers to simulate baseline stream chemistry throughout the Monongahela National Forest and central Appalachia. Water-quality samples collected monthly at 53 sites over a period of 2 1/2 years were analyzed for EC, pH, acidity, alkalinity, Ca, Mg, Na, K, Fe, SO_4, and NO_3. Cluster analysis was used to identify relationships in stream chemistry between and within geologic/soil units. A predictive model was developed to simulate EC and pH concentrations using mass-balance concepts. The independent variables of the model include discharge, precipitation input, drainage density, and a geologic-soil enrichment factor. The model can account for the effect of single or multiple geologic/soil units within a given watershed. From this work, land managers in the Monongahela National Forest and in the Allegheny section of central Appalachia can better assess changes in water quality resulting from prescribed land-management practices.

360.
Trimble, G. R., Jr. 1952. **A method of measuring increase in soil depth and water-storage capacity due to forest management.** Stn. Pap. 47. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Past studies of forest soils, in connection with flood control surveys in the Northeast indicate that the depth and water-storage capacity of shallow forest soils can be increased through the use of forest management that will maintain well-stocked stands.

361.
Trimble, G. R., Jr. 1954. **Forests are important on the watershed.** West Virginia Conservation. 18(1): 3-7.

If managed correctly, forested lands will produce the maximum of pure, clear water. The supply will naturally be less in dry weather, but well-managed forest land will yield more usable water at all times than burned or poorly logged forest land. Flash floods are minimized in areas of good forest growth. Indications are that the forest can be managed to supply both timber and good water. A number of recommendations are given that if followed on logging operations will materially reduce damage to water supplies.

362.
Trimble, G. R., Jr. 1960. **Relative diameter growth rates of five upland oaks in West Virginia.** Journal of Forestry. 58: 111-115.

Diameter-growth rates of northern red oak and chestnut oak were observed under similar conditions and reported in 1957. Since then, growth data have been compiled for three more upland oaks in the area: scarlet oak, black oak, and white oak. The relative growth rates of these five oaks are described. It is possible to compare the potential diameter-growth rate in West Virginia of the five oaks under consideration based on 10-year d.b.h. growth rates of Vigor I trees. The growth of this vigor class is affected by competition and most truly expresses growth capacity of the species. Thus, we have in order of decreasing growth rate: northern red oak, black oak, chestnut and scarlet oaks, and white oak.

363.
Trimble, G. R., Jr. 1961. **Managing mountain hardwoods--a ten-year appraisal.** Stn. Pap. 143. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 25 p.

Ten years ago, the first cuts were made under each of four different management programs on 5-acre plots located in Appalachian hardwood stands on good sites: commercial clearcut, 16-inch diameter cut, extensive-selection management, and intensive-selection management. Ten years after the first cut, second cuts were made in the selectively managed plots. Before marking for these second cuts, detailed silvicultural goals were set up as guides to management. Average annual growth for the 10-year period in board feet were clearcut, 86; diameter-limit, 446; extensive management, 424; and intensive management, 524. After 10 years, cull material was greatly reduced in the selectively cut and diameter-limit plots; in the commercial clearcut area it amounted to at least 42 percent of the residual sawtimber volume. The original stands contained only about 25 percent of the sawtimber volume in log grades 1 and 2. Today, the percentages of log grades are: clearcut, none; diameter-limit cut, 40 percent; extensive management, 48 percent; and intensive management, 49 percent. Reproduction of commercial species is abundant and well distributed on all plots.

364.
Trimble, G. R., Jr. 1961. **Water management–one of the multiple uses of forest land.** Virginia Technical Forester. 13: 17-21.

Consideration of the water resource is an important part of forest land management. Water problems can be of two types, water supply (too much or too little) and water quality. Water supply can be affected by forest management activities. By maintaining forest cover, flood peaks can be reduced. Cutting forests reduces the amount of water used by vegetation and increases flow. Water quality can best be protected by minimizing erosion. Guidelines for preventing soil erosion from logging roads are presented.

365.
Trimble, G. R., Jr. 1962. **Good and bad logging.** Northern Logger. 11(3): 18.

Two logging jobs within 2 miles of each other on opposite slopes of the same West Virginia valley are described. One is characterized as a "bad" logging and the second as a "good" logging job. The difference between the two is detailed.

366.
Trimble, G. R., Jr. 1963. **Hybrid poplar grows poorly on acid spoil banks at high elevations in West Virginia.** Res. Note NE-7. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

A clonal test of hybrid poplar was established in 1951-52 on acid spoil banks from coal stripmining in northern West Virginia. Limestone treatment also was evaluated. Survival and growth on the unlimed blocks was poor, while lime treatment had a favorable effect on the poplars. In general, hybrid poplars are not well suited to such sites.

367.
Trimble, G. R., Jr. 1963. **Watershed management research - Northeastern Forest Experiment Station.** Tech. Pap. 63-P-3. Washington, DC: American Pulpwood Association. 6 p.

Defines forest hydrology research as the study of the effects of forest management on streamflow. Experimental installations in the Appalachians are described and research on water yield and water quality is summarized.

368.
Trimble, G. R., Jr. 1964. **An equation for predicting oak site index without measuring soil depth.** Journal of Forestry. 62: 325-327.

A regression equation for predicting oak site index from measurements of aspect, slope position, and slope percent was developed on three sandstone and shale soil series for the mountain province in West Virginia and a part of Maryland. Based on data previously used to develop a prediction equation from these three factors plus total soil depth, this new equation, without the use of soil depth, provides for nearly as accurate a prediction. The necessary data for prediction can be collected much more easily because laborious soil depth observations are not required. The close relationship between soil depth and the two topographic factors, slope position and slope percent, allows the elimination of soil depth from the estimating equation.

369.
Trimble, G. R., Jr. 1965. **Improvement in butt-log grade with increase in tree size for six hardwood species.** Res. Pap. NE-31. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 15 p.

A study in natural undisturbed stands of the effect of tree size on butt-log grade provided well-defined relationships for six hardwood species in West Virginia: northern red oak, white oak, chestnut oak, sugar maple, yellow-poplar, and beech. The improvement in grade with increasing tree d.b.h. varied with species.

370.
Trimble, G. R., Jr. 1965. **Reducing the proportion of cull material in hardwood stands.** Northern Logger. 14(2): 26-27.

The selection method of cutting provides an excellent opportunity for an appreciable reduction in the proportion of cull in hardwood stands. An opportunity to evaluate the effects of selection management on cull reduction and to estimate the ultimate level of cull in a managed stand was provided by records from the Fernow Experimental Forest. The average stand had 17.3 percent of its total sawlog volume in cull trees when management was begun. Just before the second cutting, the stands had a weighted average of only 0.7 percent of their sawlog volume in cull trees. On the two areas where third cuttings were made, scale deductions were down to 4.8 percent of the gross log scale. It seems probable that by the third cutting on these selection-management areas, the amount of defective material has stabilized and that the process of reducing cull material has reached an end. Thus, we can expect to maintain volumes of cull trees at 1 percent or less of the gross board-foot volume and to produce sawlogs with average scaling deductions of 4 to 5 percent.

371.
Trimble, G. R., Jr. 1965. **Species composition changes under individual tree selection cutting in cove hardwoods.** Res. Note NE-30. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

In recent years, large areas of cove hardwoods in the Appalachians have been placed under some type of forest management. In many cases, the system used consists of frequent light cutting based on individual-tree selection. Research on the Fernow Experimental Forest suggests that under such treatments, the proportion of sugar maple will increase appreciably and consistently. At the same time, the proportion of yellow-poplar, red oak, and black cherry probably will decrease to a point where these species are no more than minor components of the stands.

372.
Trimble, G. R., Jr. 1965. **Timber by the pound--not a desirable trend for hardwood sawlogs.** Journal of Forestry. 63: 881.

Under the present market demand for hardwood sawtimber, a realistic appraisal of value must provide for recognition of species, log diameter, log grade, and volume. Weight scaling alone does not meet most of these criteria. If weight scaling could be combined with sample grading, either in the standing tree or in the log, to provide for recognition of quality, it might be acceptable.

373.
Trimble, G. R., Jr. 1968. **Multiple stems and single stems of red oak give same site index.** Journal of Forestry. 66: 198.

The relationship between site index of multiple stems and single stems of red oak was determined on seven 1/5-acre plots in Tucker County, West Virginia. Site index of the study plots ranged from 65 and 75 feet. Analysis of variance with these data revealed no significant difference at the 5-percent level in site index between multiple and single stems of dominant and codominant trees. On the basis of this study, it appears that multiple-stem red oaks in the dominant or codominant positions are reliable indicators of site index and length of clear bole.

374.
Trimble, G. R., Jr. 1969. **Diameter growth of individual hardwood trees–the effect of certain tree and environmental factors on the growth of several species.** Res. Pap. NE-145. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 25 p.

Between 1959 and 1967, the d.b.h. growth rate of individual hardwood trees was studied near Parsons, West Virginia. The correlation of the more easily used crown classification with d.b.h. growth is as good or better than the correlation of vigor classes with d.b.h. growth. When crown classes are identified, crown measurements such as width and length add nearly nothing of predictive value. Tree d.b.h. is positively and strongly correlated with d.b.h. growth in these mixed hardwood stands. A measure of total surrounding basal area is not a good predictor of individual tree d.b.h. in these stands.

375.
Trimble, G. R., Jr. 1968. **Harvest cuttings in Appalachian hardwoods from a silvicultural viewpoint.** In: Proceeding of western Maryland forest improvement conference. [Place of publication unknown]: [Publisher name unknown].

The use of even-aged and uneven-aged cutting systems in the management of hardwood forests is discussed. To decide which system to use, the forester must ask: Which system best fits the particular forestry situation for which I am responsible? The answer depends on many factors, including those related to the owner, economic considerations related to harvesting cost and products markets, and silvical factors.

376.
Trimble, G. R., Jr. 1969. **Research findings on even-aged management of hardwoods in the Appalachian area and the central states.** In: Proceedings, Monongahela National Forest timber management conference proceeding. [Place of publication unknown]: [Publisher name unknown].

Results are discussed from a number of studies examining the effects of even-age management on timber production and watershed relationships. Even-age management is increasingly profitable because of broadening markets for more species and smaller trees than previously existed. Research and observation indicate that even-age management will have some beneficial effects on watershed relationships, albeit minor. There will be little effect on recreational values, and spotty but positive effects on game populations. Even-age management has the potential for growing more and better timber on the same acreage of land.

377.
Trimble, G. R., Jr. 1972. **Reproduction 7 years after seed-tree harvest cutting in Appalachian hardwoods.** Res. Pap. NE-223. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 19 p.

Seven years after seed-tree cutting in Appalachian hardwood stands, reproduction stems of commercial species were abundant and well distributed. Species composition varied by site quality, but a wide variety of species was represented on all sites. Early indications are that the 1- to 5-inch residual stems from the old stand have potential for adversely affecting the new stand by shading it.

378.
Trimble, G. R., Jr. 1973. **Appalachian mixed hardwoods.** In: Silvicultural systems for the major forest types of the United States. Agric. Handb. 445. Washington, DC: U.S. Department of Agriculture: 80-82.

Describes the Appalachians mixed hardwood type, also known as cove hardwood: range, acreage, productivity, and site characteristics. Species composition ranges from nearly pure northern red oak to pure yellow-poplar, but it is more typically a mixture that may contain 20 or more commercial species. The regenerative potential of the Appalachian hardwood type is strong, and the variety of species and favorable reproductive mechanisms results in abundant reproduction following any system of cutting. However different degrees of shade tolerance lead to changes in species composition with different silvicultural systems.

379.
Trimble, G. R., Jr. 1973. **Natural regeneration of central Appalachian hardwoods in West Virginia.** In: Proceedings, 1st annual hardwood symposium of the Hardwood Research Council; 1973 May 2-5; Cashiers, NC. Cashiers, NC: Hardwood Research Council: 45-57.

Reproduction has been found satisfactory in numbers and distribution after both clearcutting and selection cutting, but the species composition differs greatly. Tolerants predominate after selection cutting, but generally a good portion of the regeneration that follows clearcutting will be composed of intolerants. Site quality influences the species composition of reproduction that follows cutting, and the effect is greater with clearcutting than with selection cutting. When group selection or patch cutting is the reproduction method, and where the objective is a good species mix including some intolerants, results of research suggest that openings should be at least 1/2 acre and preferably 1 acre.

380.
Trimble, G. R., Jr. 1973. **Response to crop-tree release by 7-year-old stems of yellow-poplar and black cherry.** Res. Pap. NE-253. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 10 p.

Five years after crop-tree release of yellow-poplar and black cherry stems in a 7-year-old stand of Appalachian hardwoods, measurements indicated that released trees were only slightly superior to controlled trees in height, diameter, and crown position. Sprout regrowth of cut tree stems and grapevines had largely nullified the effects of release. Indications are that for release to be effective, crop trees of these species on good sites should be 15 to 20 feet tall.

381.

Trimble, G. R., Jr. 1973. **The regeneration of central Appalachian hardwoods with emphasis on the effects of site quality and harvesting practice.** Res. Pap. NE-282. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 14 p.

Summarizes research results from studies mostly in West Virginia and shows the relationship of site quality and cutting practices to hardwood reproduction, with emphasis on species composition. Reproduction has been satisfactory in numbers and distribution after both clearcutting and selection cutting, but the species composition differs greatly; shade-tolerant species predominate after selection cutting, but a good proportion of the regeneration that follows clearcutting generally will be composed of intolerant species. This depends somewhat on the density of advance reproduction and the abundance and species composition of stump sprouts. Site quality influences the species composition of reproduction after cutting, and the effect is greater with clearcutting than with selection cutting. After clearcutting, on the excellent sites we can expect a good representation of yellow-poplar and black cherry; on the fair sites we can expect a variable number of oak stems. After selection cutting, we get beech and sweet birch on both sites with sugar maple predominant on the excellent site and red maple better represented on the fair site. When group selection or patch cutting is the reproduction method, and where the objective is a good species mix including some intolerants, results of research suggest that openings should be at least 1/2 acre and preferably 1 acre. Some factors other than site quality and cutting practice that affect the nature of regeneration are species composition of the overstory, season of cutting, density of low vegetation, presence of grapevines, and damage by spring frosts.

382.

Trimble, G. R., Jr. 1974. **Response to crop-tree release by 7-year-old stems of red maple stump sprouts and northern red oak advance reproduction.** Res. Pap. NE-303. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Discusses the crop-tree release of two species typical of a fair site: red maple stump sprouts and northern red oak advance reproduction. The feasibility of doing a crop-tree release immediately after the canopy closed and crown classes could be distinguished was tested in a 7-year-old, even-aged hardwood stand on the Fernow Experimental Forest near Parsons, West Virginia. The following variables were compared between released and control trees: total height growth, d.b.h. growth, length of clear stem, and change in crown class. For the red maple sprouts, two crown classes were studied: dominants and codominants. For the red oak, three crown classes were studied: dominants, codominants, and intermediates. After the initial measurements, repeat measurements were made at 2 and 5 years following treatment. For the type of release, species, and site studied, release had no significant effect on height growth. Diameter growth was favorably affected by release of the red maple stump sprouts, but release had no significant effect on the diameter growth of red oak advance reproduction. Length of clear stem was retarded during the 5-year period by release, but during this period red oak cleared up at a faster rate than red maple. Changes in 5-year crown class indicate that release had a minor effect on red oak, where crowns retrogressed heavily in dominance in both the release and control categories. However, released red maple codominants were more dominant than controls 5 years after release. Mortality was slight in all of the stem categories.

383.

Trimble, G. R., Jr. 1980. **Management and stand factors affecting residue in the woods.** In: Brooks, Maurice L.; Hall, Carter S.; Luchok, John, eds. Proceedings of the logging residue conference; 1975 June 4-6; Morgantown, WV. Morgantown, WV: West Virginia University: 13-14.

Several factors are discussed that influence the amount and nature of residue from logging Appalachian hardwood stands. Factors include product markets, logging techniques, and stand-site characteristics.

384.
Trimble, G. R., Jr.; Barr, Carl R. 1960. **Cost of skid roads for arch logging in West Virginia.** Southern Lumberman. 201: 33-34.

Describes the method of road construction on the Fernow Experimental Forest and associated costs. The data are from seven different logging jobs totaling 660 acres over several years.

385.
Trimble, G. R., Jr.; Fridley, Burley D. 1963. **13 years of forestry research in West Virginia.** Res. Pap. NE-5. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 55 p.

Describes the Fernow Experimental Forest and early research, concentrated on timber and water management. Several early studies are described in detail.

386.
Trimble, G. R., Jr.; Gibbs, Carter B.; Barr, Carl R. 1963. **Truck roads and small forest products.** Northern Logger. 11(12): 16-17, 40-41, 46-47.

Harvesting small hardwood forest products poses serious problems in mountainous areas, mainly due to the low return which allows only a small margin to cover cost. Truck roads were installed in a small hardwood products cut and evaluated. The road system was not economical for cordwood but may pay off in harvesting more valuable products (sawlogs).

387.
Trimble, G. R., Jr.; Hart, George. 1961. **An appraisal of early reproduction after cutting in northern Appalachian hardwood stands**. Stn. Pap. 162. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 22 p.

Numbers, distribution, and species composition are related to site and cutting intensity. Research cutting practices on the Fernow Experimental Forest range from single-tree selection cuts to commercial clearcuts. Reproduction of commercial species was abundant on all sites after all cutting methods. Cuttings that removed 75 percent or more of the sawtimber volume reproduced new stands in which up to one-half of the stems were shade-tolerant species. Selection cuttings favored reproduction of tolerant species.

388.
Trimble, G. R., Jr.; Mitchell, Wilfred; Barr, Carl R. 1958. **Logging damage no obstacle to tree-length logging.** Southern Lumberman. 197(2465): 111-112.

389.
Trimble, G. R., Jr.; Mitchell, Wilfred; Barr, Carl R. 1959. **Logging damage slight in partial cutting.** Northern Logger. (7): 12-13, 38.

Different harvesting options were evaluated as to the resulting injury to residual trees. Partial cutting resulted in destruction of only 1 to 5 percent of the volume of the residual stand. There was no difference in damage between diameter-limit cutting and two intensities of individual tree selection. More trees were damaged in the smaller (6 to 10 inches) diameter class, but slightly more volume was destroyed in the sawtimber (more than 12 inches) class. More than 3 times as many 6 to 10 inch trees were destroyed in felling as in skidding.

390.

Trimble, G. R., Jr.; Patric, James H.; Gill, John D.; Moeller, George H.; Kochenderfer, James N. 1974. **Some options for managing forest land in the central Appalachians.** Gen. Tech. Rep. NE-12. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 39 p.

For years foresters have recognized the principle of multiple use, and progress has been made toward managing forest resources to satisfy more than a single need. But much more progress is needed if our forest land is to satisfy the many needs of a growing population with more free time and more money. This publication is intended to broaden the forester's perspective in evaluating the suitability of tracts for a variety of uses and use mixes. We attempted to evaluate for the area of the central Appalachians the general effects of different forest practices on the following resources: timber, water, visual appeal, and wildlife. The management options presented apply to the forest ecosystems that predominate in the central Appalachian region: (1) the oaks, (2) Appalachian mixed hardwoods, (3) northern hardwoods, (4) white pine, (5) Virginia pine, (6) red spruce, and (7) floodplain hardwoods. Each of these ecosystems, and quality of forest sites likely to occur within it, was rated as to its inherent capacity to supply each of the four resources. Three broad management methods were considered for each ecosystem; even-age management, uneven-age management, and no commercial harvesting. The first two of these methods were subdivided into conventional cutting practices, and all were rated as to desirability to produce timber, water, visual appeal, and wildlife. The desirability ratings have no quantitative significance; they express a specialist's judgment of how each forest product is likely to be influenced by the specified practice. Thus, users are presented with a series of forest management options from which they may choose those cutting practices best suited to their particular combination of forest resources and ownership objectives. Examples show how options might be selected in actual forest management.

391.

Trimble, G. R., Jr.; Reinhart, K. G.; Webster, Henry H. 1963. **Cutting the forest to increase water yields.** Journal of Forestry. 61: 635-640.

Is it practical to cut the forest to increase water yields? What are the flood risks and water-quality hazards? What is the direct cost that may be incurred? And what are the losses in timber income and other forest resources to be considered? These questions are discussed in terms of the results from watershed research on the Fernow Experimental Forest in West Virginia, a mountain hardwood forest in a region of heavy, well-distributed rainfall. Four degrees of forest cutting ranging from a commercial clearcutting to a light selection cutting were made on 40- to 95-acre watersheds. Increases in water yield were roughly proportional to the amount of timber removed and occurred mostly in the growing season. Cutting effects on high flows were not great; periods of high flow are most frequent in the dormant season. Vegetation regrowth was rapid and the effects of cutting on streamflow diminished quickly. Water quality was adversely affected by poor logging practices that resulted in erosion and sedimentation. The effects of cutting on water quality were greatest during the period of active logging and diminished soon afterward.

392.

Trimble, G. R., Jr.; Rosier, R. L. 1972. **Elimination of scattered residual saplings left after clearcut harvesting of Appalachian hardwoods.** Res. Note NE-146. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Basal-spraying and power-saw felling were compared as methods for eliminating the 1- to 5-inch d.b.h. understory stems after clearcutting. Felling leaves the area more aesthetically acceptable, and costs are lower.

393.
Trimble, G. R., Jr.; Seegrist, Donald W. 1973. **Epicormic branching on hardwood trees bordering forest openings.** Res. Pap. NE-261. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Epicormic branching in hardwoods can degrade logs and reduce the dollar returns from growing trees. A study made around clearcut openings of various sizes showed that the following variables were related to the degree of epicormic branching on trees bordering the opening: size of opening, species, tree dominance class, exposure of tree bole, and position on tree bole.

394.
Trimble, G. R., Jr.; Smith, H. Clay. 1963. **What happens to living cull trees left after heavy cuttings in mixed hardwood stands?** Res. Note NE-12. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Using records from several commercially clearcut areas on the Fernow Experimental Forest, cull-tree behavior was examined. After heavy cutting, a higher proportion of small culls than large culls died over the 5- and 10-year study periods, and losses of cull trees generally were greater during the first 5 years after logging. Management recommendations are presented.

395.
Trimble, G. R., Jr.; Smith, H. Clay. 1970. **Sprouting of dormant buds on border trees.** Res. Pap. NE-179. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Dormant-bud sprouting was studied on codominant, middle-aged red oak and yellow-poplar trees released on one side by patch cutting. A higher percentage of buds sprouted on red oak than on yellow-poplar; more buds sprouted on the exposed than on the unexposed bole face; a higher percentage of buds sprouted on the second log than on the first; and most of the buds that sprouted, did so shortly after release.

396.
Trimble, G. R., Jr.; Tryon, E. H. 1966. **Crown encroachment into openings cut in Appalachian hardwood stands.** Journal of Forestry. 64: 104-108.

A study was made to determine the rate and extent of border-tree crown expansion into openings cut to obtain reproduction in sawtimber stands of Appalachian hardwoods. Poletimber- and sawtimber-size trees of red oak and yellow-poplar were measured. A regression was developed for each species based on the independent variables of tree d.b.h. and the number of years since cutting. Red oak crowns extended farther and grew faster laterally than yellow-poplar crowns. However, the rate of crown encroachment into openings was surprisingly slow for both species.

397.
Trimble, G. R., Jr.; Tryon, E. H. 1967. **Seeding characteristics of eleven Appalachian hardwood species.** Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 20 p.

Information is provided on the seeding characteristics of 11 hardwood species found in the central Appalachians: white ash, American basswood, American beech, black cherry, black locust, red maple, sugar maple, black oak, northern red oak, white oak, and yellow-poplar.

398.
Trimble, G. R., Jr.; Tyron, E. H. 1974. **Grapevines, a serious obstacle to timber production on good hardwood sites in Appalachia.** Northern Logger. 23(5): 22-23, 44.

Wild grapevines are damaging to timber production in Appalachian hardwood stands. Although grapevines reproduce by both seeds and sprouts, damage from sprouts is more serious because they grow so much faster than seedlings. Because grapevines are shade intolerant, they are much more of a problem after clearcutting than selection cutting. Grapevines are more common on the better sites.

399.
Trimble, G. R., Jr.; Tryon, E. H. 1976. **Grapevine control in young even-aged hardwood stands.** Northern Logger. 24(9): 12-13.

The objective of this study was to determine how stand age and tree height affect the regrowth of severed grapevines into the crowns of thinned and unthinned stands of young even-aged hardwoods on good sites. We conclude that grapevines can be eliminated by cutting them in stands as young as 12 years old and out of crop trees 25 feet tall (or perhaps even shorter) under both thinned and unthinned conditions.

400.
Trimble, G. R., Jr.; Tryon, E. H. 1979. **Silvicultural control of wild grapevines.** Bull. 667. Morgantown, WV: West Virginia University Agricultural and Forestry Experiment Station. 19 p.

Wild grapevines can decrease growth and increase mortality of important hardwood trees. Although best methods of controlling grapevines have not been determined for all stand conditions, studies at the Fernow Experimental Forest indicate that severing vines growing in well-stocked stands is an effective and inexpensive way of eliminating them. This method works because grapevines are shade intolerant; under the shade of a forest canopy, the sprouts from grapevine stumps will not develop and climb into the crowns. In older stands approaching maturity and a clear cutting harvest, grapevines should be cut at least 4 years before harvest. In any stand an attempt should be made to cut all grapevines in all tree crowns.

401.
Trimble, G. R., Jr.; Tryon, E. H.; Smith, H. Clay; Hillier, J. D. 1986. **Age and stem origin of Appalachian hardwood reproduction following a clearcut and herbicide treatment.** Res. Pap. NE-589. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Seven years after a clearcut and herbicide treatment in a West Virginia stand of Appalachian hardwoods, root and stem ages were determined for sugar maple, black cherry, and white ash. Age was used to verify origin and origin was used to evaluate reproduction stem development 7 years after clearcutting. Sugar maple stems originated from advanced reproduction; black cherry originated primarily from seedlings that germinated during or after treatment; and white ash stems were a mixture of seedlings, advanced reproduction, and stump sprouts.

402.
Trimble, G. R., Jr.; Weitzman, Sidney. 1954. **Effect of a hardwood forest canopy on rainfall intensities.** Transactions of the American Geophysical Union. 35(2): 226-234.

Ground rainfall intensities and throughfall were measured under a fully stocked hardwood forest in West Virginia for 1 year. Maximum 5- and 15-minute intensities were compared with similar measurements made in the open. The results were analyzed separately for winter and summer conditions, that is, bare canopy versus canopy in full leaf. Regression equations were calculated for estimating intensities and throughfall under canopy from rainfall measurements made in the open. The study shows that low rainfall intensities are reduced more by summer, and high intensities are reduced more by winter canopy. Throughfall is reduced by canopy interception about equally in both summer and winter.

403.

Trimble, G. R., Jr.; Weitzman, Sidney. 1956. **Chaff seeding--one answer to soil washing on logging roads.** West Virginia Conservation. 19(12): 12-13.

Logging roads probably are the greatest single source of erosion in forested areas. Any measure that reduces the erosion from these roads is worth considering as a means of maintaining clean water supplies and reducing silting in reservoirs and stream channels. One method studied was revegetation, that is seeding skid roads, old log decks, and truck roads by scattering chaff from local harvest operations. Chaff was used because it is easily and cheaply obtained in most localities. It is easy to apply and contains many types of seeds, some of which are likely to be successful under a variety of conditions. Chaff seeding of logging roads accompanied by the use of lime and fertilizer will develop a protective cover of vegetation. When used in conjunction with water bars after logging, chaff seeding is a cheap and easy method of erosion control.

404.

Trimble, G. R., Jr.; Weitzman, Sidney. 1956. **Site index studies of upland oaks in the northern Appalachians.** Forest Science. 2: 162-173.

The productivity of most of the forest land in northern Appalachians can be estimated from information on: (1) aspect of the site; (2) position of the site on the slope, i.e., distance from the ridge line; (3) grade of the slope at the site; and (4) total soil depth to bedrock. Such estimates may be 9 percent in error at the point of average site index--66 feet. Use of length of clear bole as a measure of site index, like ground cover, is useful only to indicate general site conditions. Humus type and depth as well as pH show some relationship to site index, but these relationships are not close enough for estimating purposes. Some of the factors affecting the error of estimate are exposure or extent of shading, stone content of soil profile, variation in soil depths over the plots sampled, past history of the stand--especially the degree of suppression and density of stocking--elevation differences, and length of slope.

405.

Trimble, G. R., Jr.; Wendel, G. W. 1963. **Cost of marking hardwood sawtimber in West Virginia.** Res. Note NE-15. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

An economic study of forest management cost and returns was begun in 1959 on a 600-acre management unit of the Fernow Experimental Forest. The cost of marking for the initial cutting operation is reported.

406.

Trimble, George R. 1959. **Logging roads in northeastern municipal watersheds.** Journal of American Water Works Association. 51: 407-410.

Many of the municipal watersheds in the Northeastern United States are forested, offering opportunities for wood production as well as water supply. However, logging a municipal watershed requires careful planning and operation to prevent impairment of water quality due to erosion and sedimentation. On the basis of research conducted on the Fernow Experimental Forest, recommendations for careful logging of these watersheds (where appropriate) are given.

407.
Trimble, George R., Jr. 1955. **Watershed research begins in New Hampshire.** Forest Notes. 46: 22-25.

Describes the planning and initiation of watershed research at the Hubbard Brook Experimental Forest in New Hampshire.

408.
Trimble, George R., Jr. 1957. **Chaff seeding does not inhibit tree reproduction.** Stn. Note 77. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 2 p.

Experimental plots were examined after five growing seasons to determine the effect of chaff seeding of logging roads on tree reproduction. Results indicate that plant cover that develops after chaff seeding on compacted areas does not hinder establishment of tree reproduction. Because chaff seeding stabilizes the soil surface, it may improve conditions for seedling establishment.

409.
Trimble, George R., Jr. 1959. **The case for directional felling.** Northern Logger. 8(5): 32-33, 41, 56.

The feasibility of directional felling using a jack was studied on a 90-acre partial cut on the Fernow Experimental Forest. Cost savings could average $0.14 per tree, which would make directional felling worthwhile. Development of a lighter, more efficient jack would make it a more effective felling tool.

410.
Trimble, George R., Jr. 1963. **Cull development under all-aged management of hardwood stands.** Res. Pap. NE-10. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 10 p.

Cull-tree development was observed at intervals of 5 and 10 years after selection management was begun in hardwood stands in West Virginia. The rate at which new culls developed was related to time after logging and cull treatment, size range of culls treated, and species. Logging damage to residual trees seemed to be the principal reason for development of the new culls particularly in the sawlog portion of the stands. Cull-tree elimination requires no more than a minor and periodic operation following one thorough initial treatment.

411.
Trimble, George R., Jr. 1967. **Diameter increase in second-growth Appalachian hardwood stands--a comparison of species.** Res. Note 75. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

A study of d.b.h. growth among eight hardwood species after partial cutting in second-growth stands showed that red oak grew fastest, followed in order by yellow-poplar, sugar maple, basswood, black cherry, white ash, and chestnut oak.

412.
Trimble, George R., Jr. 1968. **Form recovery by understory sugar maple under uneven-aged management.** Res. Note NE-89. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

A study of advanced sugar maple reproduction on a good site in West Virginia indicated that considerable improvement of stem form takes place after selection cutting in the overstory. The study stems were 1 to 6 inches in d.b.h. and many of them were more than 50 years old. To an appreciable extent, flat tops and minor crooks were overcome after partial release.

413.
Trimble, George R., Jr. 1968. **Growth of Appalachian hardwoods as affected by site and residual stand density.** Res. Pap. NE-98. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 13 p.

In a 10-year growth study, Appalachian hardwoods were cut to different residual basal areas on an excellent site (index 85 for oak) and a fair site (index 63 for oak). There were large differences in growth between the two sites, the excellent site producing 1.4 times more cubic volume than the fair site. Apparently, the lower density on the excellent site reduced stocking of larger trees to a point below full occupancy of the site. However, growth rates of the individual residual trees were greatest at the lowest density, regardless of size.

414.
Trimble, George R., Jr. 1968. **Log grades should reflect lumber grades.** Northern Logger. 16(11): 24.

Within the lumber industry, log grades are used increasingly to measure log or tree value. When these grades are based on the value of the lumber that can be sawed from the logs, they are a useful and fair means of establishing log value, either for sale or purchase. Any grading system for factory logs should be based on converting the log to standard grades of lumber and should be supported by adequate data showing the lumber-grade yields for those log grades.

415.
Trimble, George R., Jr. 1969. **More intensive forest management ahead in northeast and Appalachians.** Pulpwood Annual. 1969: 105-106.

Even-age systems will be used to manage the Third Forest of the Northeast and the Appalachians for wood products, and intensive silvicultural measures will be practiced. We can expect that on the rougher lands of the Northeast and Appalachia where most future woodlands will be concentrated, forestry will be practiced more or less in traditional fashion--but with considerable intensification of cultural operations. Intensification of cultural operations will mean a stepping up of such measures as cleaning, thinning, and pruning. These operations are carried out to improve species composition, increase utilizable growth, reduce rotation length, and raise the unit value of the crop. Improvement in species composition will mean crop-tree release in young stands. The public will place even stronger emphasis on aesthetics, which will require increased attention to landscape appearance in planning cutting areas.

416.
Trimble, George R., Jr. 1969. **Panel comments.** In: Sugar maple conference proceedings; Houghton, MI. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 28.

417.
Trimble, George R., Jr. 1970. **20 years of intensive uneven-aged management: effect on growth, yield, and species composition in two hardwood stands in West Virginia.** Res. Pap. NE-154. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

A 20-year study was made on two 31-acre hardwood stands in West Virginia that were cut periodically under an individual-tree selection system. Under this system of cutting, species composition is changing from a preponderance of cove hardwoods (yellow-poplar, black cherry, red oak, etc.) to red and sugar maple, sweet birch, and beech. Apparently, these stands will yield about 3,000 board feet of sawtimber and 3 to 6 cords of bulk products per acre at 10-year cutting cycles, during the early part of the conversion period from uneven-age to all-age condition. As species composition changes, future growth rates also may change.

418.
Trimble, George R., Jr. 1971. **Diameter-limit cutting in Appalachian hardwoods: boon or bane?** Res. Pap. NE-208. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 14 p.

Diameter-limit cutting is not recommended as a method of repeatedly harvesting hardwood stands. When diameter limits are set low, periods between cuts are too long or only small trees are available in the recuts. When the diameter limit is set high, the potential silvicultural disadvantages of the system are postponed, that is, a long period will pass before they show up. Another drawback to diameter-limit cutting is that with many crews, supervision costs are high. A number of modifications can be made in diameter-limit cutting to improve its performance and soften the impact of its poor features. These include killing culls below the minimum diameter, different diameter limits for different species to conform to their physiological and financial maturity sizes, and setting diameter limits based on stand inventories so as to leave a residual stand that fully occupies the site. In many cases, cutting to a diameter limit has immediate short-range economic advantages. Moreover, if it is done right, such as making only one diameter-limit cutting and setting the limit high so as to remove only old residuals, there should be no adverse long-range silvicultural effect on the stand.

419.
Trimble, George R., Jr. 1971. **Early crop-tree release in even-aged stands of Appalachian hardwoods.** Res. Pap. NE-203. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

Selected crop trees were released at an early age from the competition of surrounding woody stems, and grapevines were removed from the crop trees. We report costs and methodology and discuss factors to be considered in carrying out crop-tree release. In most stands, the release should be postponed until the stand is 9 to 12 years old. Carefully trained personnel should make the judgement calls for release. Release work should be done in the dormant season by mechanical means. Selection among intolerant species should be limited to dominant or codominant stems.

420.
Trimble, George R., Jr. 1971. **Some hardwood culls do not need treatment–and these can be identified.** Northern Logger. 20(1): 12, 32-33.

It is common to remove all cull trees from a stand. A study on the Fernow Experimental Forest has shown that many of the culls need not be treated as they will eventually fade from competition. Recommendations for stands managed under the selection system are given.

421.
Trimble, George R., Jr. 1975. **Summaries of some silvical characteristics of several Appalachian hardwood trees.** Gen. Tech. Rep. NE-16. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

A number of Appalachian hardwood trees are ranked according to the following silvical characteristics: shade tolerance, development of epicormic branching, susceptibility to frost damage, diameter growth rate, and seed dormancy.

422.
Trimble, George R., Jr. 1977. **A history of the Fernow Experimental Forest and the Parsons Timber and Watershed Laboratory.** Gen. Tech. Rep. NE-28. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 46 p.

This is a history of the people and the research they have carried out on the Fernow Experimental Forest during the past 43 years. The beginning of USDA Forest Service timber management research in West Virginia dates to May 28, 1934, when the Fernow Experimental Forest was established. In 1950, watershed-management research was begun, and now both are carried out--along with additional multiple-use projects--as responsibilities of the Timber and Watershed Laboratory at Parsons, West Virginia. Except for the war years in the 1940's, an intensifying program of research has been carried out at this location. In the initial years, the old Appalachian Forest Experiment Station directed the program of research; since 1948, the Northeastern Forest Experiment Station has been responsible for this work.

423.
Trimble, George R., Jr.; Barr, Carl R. 1960. **Cost of skid roads for arch logging in West Virginia.** Stn. Note 97. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Some doubt has existed about the profitability of tree-length skidding in the central Appalachians. Detailed cost descriptions for skid roads for arch logging in West Virginia are presented. Costs are considered modest, particularly if one considers that most of it is capital investment that need not be repeated.

424.
Trimble, George R., Jr.; Manthy, Robert S. 1966. **Implications of even-aged management on timber.** In: Trends for selection cutting to even-aged management: proceedings of the annual winter meeting of the Allegheny Section of the Society of American Foresters; 1966 February 10-11; Philadelphia, PA. Washington, DC: Society of American Foresters: 62-75.

In this discussion of the implications of even-aged hardwood management, a good case is made for even-age management as a profitable system; but there are also times when uneven-age management might be better. Land-ownership objectives frequently require uneven-age management regardless of its relative profitability. On a strictly economic basis, the study indicates that even-age management usually would be the most profitable system when the area managed is large enough to provide an annual harvest. If annual harvests were not practical, even-age management still would be more profitable if periodic yields occur at nearly the same interval as would be obtained from uneven-age cutting cycles.

425.
Trimble, George R., Jr.; Mendel, Joseph J. 1969. **The rate of value increase for northern red oak, white oak, and chestnut oak.** Res. Pap. NE-129. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 29 p.

Financial maturity information for northern red oak, white oak, and chestnut oak is based on rate of value increase, which combines economic factors with growth, vigor, and sawlog quality. Species-specific tables summarizing diameters for financial maturity based on value increase by growth alone are presented. Guidelines can be applied to both even-age and uneven-age management practices.

426.
Trimble, George R.; Mendel, Joseph J.; Kennell, Richard A. 1974. **A procedure for selection marking in hardwoods combining silvicultural considerations with economic guidelines.** Res. Pap. NE-292. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 13 p.

This method of applying individual-tree selection silviculture to hardwood stands combines silvicultural considerations with financial-maturity guidelines into a tree-marking system. To develop this system it was necessary to determine rates of return based on 4/4 lumber for many of the important Appalachian species. Trees were viewed as capital investments that should be liquidated when they fail to yield an acceptable rate of return. Present values of sawlog-size trees were determined by species, size, and log grades. Future values in 10 years were based on growth rates and projected changes in log grade. Actual stumpage values were determined, working back from standard lumber prices by deducting conversion costs. The first consideration in appraising a stand for marking is to mark for removal the poor-quality, poor-risk, and short-lived trees, then mark the good trees according to their rate of return. Tree sizes to mark were established for 2-, 4-, and 6-percent return rates. Different rates were determined by site-quality classes. Guidelines were established for satisfactory residual basal areas, and examples are given of adjustments that sometimes are necessary in unmanaged stands where it may not be possible with the rate of return chosen to make a profitable cut and leave a satisfactorily stocked stand.

427.
Trimble, George R., Jr.; McClung, Lester. 1966. **Even-aged forest management comes to the mountain hardwood country. I.** West Virginia Conservation. 30(7): 16-18.

Uneven-age management, achieved through the selective cutting or harvesting of scattered mature trees and some of the younger trees of low potential, has long been recommended for mountain hardwoods. However, even-age management, which includes clearcutting methods of harvesting is being recommended more as desirable forestry. Even-age management means raising a crop of trees that are all one age. To do this, the trees must be harvested when mature, all at one time--like most field crops. Even-age management includes both the harvesting of the mature trees and the planned tending of the new even-aged forest that results. Even-age management encompasses much more than the cutting method. It provides for a new stand and future harvest and it facilitates the production of high volumes of top-quality timber in a relatively short time.

428.
Trimble, George R., Jr.; McClung, Lester. 1966. **Even-aged vs uneven-aged forest management. II.** West Virginia Conservation. 30(9): 2-4.

Even-age forest management has many advantages for the central Appalachians. It favors high-value species such as the oaks, black cherry, and yellow-poplar, larger, more efficient equipment can be used in clearcutting, there are improved opportunities for introducing genetically improved trees; logging injury to residual trees may be reduced; and browse and shelter for some wildlife may increase.

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428.

Trimble, George R., Jr.; McClung, Lester. 1966. **Even-aged vs uneven-aged forest management. II.** West Virginia Conservation. 30(9): 2-4.

Even-age forest management has many advantages for the central Appalachians. It favors high-value species such as the oaks, black cherry, and yellow-poplar, larger, more efficient equipment can be used in clearcutting, there are improved opportunities for introducing genetically improved trees; logging injury to residual trees may be reduced; and browse and shelter for some wildlife may increase.

The F and H layer appeared to diminish but the net weight of organic matter remained uniform throughout the period (12,700 kg/ha). The oven-dry weight of roots (roots < 1.27 cm) in the upper 15 cm of soil decreased linearly with time (4,800 to 2,600 kg/ha). Average soil density, excluding rock, for the 1,770-cm^3 sample increased linearly (0.36 to 0.57), though the stone content remained constant. Loss on ignition decreased in the A_1 horizon (12.8 to 10.7 percent) and in the A_3 horizon (7.7 to 6.8 percent); however, the combined net weight of organic matter in the upper 15 cm of soil rose (53,000 to 73,000 kg/ha) due to soil settling. The infiltration rate decreased (250 to 50 cm/hr). Turbidity and soil erosion were minimal. Nutrient export from the basin rose during the study period but has declined rapidly during the past 4 years. Above-ground biomass has risen from 225 kg/ha in the last year of herbicide treatment, to 54,000 kg/ha during the fourth growing season.

438.

Troendle, C. A.; Homeyer, J. W. 1971. **Stormflow related to measured physical parameters on small forested watersheds in West Virginia.** Transactions of the American Geophysical Union. 52(4): 204. Abstract.

This investigation is an outgrowth of subsurface stormflow studies at the Fernow Experimental Forest near Parsons, West Virginia. A 12-acre headwater area within a 90-acre watershed was segmented into six nested sub-watersheds, each gaged by a 90° V-notch weir. Sub-watersheds ranged in size from 1.5 to 12 acres. Streamflow measurement identified the relative importance of sub-watersheds as contributors to the storm hydrograph. Storm response varied with antecedent soil-moisture content. Soils were relatively dry in the growing season and stormflow was derived mostly from interception in and along perennial channels. The transition from growing to dormant season was accompanied by progressive soil wetting. Although channel interception continued to cause the initial response, most dormant-season stormflow drained from a much larger portion of the watersheds. Precipitation in the form of subsurface stormflow drained into main channels from saturated soils via temporary headward and lateral channel extensions. These seasonal responses are being modeled using measured physical parameters including soil physical properties, soil moisture, slope conditions, channel characteristics, and precipitation.

439.

Troendle, Charles A. 1970. **A comparison of soil-moisture loss from forested and clearcut areas in West Virginia.** Res. Note NE-120. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Soil-moisture losses from forested and clearcut areas were compared on the Fernow Experimental Forest. As expected, hardwood forest soils lost moisture while revegetated clearcuttings, clearcuttings, and barren areas lost less, in that order. Soil-moisture losses from forested soil also correlated with evapotranspiration and streamflow.

440.

Troendle, Charles A. 1970. **The flow interval method for analyzing timber harvesting effects on streamflow regimen.** Water Resources Research. 6(1): 328-332.

A flow interval method of determining the timing of significant portions of annual streamflow was applied to the discharge data from five small mountain watersheds (four treatment watersheds and one control watershed) in West Virginia. Different degrees of timber harvesting had varying effects on the interval lengths and occurrence. The heavier cutting caused an apparent lengthening in the shortest 25- and 50- percent intervals. In nearly every instance, harvesting resulted in a decrease in the length of the longest 1- and 5- percent intervals.

433.
Trimble, George R., Jr.; Tryon, E. H. 1969. **Survival and growth of yellow-poplar seedlings depend on date of germination.** Res. Note NE-101. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

A study of yellow-poplar seedlings showed that early survival and growth were best among stems that originated in May and early June. Few, if any, seedlings that emerged after July 1 were in favorable competitive condition 3 years later. This indicates that the clearcutting made for maximum natural regeneration of yellow-poplar should be carried out in fall and winter to allow early germination in the spring.

434.
Trimble, George R., Jr.; Tryon, Earl H. 1976. **Grapevine control in even-aged hardwood stands.** West Virginia Forestry Notes. 6: 12-14.

The objective of this study was to determine how stand age and tree height affect the regrowth of severed grapevines into the crowns of thinned and unthinned stands of young even-aged hardwoods on good sites. Results show that grapevines can be eliminated by cutting them in stands as young as 12 years old and out of crop trees 25 feet tall (or perhaps even shorter) under both thinned and unthinned conditions.

435.
Trimble, George R., Jr.; Weitzman, Sidney. 1953. **Soil erosion on logging roads.** Soil Science Society of America Proceedings. 17(a): 152-154.

In rugged mountainous country, skid roads used in logging operations can cause serious erosion. To determine the important factors in skid-road erosion and to find ways to reduce this erosion, sample skid roads were studied before, during, and after experimental logging operations on the Fernow Experimental Forest in West Virginia. Erosion was related to grade, length of slope, intensity of use, soil vegetation, and climatic factors. Degree of erosion was determined for different skid-road conditions. Measures for reducing erosion are recommended for use in locating, constructing, using, and maintaining skid roads. Drainage measures such as diversion ditches and water bars are essential. Spacings for water bars are recommended for different grades.

436.
Trimble, George R., Jr.; Wendel, George. 1966. **A cost figure for a chemical release in Appalachian hardwoods.** Northern Logger. 14(7): 24,42.

Cost information is provided for applying an early basal spray treatment following a seed-tree removal cut. Hardwoods 1.0 to 3.0 inches d.b.h. were treated on a 13.2-acre area. About 265 trees were treated per acre with 2,4,5-T. Twenty-three man hours were needed and the crew used 3.7 gallons of herbicide and 50 gallons of fuel oil. No results were available on the effectiveness of the treatment or the long-term treatment benefits for the stand.

437.
Troendle, C. A.; Aubertin, G. M.; Kochenderfer, J. N. 1974. **Decomposition of the forest floor following deforestation and annual herbiciding.** Agronomy Abstracts: 179.

In 1967, the remaining half of a 55-acre forested watershed in West Virginia was deforested and treated annually with herbicides to prevent regrowth. Two hundred to 400 samples were collected from the L, F+H, A_1 (0 to 7.5 cm), and A_3 (7.5 to 15cm) horizons annually for 4 years to monitor changes in root, stone, soil, and combustible organic matter content. The litter layer (2,300 kg/ha) was depleted after the first year.

441.

Troendle, Charles A. 1970. **Water storage, movement, and outflow from a forested slope under natural rainfall in West Virginia.** Transactions of the American Geophysical Union. 51(4): 279. Abstract.

A 50-foot trench across the base of a 175-foot slope on a gaged watershed intercepted water moving downslope above the bedrock and directed it into a small HS flume. Neutron-probe access tubes, tensiometers, and recording piezometers were used to continuously monitor the amount and energy status of moisture in the five-foot-deep soil. Parallel off-plot instrumentation aided in the interpretation of plot and parent watershed responses. Precipitation on the plot percolated to the lower soil horizons, creating a temporary saturated zone above bedrock, causing lateral flow to move downslope. The responsiveness of this zone of saturation depended on antecedent moisture conditions, position on slope, and size of storm. On only one occasion had precipitation been intense enough to cause saturated lateral flow at the interface between the A and B horizons. Comparisons were made between plot and watershed response for a continuum of antecedent conditions from wet to dry. Fluctuations in plot outflow also compared well with watershed hydrographs. Plot and off-plot data support current source-area concepts on the origin of watershed streamflow.

442.

Troendle, Charles A. 1976. **Comments for summary report for West Virginia.** In: Proceedings, Region III workshop on forest practices and water quality. Washington, DC: American Forestry Association: 4-5.

443.

Troendle, Charles A. 1979. **Hydrologic impacts of silvicultural activities.** Journal of the Irrigation and Drainage Division, Proceeding of the American Society of Civil Engineers. 105(IR1): 57-70. March 1979.

Procedures and methodology were developed to predict selected hydrologic impacts of silvicultural activities on the hydrologic cycle. Regional coefficients and modifiers were developed from simulations using available hydrologic process models. Observed data from representative and experimental watersheds from each region were used to calibrate the models. There was no true statistical evaluation of the simulation; 'goodness of fit' was subjectively interpreted by how well the simulations matched either the observed hydrograph, soil-moisture distributions as they were understood, or local ET estimates. The methology developed is a means by which the user can extrapolate the results of research and long-term observations on specific sites to other offsite locations.

444.

Troendle, Charles A.; Leaf, Charles A. 1979. **Hydrology.** In: Water resources evaluation-impacts of silvicultural activities on non-point pollution. EPA Rep. EPA-1-AG-D6-0060. Washington, DC: U.S. Environmental Protection Agency.

445.

Troendle, Charles A.; Phillips, James D. 1970. **Evaporation–rain falling up.** West Virginia Agriculture and Forestry. 3(2): 5, 11.

The relationship of daily evaporative losses from a standard Weather Bureau evaporation pan to solar radiation, air temperature, windspeed, and water temperature was investigated using regression analysis. The best estimators of daily pan evaporation were solar radiation, windspeed, and maximum daily air temperature. An evapotranspiration coefficient for local climate conditions was developed.

446.
Tryon, E. H.; Trimble, G. R., Jr. 1970. **Effect of distance from stand border on height of hardwood reproduction in openings.** West Virginia Academy of Science Proceedings. 41: 113-125.

The influence of size of reproduction opening cut in hardwood stands on height growth of established reproduction was studied. Results indicated that the surrounding had little or no effect on height growth of the reproduction until the plots were as small as one-quarter acre. This held true even for intolerant species.

447.
Weitzman, Sidney. 1949. **The Fernow Experimental Forest.** Misc. Publ. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 16 p.

Describes the Fernow Experimental Forest, which in 1949 was under the supervision of the Mountain State Research Center, a branch of the Northeastern Forest Experiment Station of the USDA Forest Service. Its history, physical and climatic conditions, cover vegetation, and general plans for the forest are described. Originally the Fernow had three objectives: to provide a field laboratory for forestry research, to provide large-scale pilot tests and demonstrations of the various kinds and intensities of timber and watershed management practices, and to develop a complete set of records of quantity and quality yields of timber and water under varying intensities of management.

448.
Weitzman, Sidney. 1950. **Forestry.** West Virginia Watershed Development Conference Proceedings: 31-37.

A conference was held in Charleston, West Virginia, on October 19-20, 1950, to discuss and guide watershed development in West Virginia. Sponsored by regional and statewide organizations concerned with the complete resource development of West Virginia's watersheds, the conference included workshop reports that provided early input into West Virginia's land management policies.

449.
Weitzman, Sidney. 1951. **Planting strip-mine spoil banks.** Forest Farmer. 11(2): 28.

450.
Weitzman, Sidney. 1952. **Mine timbers--growth and harvest.** West Virginia Conservation. 16(10): 4-5, 22-24.

Management of forests for mine timbers is discussed. Three treatments were evaluated: an 8-inch, 12-inch, and 16-inch diameter-limit cut. Results indicate that the best economic return would be realized with the 16-inch cutting. The stand retains vigorous growing stock and watershed values are protected.

451.
Weitzman, Sidney. 1952. **Mountain log roads--design and construction.** West Virginia Conservation. 16(3): 16-21.

The importance of planning skid roads is described. Advantages of planned roads are lower costs, decreased maintenance, and decreased erosion. Guidelines for planning and constructing skid roads are presented.

452.
Weitzman, Sidney. 1952. **Mountain logging.** Southern Lumberman. 185(2321): 199-202.

More effective logging of mountain hardwoods requires careful planning. Planning the skid-road system reduces cost. A planned system on the Fernow Experimental Forest required only one-fourth of the mileage of skid-road of an adjacent unplanned system. Rules for locating, constructing, and maintaining the skid-road system are described.

453.
Weitzman, Sidney. 1952. **Mountain logging–equipment and methods.** West Virginia Conservation. 16(5): 10-13.

Modern equipment has many advantages for loggers in West Virginia. Power saws can cut more logs for less money and are easier to operate than conventional saws. Use of a tractor and logging arch for skidding tree lengths protects the soil, allows skidding in any direction, and makes bucking trees at the landing easier. Logging crews must be properly trained, but newer methods are worth the effort.

454.
Weitzman, Sidney. 1953. **Five years of research on the Fernow Experimental Forest.** Stn. Pap. 61. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 44 p.

Describes results of the first 5 years of research on the Fernow Experimental Forest. A detailed history and description of the Fernow is included.

455.
Weitzman, Sidney. 1953. **Management for farm forests.** West Virginia Conservation. 16(11): 20-23.

On the Fernow Experimental Forest, two areas were chosen to be managed as farm forests in order to learn what a farmer could do with them. The two areas were selected because they represent conditions common in the state. An effort was made to simplify the farmer's marketing problem by cutting only one major product each year. Results to date indicate that growing timber as a crop is good business, especially if the farmer has the time, equipment, and knowledge to do the job. The average annual net income from farm forests was more than $150 or more than $5 per acre per year.

456.
Weitzman, Sidney. 1954. **Why we need watershed research in West Virginia.** West Virginia Conservation. 17(12): 4-7.

West Virginia is called the "Mother of Rivers." Because of the importance of the state's water and the increasing demand for water, it is important to understand stream fluctuation, pollution, sediment problems, and flooding. Watershed research such as that conducted on the Fernow Experimental Forest near Parsons can help find solutions.

457.

Weitzman, Sidney. 1956. **Research on the Fernow Experimental Forest.** Northern Logger. 4(7): 14-15, 31.

The general objective of research on the Fernow Experimental Forest is to develop improved timber and watershed practices appropriate for use in forested watersheds and mountainous areas. Specific research studies are described.

458.

Weitzman, Sidney; Holcomb, Carl J. 1952. **How many trees are destroyed in logging?** Stn. Note 17. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

A preliminary study was made on three experimental logging jobs to determine the amount and distribution of logging damage. Three intensities of cutting were evaluated: 16-, 14-, and 8-inch diameter-limit cuts. Damage considered in this study was complete destruction of the tree. Only 3 to 5 percent of the trees to be left were lost to logging damage, with an estimated volume loss of 0.5 to 1.6 percent of the original stand volume. These losses were small enough to be considered of no consequence.

459.

Weitzman, Sidney; Lindahl, Robert R. 1956. **Eliminate worthless trees.** Virginia Forests. 11: 4-7.

Eliminating defective trees from the stand is one of the first steps in converting unmanaged stands into a healthy productive forest. One problem is how to eliminate these trees economically. Methods of cull removal tested included girdling and chemical removal. Only one chemical method was used--an application of ammonium sulfate salt. Results show that the latter is better than girdling for killing trees. On a per-acre basis, the cost of chemical treatment was about $1.60 per acre; double-hack girdle $1.10 per acre; and power-saw girdle $1 per acre. These figures include treatment and travel costs and lost time. Indications are that cull removal will pay off. Where culls were removed, growth was greater and the total amount was put on sound, healthy, merchantable trees. The method used to remove cull trees will depend on many factors: the time of year, the equipment available to the landowner, and whether he or she wants to eliminate sprouting.

460.

Weitzman, Sidney; Reinhart, Kenneth G. 1957. **Water yields from small forested watersheds.** Journal of Soil and Water Conservation. 12(2): 56-59.

A knowledge of the relationship between rainfall and runoff for each season of the year is one of the key factors in planning for an adequate water supply. Rainfall and runoff data from small forested watersheds in West Virginia are presented, and a method for using such data in planning for water supplies is outlined. There is a great difference in the proportion of rainfall that finds its way into the stream with the season and month of the year. Between 16 and 30 percent of the precipitation reached the stream during the growing season. The dormant season generally is a time of plenty: from 48 to 72 percent of the rainfall became streamflow. This information can be applied by users of streamflow from areas similar to the Fernow Forest who do not have records that provide estimates of potential streamflow based on rainfall data.

461.
Weitzman, Sidney; Trimble, G. R., Jr. 1952. **Skid-road erosion can be reduced.** Journal of Soil and Water Conservation. 7(3): 122-124.

A study of skid-road erosion on an experimental logging job evaluated four intensities of forest cutting. Results indicate that erosion on skid roads can be controlled by limiting the gradient of the road and by installing water bars. In addition, careful planning to reduce mileage of skid roads can result in significant decreases in erosion.

462.
Weitzman, Sidney; Trimble, G. R., Jr. 1955. **A capability classification for forest land.** Journal of Soil and Water Conservation. 10(5): 228-232.

Land classification for agricultural land management is an accepted practice. A system for classifying hardwood forest lands according to productivity is proposed. Four factors are related to site index of oak in the northern Appalachians: aspect, topographic position, steepness of slope, and soil depth to bedrock. These variables were used to develop land capability classes. Guidelines for use of these classes are presented.

463.
Weitzman, Sidney; Trimble, G. R., Jr. 1955. **Integrating timber and watershed management in mountain areas.** Journal of Soil and Water Conservation. 10: 70-75.

For logging forest areas, measures such as planned road systems, low grades, location of roads on side slopes, minimal stream crossing, and proper maintenance are recommended to greatly reduce negative impacts on water quality. These recommendations have proved financially sound in actual practice. On critical watershed areas, even greater care is required, so the advice of a watershed management expert should be sought.

464.
Weitzman, Sidney; Trimble, G. R., Jr. 1957. **Some natural factors that govern the management of oak.** Stn. Pap. 88. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 40 p.

Natural factors that affect the management of mixed oak stands in the northern Appalachian area were studied. Data were collected on 71 oak plots covering a wide range of forested conditions within the study area. Results indicate that management systems, growing-stock levels, and cutting cycles should be tailored to the site for best results. To help identify site quality in the field, the four major factors that affect it were identified, evaluated, and presented in tabular form for easy field use. The proportion of oaks in the stand decreases with improved site; the variety of other forest-tree species increases. There are more total stems per acre on poorer sites; there are more of the larger trees per acre (more than 5.0 inches d.b.h.) on the better sites. Established oak reproduction is most abundant on medium to poor sites. On the best sites, oak reproduction is in severe competition with faster growing species. The relative growth rates by vigor class indicate that for maximum productivity, stands should be thinned so that Vigor III and IV trees are eliminated or converted to higher vigor. Average growth rates indicate that on good sites, frequent thinning is acceptable because even low-vigor trees can reach merchantable size. On poorer sites, low-vigor trees may never reach merchantable size before they die out. Data on site, stand structure and composition, growth by vigor and site classes, and tree grades can be applied in practical stand management.

465.
Wendel, G. W. 1971. **Converting hardwoods on poor sites to white pine by planting and direct seeding.** Res. Pap. NE-188. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 19 p.

On the basis of recent research results and published data, recommendations are made for converting hardwoods growing on poor sites to white pine. Underplanting of poor site hardwood stands, with subsequent harvesting of the overstory in 5 to 10 years, may be the most efficient method of artificial regeneration.

466.
Wendel, G. W. 1972. **Longevity of black cherry seed in the forest floor.** Res. Note NE-149. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Observations on the Fernow Experimental Forest in West Virginia indicate that some black cherry seeds remain viable in the forest floor for more than three winters. On average, less than 10 percent of the seeds stored in the forest floor germinated the first spring, about 50 percent germinated the second spring, and 25 percent germinated the third spring.

467.
Wendel, G. W. 1974. **Celastrus scandens L. American bittersweet.** In: Seeds of woody plants in the United States. Agric. Handb. 450. Washington, DC: U.S. Department of Agriculture: 295-297.

American bittersweet is a deciduous climbing shrub of eastern North America. Its flowering and fruiting, growth habit, occurrence, and use are described.

468.
Wendel, G. W. 1975. **Stump sprout growth and quality of several Appalachian hardwood species after clearcutting.** Res. Pap. NE-329. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9 p.

Results of a 10-year study showed that stumps from 50- to 60-year-old red oak, black cherry, yellow-poplar, white oak, and chestnut oak trees sprouted vigorously. A high percentage of the dominant sprouts had good stem form, and many had excellent height and diameter growth. For all species, the proportion of stumps sprouting, number of sprouts per stump, and dominant-sprout height were not correlated with parent-tree vigor or parent-tree d.b.h. In red oak, sprouting was not related to season of cutting or site quality.

469.
Wendel, G. W. 1977. **Longevity of black cherry, wild grape, and sassafras seed in the forest floor.** Res. Pap. NE-375. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

The results of this study show that: (1) black cherry seed remains viable in the forest floor for 3 years, with a small amount of seed germinating after 4 or 5 years; (2) sassafras seed remains viable for 5 years in the forest floor: and (3) some wild grape seed retains its viability for at least 8 years. These results are important to the forest manager in setting up harvest schedules and controlling unwanted species in the new stand.

470.

Wendel, G. W. 1979. **Growth and survival of three hardwood species as affected by artificial regeneration method.** Tree Planters' Notes. 30(1): 16-19.

The survival and growth of 1-0 bare-rooted, container-grown, and direct-seeded seedlings were compared on two harvested areas of the Fernow Experimental Forest. Northern red oak, black cherry, and yellow-poplar were compared at the end of 7 years. A majority of the surviving 1-0 yellow-poplar seedlings were in the dominant/codominant crown position after 7 years, and about one-third of the black cherry and only one-fourth of the red oak bare-rooted seedlings were classified as dominant or codominant. Survival of the seedspot and containerized seedlings was poor due to the grazing of rodents and shading by grasses and herbaceous materials. Bare-rooted stock is the best way to artificially regenerate black cherry, red oak, and yellow-poplar on these cutover sites.

471.

Wendel, G. W. 1980. **Growth and survival of planted northern red oak seedlings in West Virginia.** Southern Journal of Applied Forestry. 4(1): 49-54.

The survival and growth of planted northern red oak seedlings were studied in relation to top pruning, fertilizing, mulching, and age and size of seedlings at planting time. Top pruning at 1 and 2 years after planting suppressed growth. Fertilizer--N, P, and combinations--and mulches did not produce a significant growth response. Seedlings of above average height at planting time retained their height during the study. Survival of all ages of stock was high. Many seedlings attained a height of more than 6 feet at 7 years from seed, regardless of treatment, and it is expected that 30 to 50 percent of these will reach maturity.

472.

Wendel, G. W. 1980. **Sugar maple provenance study: West Virginia outplanting--10-year results.** Res. Pap. NE-460. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

After 10 years, survival of sugar maple provenances outplanted in West Virginia did not differ significantly. Total height, height growth, and d.b.h. were significantly different among provenances. Fifty percent of the trees had major forks below 9 feet. Thirty-eight percent of the trees had no forks but 71 percent of these were in the intermediate or overtopped crown class. Forking was not related to provenance. Latitude, longitude, and elevation of provenances were not strongly correlated with provenance performance.

473.

Wendel, G. W. 1981. **Longevity of summer grape stored in the forest floor.** Wildlife Society Bulletin. 9(2): 157-159.

Mature summer grape fruits were collected from vines near Parsons, West Virginia, in the fall of 1968. Seed samples were broadcast onto 21 x 41-cm plots under a fully stocked mature hardwood stand. Samples also were placed in 15 x 30-cm fiberglass screen envelopes and stored on the forest floor next to the broadcast samples. Each spring during the next 11 years, samples were retrieved and germination evaluated. Germination of the 11-year-old envelope-stored seed ranged from 5 to 39 percent and averaged 19 percent for all samples. Germination of broadcast seed ranged from 1 to 3 percent and averaged 1.3 percent. Implications for management of timber and wildlife are discussed.

474.

Wendel, G. W. 1981. **Red oak growth affected by age of planting stock, mulching, top pruning, and fertilization.** In: Workshop on seedling physiology and growth problems in oak planting; 1979 November 6-7; Columbia, MO. Gen. Tech. Pap. NE-62. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 17. Abstract.

Survival and growth of planted northern red oak seedlings on cutover forested sites were studied in relation to top pruning, fertilizing, age, and size of seedlings at planting time, and method of artificial regeneration. Top pruning at planting time and at 1 and 2 years suppressed annual height growth, produced smaller diameter seedlings, and significantly reduced survival of 1-0 seedlings. Mulching in combination with top pruning did not significantly affect height growth or survival. Fertilizing with combinations of N and P, with and without plastic mulching, did not significantly affect growth of 2-0 seedlings 5 years after treatment. The use of calcium cyanamide as a fertilizer herbicide did not significantly affect red oak seedlings. Nearly all of the direct-seeded acorns and 5- to 6-week-old tubelings were destroyed by rodents. If oaks are to be artificially regenerated, planting bare-rooted seedlings offers the best hope of success. Overall, 30 to 50 percent of the planted seedlings averaged more than 6 feet in height at 7 years from seed, regardless of treatment. It is expected that many of those that are now dominant or codominant will reach maturity in the new stand.

475.

Wendel, G. W. 1985. **Performance of white ash progenies after 7 years in a West Virginia planting.** In: Proceedings, 29th northeastern forestry tree improvement conference; 1984 July 18-20; Morgantown, WV. Morgantown, WV: West Virginia Division of Forestry: 90-97.

White ash seedlings from 45 sources representing 29 counties in 15 states were outplanted in West Virginia in April 1976. At the end of 7 years, overall survival was 61 percent. Average survival of the Arkansas, Louisiana, Mississippi, and Alabama families was 27 percent compared to 75 percent for the families north of southern Tennessee. Average total height was 4.7 feet for the 33 families used in the analysis; average 7-year height growth was 3.8 feet. Average stem diameter was 0.7 inch and 7-year average stem-diameter growth was 0.5 inch. The best performance was recorded for Barbour County families. All of the best performers, however, were from latitudes between 38° and 40° N. Families from latitudes south of Tennessee are not recommended for planting in West Virginia.

476.

Wendel, G. W. 1987. **Abundance and distribution of vegetation under four hardwood stands in north-central West Virginia.** Res. Pap. NE-607. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Forest-floor samples were collected from four hardwood forest stands in West Virginia to study species composition, abundance, and distribution of vegetation that originated from seeds, rootstocks, rhizomes, and so on. The abundance and distribution of plants on square-foot sections of forest floor that were lifted and moved to the greenhouse indicate that under the most ideal conditions, upwards of 800,000 stems per acre may develop during the first year. Sweet birch was the most abundant tree species, blackberry the most abundant shrub, and species of violets the most abundant herbaceous plants. Implications of this vegetation on the regeneration of the forest are discussed.

477.
Wendel, G. W. 1991. **Prunus pensylvanica L. F. Pin cherry.** In: Burns, Russell M.; Honkala, Barbara H., tech. coords. Silvics of North America. Volume 2. Hardwoods. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture: 587-592.

Pin cherry (Prunus pensylvanica) is a small common tree inhabiting a great variety of lands in the northern part of the United States and Canada. It is sometimes called fire cherry for its value as a reforesting agent after forest fires. It forms pure stands that provide shade for seedlings of slower growing species, then dies off, making way for the new trees. Another common name, bird cherry, reflects the prevalent use of the fruit by birds as food. It also is called northern pin cherry, wild red cherry, and pigeon cherry. The soft porous wood is of little commercial value.

478.
Wendel, G. W.; Cech, F. C. 1975 **Recovery of herbicide-damaged eastern white pine.** Tree Planters' Notes. 26(4): 18-21.

In mid-August 1969 and 1970, a white pine plantation was treated with 2.4 pounds of 2,4,5-T acid in 6 gallons of fuel oil/water per acre to reduce a dense stand of blackberries, greenbrier, and hardwood sprouts. The herbicide was effective in killing much of the competing vegetation, but it also killed about 3 percent of the white pine seedlings and damaged terminal leaders and needles on several hundred seedlings. Three years after treatment, however, mortality of damaged seedlings was negligible, and most of the seedlings had recovered and were making good growth.

479.
Wendel, G. W.; Cech, Franklin. 1976. **Six-year results of a white pine seed source test in West Virginia.** Res. Note NE-244. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

The best white pine growth during a 6-year period in a West Virginia outplanting was obtained with seedlings grown from seed collected in Tennessee, Georgia, and North Carolina. These seed sources are recommended for planting in West Virginia.

480.
Wendel, G. W.; Della-Bianca, Lino; Russell, James; Lancaster, Kenneth F. 1983. **Eastern white pine including eastern hemlock.** In: Silvicultural systems for major forest types of the United States. Agric. Handb. 445. Washington, DC: U.S. Department of Agriculture: 131-134.

Describes the growth habit, distribution, regeneration, germination requirements, and silviculture of eastern white pine and eastern hemlock.

481.
Wendel, G. W.; Della-Bianca, Lino; Russell, James; Lancaster, Kenneth F. 1984. **Eastern white pine, including eastern hemlock.** In: Final environmental impact statement for regional guide-eastern region. Milwaukee, WI: U.S. Department of Agriculture, Forest Service, Eastern Region: D-74-84.

Describes the growth habit, distribution, regeneration, germination requirements, and silviculture of eastern white pine and eastern hemlock.

482.

Wendel, G. W.; Dorn, Donald E. 1985. **Survival and growth of black walnut families after 7 years in West Virginia.** Res. Pap. NE-569. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Average survival, 7-year stem diameter, and stem-diameter growth differed significantly among 34 black walnut families planted in West Virginia. Average total height, height growth, and diameter at breast height were not significantly different among families. Families were from seed collected in West Virginia, Pennsylvania, North Carolina, and Tennessee. The 7-year results indicated that although survival was significantly different among families, differences in height growth were not well enough defined to recommend sources for planting.

483.

Wendel, G. W.; Gabriel, W. J. 1975. **Sugar maple provenance study: West Virginia outplanting, 6-year results.** Northeastern Forest Tree Improvement Conference Proceedings. 22: 163-171.

As part of a range wide sugar maple provenance study, seedlings from 15 provenances each represented by seven or eight parent trees were outplanted on a previously forested site on the Fernow Experimental Forest near Parsons, West Virginia. Survival was 97 percent after 6 years. Tree heights range from 3.5 m for the Lewis County, New York, provenance to 2.5 m for the Cass County, Minnesota, provenance. Height growth for 1973 ranged from 86.2 cm for the Franklin County, Vermont, provenance to 60.1 cm for the Cass County, Minnesota, provenance. Incidence of cold injury was slight, as was damage from insects or diseases. Deer browsing, which can be a problem in some parts of the species' range, was light during the first few years but most trees are now out of the reach of deer.

484.

Wendel, G. W.; Kochenderfer, J. N. 1978. **Damage to residual hardwood stands caused by cable yarding with a standing skyline.** Southern Journal of Applied Forestry. 2(4): 121-125.

Yarding logs with a standing skyline cable system in a partially cut hardwood stand injured or destroyed about 7 percent of the residual stand stems larger than 1 inch d.b.h. One tree per acre was abraded, 16 per acre were skinned (sapwood exposed), 2 per acre suffered root damage, and 15 per acre were destroyed. Results of this study are compared with published reports on tree injuries caused by cable yarding and skidding with crawler tractors and rubber-tired skidders in the Eastern and Western United States.

485.

Wendel, G. W.; Kochenderfer, J. N. 1982. **Glyphosate controls hardwoods in West Virginia.** Res. Pap. NE-497. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Applications of Roundup, a glyphosate, by mistblower were effective in controlling hay-scented fern, blackberries, and some tree, shrub, and herbaceous species on an experimental watershed in West Virginia. Damage to planted Norway spruce was slight at rates of 1, 2, and 3 qt/acre (0.75, 1.50, and 2.25 lb/acre of the acid glyphosate). A variety of hardwood species was killed following injections of 20 or 50 percent solution of Roundup at a rate of 1.5 ml per incision. The cuts were spaced at 1.5 inches, edge to edge, around the stem near groundline. Resprouting of the treated hardwood was minimal after 2 years.

among the more rapid growing northern forest conifers, eastern white pine is an excellent species for reforestation projects, landscaping, and Christmas trees, and has the distinction of being one of the more widely planted American trees.

490.

Wendel, George W. 1966. **Aerial spraying of low-grade hardwood stands with 2,4,5-T in West Virginia.** Res. Note NE-45. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Describes the results of an aerial application of herbicide by helicopter to hardwoods on a site where partial conversion to white pine by aerial seeding is planned. Results suggest that seeding should be done at once on cutover areas to take advantage of improved seed beds, but that spraying should be delayed for 4 or 5 years.

491.

Wendel, George W. 1967. **Seedbed scarification from horse skidding during clearcutting.** Northern Logger. 15(8): 12, 27.

Reports the amount and distribution of soil disturbance that resulted from clearcutting on a fairly steep slope (average: 50 percent) where skidding was done with horses. After cutting, an average of 25 percent of the surface area was in mineral soil, 19 percent a mixture of soil and humus, 44 percent in undisturbed litter, and 12 percent in other types of surface material. Favorable seedbed conditions were distributed evenly over the area.

492.

Wendel, George W. 1972. **Results of a 20-year test of hybrid poplars in West Virginia.** Res. Pap. NE-237. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

Fifty hybrid poplar clones of the genus Populus were outplanted on a bottomland site in West Virginia. After 20 years, seven clones have averaged 0.40 inch or more annual d.b.h. growth, and five have averaged more than 3.5 feet height growth per year. The best overall clone was NE-50, which averaged 10.0 inches d.b.h. and 80.5 feet in height.

493.

Wendel, George W.; Smith, H. Clay. 1980. **Eastern white pine.** In: Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters: 25-26.

Describes the habitat, life history, special uses, and genetics of eastern white pine.

494.

Wendel, George W.; Kochenderfer, James N. 1984. **Aerial release of Norway spruce with Roundup in the central Appalachians.** Northern Journal of Applied Forestry. 1(2): 29-32.

Restrictions on use of 2,4,5-T have created a need for herbicides that can be used for conifer release. Seven-year-old Norway spruce was released from competing vegetation with aerially applied Roundup, a glyphosate. A wide spectrum of competing species was controlled and most hardwoods did not resprout during the 2-year evaluation period following treatment. Norway spruce appeared to respond to treatment and suffered negligible damage. Roundup appears to be a safe, effective herbicide that can be used to release Norway spruce.

486.
Wendel, G. W.; Kochenderfer, J. N. 1988. **Release of 7-year-old underplanted white pine using hexazinone applied with a spot gun.** Res. Pap. NE-614. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Hexazinone, Velpar-L, applied at rates of 1.0, 1.5, and 1.75 ml per spot, controlled competing hardwoods around 7-year-old underplanted white pine. Growth response was more pronounced when hexazinone was applied to release individual pines than when the entire area was treated on a 6- by 6-foot grid. In most cases, hexazinone killed white oak, chestnut oak, American beech, sourwood, red maple, and black gum. Yellow-poplar, red oak, cucumbertree, black cherry, sugar maple, sweet birch, and sassafras showed variable sensitivity to hexazinone. Three years after treatment, resprouting of killed stems and white pine mortality remain low.

487.
Wendel, G. W.; Lamson, Neil I. 1987. **Effects of herbicide release on the growth of 8- to 12-year-old hardwood crop trees.** Res. Pap. NE-598. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

In 8- to 12-year-old Appalachian hardwood stands, crop trees were released by stem injecting competing trees with a 20 percent aqueous solution of glyphosate. Species released were black cherry, red oak, and sugar maple. Release treatments were injection of all trees within a 5-foot radius of the crop-tree bole, and injection of all trees whose crown touched the crop tree. Five-year diameter growth of all species was significantly increased by both release treatments, but height growth was not affected by either treatment. Survival of released crop trees was higher and crown-class retrogression of released trees was less than that of unreleased trees. Glyphosate was effective in controlling most hardwood species during the 5 years of observation.

488.
Wendel, G. W.; Smith, H. Clay. 1986. **Effects of a prescribed fire in a central Appalachian oak-hickory stand.** Res. Pap. NE-594. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Five years after a single prescribed fire in a second-growth central Appalachian oak-hickory stand, many overstory trees died or declined in vigor. There was a major reduction in butt-log quality on the residual trees. Fire scars were prevalent on a large number of trees and scars showed various stages of decay. Advanced seedling and sprout reproduction increased for red maple, northern red oak, and hickory. Overall stocking of advance reproduction of red maple, black locust, and hickory increased during the 5 years; red and chestnut oak were poorly distributed and accounted for only 3 percent of the stocking. Striped maple was the most abundant and widespread noncommercial species before and after burning. The large amount of damage to the overstory stand and failure to control the large number of noncommercial understory stems with a single prescribed fire indicate that additional research is needed before fire can be recommended for use as a regeneration tool in central Appalachian hardwood stands.

489.
Wendel, G. W.; Smith, H. Clay. 1991. **Pinus Strobus L. Eastern white pine.** In: Burns, Russell M.; Honkala, Barbara H., tech. coords. Silvics of North America. Volume 1. Conifers. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture: 476-488.

Eastern white pine (Pinus strobus), also called northern white pine, is one of the most valuable trees in Eastern North America. Before the arrival of white men, virgin stands contained an estimated 3.4 billion cubic meters of lumber. By the late 1800's most of those vast stands had been logged. Because it is

495.
Wendel, George W.; Kochenderfer, James N.; Biller, Cleveland J. 1974. **Skyline cable logging in West Virginia.** Northern Logger. 22(12): 14-15.

In November 1973, a small mobile skyline yarding system was tested on the Fernow Experimental Forest near Parsons, West Virginia, in cooperation with the Monongahela National Forest. The purpose of the test was to demonstrate that a skyline system can be used to harvest selectively marked and clearcut hardwood timber in the steep mountainous terrain of West Virginia and at the same time reduce the amount of surface disturbance from road building and skidding. Results indicated that skyline cable logging has a tremendous potential for reducing the environmental impact of timber harvesting in the Appalachians. The URUS, one of several systems available, was set up quickly; it worked well in a partial cut as well as in a clearcut; it was highly mobile and it seemed to be sturdy enough for continuous operation. By using the skyline cable system, we can eliminate many poorly located, poorly drained skid roads that account for most of the muddy water coming from logged over areas.

496.
Wendel, George W.; Trimble, George R., Jr. 1968. **Early reproduction after seed-tree harvest cuttings in Appalachian hardwoods.** Res. Pap. NE-99. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 16 p.

Three years after seed-tree cutting in Appalachian hardwood stands, and immediately after the removal of the seed trees, small reproduction (stems 1 foot tall to 1 inch d.b.h.) of desirable species was abundant and well distributed, and was composed of a large proportion of seedling-origin stems. Both species composition of the reproduction and relative abundance of the different species varied greatly with site quality.

497.
Wiant, Harry V., Jr.; Lamson, Neil I. 1983. **Site index equations for even-aged oak stands in northwestern West Virginia.** West Virginia Forestry Notes. 10: 11-12.

Site index tables for northwestern West Virginia were derived from a set of linear regression equations for each 5-year interval from 20 to 70 years. The final equations are presented and discussed.

498.
Wildensee, F.; Strickland, T. C. 1990. **Nitrogen processing in soils of two watersheds in the Fernow Experimental Forest in the central Appalachian mountains.** Agronomy Abstracts: 341.

Nitrogen transformations in soils can play an important role in regulating the acidification of stream waters. Soil collected from A- and B-horizons of the Berks and Calvin soil series (Typic Dystrochrept) of two adjacent watersheds were placed in lysimeters and amended with ^{15}N-labelled ammonium chloride. Leachate water was collected regularly and analyzed for ^{15}N in the total organic nitrogen, ammonium, and nitrate pool. After an 18 month period the soil in the lysimeters was sacrificed and pool sizes of extractable nitrate, ammonium, and total Kjeldahl nitrogen as well as the atom-% of ^{15}N in each pool were determined. The in situ lysimeter technique is an effective means of measuring actual transformation rates in the field while minimizing disturbance It is not limited by leaching constraints. The ^{15}N data allow the quantification of nitrogen transformation processes in each soil horizon which, in turn, allow the estimation of in situ production of acidity.

499.
Williams, Roger N.; Galford, Jimmy R.; Purrington, Foster F. 1991. **Parasites of Stelidota (Coleoptera:Nitidulidae).** Entomological News. 102(2): 90-94.

The distribution of Microctonus nitidulidis (Hymenoptera: Braconidae) has been expanded to include two new locations in Ohio and Florida. The host range of M. nitidulidis has been expanded to include Stelidota octomaculata and Carpophilus hemipterus in the field. The geographical range of Brachyserphus abruptus can now be tied to nitidulid host (larvae of S. geminata and S. octomaculata) in Pennsylvania, Florida, and Ohio. Fruit hosts of these Stelidota are also listed.

500.
Williams, Roger N.; Peng, Chengwang; Galford, Jimmy R. 1990. **Male genitalia for Stelidota (Coleoptera:Nitidulidae) identification in America north of Mexico.** Florida Entomologist. 72(3): 537-540.

Male genitalia of the three species of the genus Stelidota in America north of Mexico are figured and described: Stelidota ferruginea Reitter; S. geminata (Say); and S. octomaculata (Say). The following male genitalic characters are constant and can be used for identification: relative size, shape, and the number, size, and location of setae.

501.
Worley, David P.; Patric, James H. 1970. **Economic evaluation of some watershed management alternatives on forest land in West Virginia.** Transactions of the American Geophysical Union. 51(4): 280. Abstract.

Timber and watershed research conducted at the Fernow Experimental Forest provides a 10-year record of timber growth and steamflow increases. An approach for evaluating streamflow increases in terms of timber growth forgone is modeled. Light cutting (up to one-fourth of the timber volume) slightly increased both timber growth and the amount of streamflow. Cutting one-third to one-half of the merchantable volume sacrificed timber regrowth for streamflow gain. Cutting one-half to three-fourths of the timber volume resulted in streamflow increases for large sacrifices of timber regrowth. Cutting three-fourths or more of the forest vegetation provided major increases in steamflow but no return from timber during the 10-year period of regrowth. Average annual water cost ranged from zero to $1.30 per thousand gallons. Although these water costs may be invalid outside the Fernow Experimental Forest, they nevertheless suggest a magnitude for water cost under similar forest conditions.

502.
Worley, David P.; Patric, James H. 1971. **Economic evaluation of some watershed management alternatives on forest land in West Virginia.** Water Resources Research. 7: 812-818.

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503.
Yandle, David O.; Myers, John R.; Mayo, Jefferson H.; Lamson, Neil I. 1988. **Development and application of a stand-based growth model for mixed hardwood stands.** In: Forest growth modelling and prediction, volume 1. Gen. Tech. Rep. NC-120. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 230-238.

A model for predicting growth in mixed hardwood stands is presented. Based on the assumption that future diameter growth is related to past diameter growth, the model is proposed for projecting the moments and functions of moments of tree-diameter frequency distributions over time. Projections are made for stand attributes including basal area, board-foot volume, and cubic-foot volume in tree distributions of even-aged, mixed-species hardwood stands. The model incorporates a measure of shade tolerance to partially account for differences in species growth. Further model enhancements are suggested.

504.
Yawney, Harry; Trimble, G. R., Jr. 1958. **West Virginia's unusual pine plantation.** Journal of Forestry. 56: 849-851.

White pine was planted on a 70-acre area (Clover Run, West Virginia) in 1933. In 1953, 6 cords per acre were removed in a thinning operation. Now 25 years old, many of the trees are 65 to 70 feet tall and are showing remarkable growth rates. Production averages 43 cords of pulpwood per acre. Sawtimber volume is 7,490 board feet per acre. This pine plantation is growing under near ideal conditions.

505.
Yawney, Harry W. 1959. **A soil-depth probe for shallow forest soils.** Journal of Forestry. 57: 435.

Depth is a important characteristic of forest soils. Although a number of tools have been devised to measure soil depth, they are not efficient for measuring the depth of stony forest soils such as those found in mountainous areas of West Virginia. A simpler soil probe has been developed by the Northeastern Forest Experiment Station's research center in Elkins, West Virginia. Designed to give depth measurements quickly and accurately in soils as deep as 3 1/2 feet, the probe consist of two parts: a solid steel shaft 3.8 feet long, 3/4-inch in diameter at the top, and tapered to a blunt point; and a extraction handle. The probe has been valuable in measuring soil depth to determine site index.

506.
Yawney, Harry W. 1961. **Introducing white pine into poor-site hardwood stands in West Virginia.** Stn. Pap. 154. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 10 p.

An exploratory study was begun in 1954 to determine sites where white pine could be interplanted or underplanted into hardwood stands with reasonable success and at minimum expense. Six-year results suggest that on sites of oak site index 40 to 50, white pine can be planted with reasonable success after a heavy cutting of all merchantable hardwoods. If there is little or no release, the upper marginal site for the introduction of white pine into hardwood stands appears to between SI 50 and 60.

507.
Yawney, Harry W. 1961. **Killing cull trees with ammate crystals–a case study.** Stn. Note 120. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Ammate (ammonium sulfamate) has been used for the past 10 years as a silvicide on the Fernow Experimental Forest. Data are presented on the cost of application and the percentages of kill with time.

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Yandle, David O.; Myers, John R.; Mayo, Jefferson H.; Lamson, Neil I. 1988. **Development and application of a stand-based growth model for mixed hardwood stands.** In: Forest growth modelling and prediction, volume 1. Gen. Tech. Rep. NC-120. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 230-238.

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Video Publications

1.
Kidd, William E., Jr.; Patric, James H.; Smith, H. Clay. 1889. **Woodlot Management: How it grows.** Video program. Morgantown, WV: West Virginia University Extension Service and U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 22 min.

2.
Kidd, William E., Jr.; Smith, H. Clay. 1990. **Woodlot Management: Helping it grow.** Video program. Morgantown, WV: West Virginia University Extension Service and U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 23 min.

3.
Kidd, William E., Jr.; Smith, H. Clay. 1991. **Woodlot Management: Managing your woodlot. Harvesting and renewing it.** Video supplement to: Woodlot management: Helping it grow. Morgantown, WV: West Virginia University Extension Service and U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 19 min.

4.
Kochenderfer, James N.; Kidd, William E., Jr. 1991. **Water in the forest.** Video program. Morgantown, WV: West Virginia University Extension Service and U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 20 min.

5.
Kochenderfer, James N.; Wendel, G. W.; Kidd, William E., Jr. 1988. **Woodlot management: Building roads.** Video program. Morgantown, WV: West Virginia University Extension Service and U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 18 min.

6.
Patric, J. H. 1978. **Woods and Water.** Slide tape program. [Place of publication unknown]: U.S. Department of Agriculture, Soil Conservation Service. 15 min.

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