Rept. used by Chief in meeting w/ Virginia Congressmen on Clearcutting Issues.

EFFECTS OF COMMERCIAL CLEARCUTTING ON NUTRIENT LOSSES IN APPALACHIAN FORESTS

M.L. - File

SUMMARY

WAYNE T. SWANK, PROJECT LEADER
COWEETA HYDROLOGIC LABORATORY
OTTO, NORTH CAROLINA

Much research has been conducted in the United States and other countries, i.e., Japan, Switzerland, Germany, New Zealand and Canada to determine the effects of forest management practices on soil nutrients. Long-term research on the effects of clearcutting on nutrient cycles has been conducted at three major forested sites within the Appalachian Highlands Physiographic Division. These sites are located in northern hardwoods in New Hampshire, central hardwoods in West Virginia, and southern Appalachian hardwoods in North Carolina. Some conclusions from these studies are:

1. Increases in dissolved nutrient (nitrogen, calcium, potassium, etc.) losses are negligible with respect to site nutrition following clearcutting and sawlog harvest on a variety of sites in central and southern Appalachian forests (Aubertin and Patric, 1974; Swank, 1985).

2. In contrast, significant leaching losses of nitrogen and calcium accompany commercial clearcutting in New Hampshire (Martin and Pierce, 1980). Practices such as buffer zones adjacent to streams and progressive strip cutting reduce the amount of nutrients that leach from the forest to streams.

3. Reasons for these different geographic responses are related to differences in biological and physical processes which control nutrient recycling (Swank, 1985).

4. Annual nutrient additions in precipitation can replenish nutrient removals associated with sawlog harvest over a normal rotation period (Swank, 1984).

5. Intensified forest management practices such as whole-tree utilization, short rotation forestry, mechanical site preparation, and broadcast burning have the potential to reduce soil fertility and hardwood productivity due to altered nutrient cycles (Waide and Swank, 1976; Swank and Waide, 1980; Rauscher et al., 1983; Swank, 1984; Swank et al., 1984). Scientists are continuing research to study the effects of more intensive forest management practices on soil fertility. However, the impacts are site specific and substantial research is needed to develop guidelines for alternative management strategies which minimize impairment of productivity.

6. Attached are:

    1. Literature cited in the above summary.

    2. Bibliography With Short Abstracts of Nutrient Cycling and Related Subjects in the Appalachians. Compiled by Soil, Water and Air, Atlanta, Georgia.

    3. Bibliography of Related Studies in Other Geographic Areas. Compiled by Soil, Water and Air, Atlanta, Georgia.

LITERATURE CITED IN SUMMARY

Aubertin, G. M. and J. H. Patric. 1974. Water quality after clearcutting a small watershed in West Virginia. In the J. of Environ. Qual., Vol. 3. pp. 243-249.

Martin, C. W. and R. S. Pierce. 1980. Clearcutting patterns affect nitrate and calcium in streams of New Hampshire. In Journal of Forestry. Vol. 78, No. 5, pp. 268-272.

Rauscher, H. M., D. W. Smith, and T. L. Sharik. 1983. A forest management gaming model of the nitrogen cycle in Appalachian upland oak forests. In Ecol. Modelling, Vol. 20. pp. 175-199.

Swank, W. T. and J. E. Douglass. 1977. A comparison of nutrient budgets for undisturbed and minipulated hardwood forest ecosystems in the mountains of North Carolina. In Watershed Research in Eastern North America. Smithsonian Institution, Washington, D.C. pp. 343-364.

Swank, W. T. and J. B. Waide. 1980. Interpretation of nutrient cycling research in a management context: Evaluating potential effects of alternative management strategies on site productivity. In Forests: Fresh Prespectives From Ecosystem Analysis, R. H. Waring, Editor. Proceedings of the 40th Annual Biology Colloquium, Oregon State University Pres, Corvallis, Oregon. pp. 137-157.

Swank, W. T. 1977. Nutrient cycling in hardwood Forest ecosystems. Prepared for Silviculture of Southern Appalachian Hardwoods Workshop. Forest Service, Cherokee National Forest. Cleveland, Tennessee.

Swank, W. T. 1984. Biological control of solute losses from forest ecosystems. To be published in Solute Processes, Wiley and Sons, 1985. pp. 1-90.

Swank, W. T. 1984. Atmospheric contributions to forest nutrient cycling. In Water Resources Bulletin, Amer. Water Res. Assoc., Vol. 20, No. 3, pp. 313-321.

Waide, J. B. and W. T. Swank. 1976. Nutrient recycling and the stability of ecosystems: Implications for forest management in the southeastern U. S. In the Soc. Amer. For. Prac. 1975. pp. 404-424.

Bibliography with Short Abstracts of
Nutrient Cycling and Related Subjects in the
Appalachians
Compiled by Southern Region Soil Scientists, Atlanta, Ga.

Boring, L.R., C.D. Monk, and W.T. Swank. 1979. The role of successional species in nutrient conservation on a clearcut appalachian watershed. Page 392 in Proceedings: Impact of Intensive Harvesting on Forest Nutrient Cycling. Syracuse, N.Y.

The components of revegetation were assessed during the first two years of recovery following disturbance by clearcut cable logging. Following disturbance, hardwood sprouts, herbs, vines, and seedlings play important roles in the initial colonization and nutrient accumulation of the site. This is a nutrient conserving process that minimizes hydrologic losses of elements and initiates a rapid recovery of nutrient cycling.

Johnson, D.W., D.C. West, D.E. Todd, and L.K. Mann. 1982. Effects of sawlog vs. whole-tree harvesting on the nitrogen, phosphorous, potassium, and calcium budgets of an upland mixed oak forest. Pages 1304-1309 in the Soil Sci. Soc. Am. J. Vol. 46. No. 6.

The above authors reported the results of the first phase of a two phase study on the effects of residue removal on the nutrient status of an upland mixed oak forest in eastern Tennessee. The removal of biomass, N,P, K, and Ca in the whole-tree harvesting was 2.6, 2.9, 3.1, 3.3 and 2.6 times that in sawlog harvesting. Due to low soil Ca content and high Ca content in woody tissues, whole-tree harvesting depleted total ecosystem Ca to a much greater extent than N,P, or K. With whole-tree harvesting soil amendments are necessary to sustain Ca supplies. Atmospheric inputs and soil reserves are adequate for sawlog harvest.

Johnson, J.E. 1983. Nutrient dynamics of the forest floor in an Appalachian oak forest stand following clearcutting and whole-tree removal. In Forestry Abstracts, Vol. 44, No. 10. VPI & SU, Blackburg, VA.

Small increases in nutrient leaching (particularly nitrogen) occured in the clearcut area when compared to an undisturbed site. However the increases were shortlived and leaching losses were the same as the undisturbed site in a few months.

McColl, J.G. and D.F. Grigal. 1979. Nutrient losses in leaching and erosion by intensive Forest harvesting. Pages 231-248 in Proceedings: Impact of Intensive Harvesting on Forest Nutrient Cycling. Syracuse, N.Y.

A study completed by G.E. Likens at Hubbard Brook Experimental Forest in New Hampshire found high losses of NO_3-N and associated cations, with streamflow nitrate concentrations as high as 82 mg/l, and 53 mg/l two years after cutting. In other forest ecosystem studies, cutting caused only modest increases in No_3-N in streams with values averaging 1mg/l or less. The Hubbard Brook study can largely be explained by the fact that the clearcut received a herbicide treatment, thus preventing any revegetation that would have absorbed nitrate released from the large amount of decomposing vegetation left on the ground.

Patric, J.H. and D.W. Smith. 1975. Forest management and nutrient cycling in eastern hardwoods. USDA For. Ser. Res. Pap. NE-324. 12p., illus. Upper Darby, PA.

These authors concluded that it is unlikely that any conventional harvesting of just sawlogs or stems would cause excessive nutrient loss. However they indicate that whole-tree harvesting could pose a threat to soil nutrient reserves.

Patric, J.H. 1977. Effects of wood products harvest on forest soil and water resources, with emphasis on clearcutting in moist climates. Pages 39-51 in The Scientific Base For Silviculture and Management Decisions in the National Forest System. 59 p. illus. Northeastern Forest Experiment Station. Parsons, W. VA.

There is little evidence that conventional wood products harvest---including clearcutting--will deplete nutrient levels in most Forest soils. Depletion following greater wood utilization on shorter rotations is possbile and must be guarded against carefully.

Patric, J.H. 1978. Harvesting effects on soil and water in the eastern hardwood forests. Pages 66-73 in in the Southern Journal of Applied Forestry. Vol. 2, no. 3.

"There is little doubt that increased soil moisture and temperature do accelerate release of nutrients contained in the organic layers on cutover forestland. Most minerals so released are promptly taken up by the regrowing trees, probably an important means of successful stand regeneration. Nevertheless, some of the released minerals will drain away in streams, resulting in a minor or short-lived enrichment".

Patric, J.H. 1980. Effects of wood products harvest on forest soil and water relations. Pages 73-80 in the Journal of Environ. Quality Vol. 9, no. 1.

Tree cutting increases streamflow and the outflow of plant nutrients dissolved in it. However, loadings of nutrients and sediment, even under clearcutting, was within the range of variation accepted as the geologic erosion rate. The author stated "viewed in the life span of Forests, these results suggest that responsible harvest of wood products caused only minor and shortlived effects".

Pritchett, W.L. Properties and Management of Forest Soils. John Wiley and Sons, New York, 1979. 500p.

In chapter 23 on Harvest Removals and Nutrient Budgets the author concludes that atmospheric inputs are considerably greater than losses by leaching from forested lands and they may largely replace nutrients removed in the harvested trees during a rotation period. He further states that "considering all factors, it would appear that most temperate forest soils have the capacity to recover from natural disturbances and timber harvests by nutrient replacements through mineral weathering and natural inputs".

Wells, C.G. and J.K. Jorgensen. 1979. Effect of intensive harvesting on nutrient supply and sustained productivity. Pages 212-230 in Proceedings: Impact of Intensive Harvesting on Forest Nutrient Cycling. 421 p. illus. Syracuse, N.Y.

Nutrient cycling studies indicate that normal stem harvest removes or causes nutrient losses from the forest ecosystem at rates compatable with nutrient inputs. However, harvesting on short rotations and biomass harvesting places demands on the soil that may exceed the natural supplying capability of the system. Fertilization, and adjustment of the rotation length and harvesting intensity can be applied to meet production objectives within the nutritional limitations of the system.

BIBLIOGRAPHY OF RELATED STUDIES IN OTHER GEOGRAPHIC AREAS

Adams, P. W., and J. R. Boyle. 1982. Soil Fertility changes following clearcut and whole-tree harvesting and burning in central Michigan. Pages 638-640 in the Soil Sc. Soc. Am. J., Vol. 46, No. 3.

Bengtson, G. W. 1981. Nutrient conservation in forestry: a perspective. Pages 50-59 in the Southern Journal of Applied Forestry, Vol. 5, No. 2.

Covington, W. W. 1981. Changes in forest floor organic matter and nutrient content following clearcutting in northern hardwoods. Pages 41-48 in the Journal of Ecology, Vol. 62, No. 1.

Gorden, R., J. H. Miller and C. Brewer. 1981. Site preparation treatments and nutrient loss following complete harvest using the Nicholson - Koch Mobile Chipper. Proceedings of the First Biennial Southern Silvicultural Research Conference. USDA For. Ser. Gen. Tech. Rep. SO-34. 375 p. illus. New Orleans, LA.

Likens, G. E., F. H. Bormann, R. S. Pierce, and D. W. Fisher. 1971. Nutrient-hydrologic cycle interaction in small forested watershed-ecosystems. Proceedings, Brussells Symposium on Productivity of Forest Ecosystems. (Ecology and Conservation, 4.) UNESCO.

Pierce, R. S., C. W. Martin, C. C. Reeves, G. E. Likens, and F. H. Bormann. 1972. Nutrient loss from clearcutting in New Hampshire. Pages 285-295 in Proc. Symp. Watersheds in Transition. Ft. Collins, CO.

Sopper, W. E., and H. W. Lull. 1967. International Symposium on Forest Hydrology. 812 p. illus. Pergamon Press, New York.

Stone, E. 1973. The impact of timber harvest on soils and water. Page 427 in Report of the President's Advisory Panel on Timber and the Environment. 541 p. illus. U.S. Govt. Printing Office, Washington, D.C.

Vance, E. D. and G. S. Henderson. 1984. Soil nitrogen availability following long-term burning in an oak-hickory forest. Pages 184-190 in the Soil Sci. Soc. Am. J., Vol. 48, No. 1.

Wells, C. G. and J. R. Jorgensen. 1973. Nutrient cycling in loblolly pine plantations. Pages 137-158 in Forest Soils and Forest Land Management. B. Bernier and C. H. Winget, eds. Les Presses de l 'Universite' Laval, Quebec.